# Estimating Quality-Adjusted Productivity In Tertiary Education: Methods and Evidence for New Zealand

Norman Gemmell, Patrick Nolan and Grant Scobie

WORKING PAPER 17/2017
November 2017

Working Papers in Public Finance

VICTORIA UNIVERSITY OF WELLINGTON
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

Chair in Public Finance
Victoria Business School

**The Working Papers in Public Finance** series is published by the Victoria Business School to disseminate initial research on public finance topics, from economists, accountants, finance, law and tax specialists, to a wider audience. Any opinions and views expressed in these papers are those of the author(s). They should not be attributed to Victoria University of Wellington or the sponsors of the Chair in Public Finance.

Further enquiries to:
The Administrator
Chair in Public Finance
Victoria University of Wellington
PO Box 600
Wellington 6041
New Zealand

Phone: +64-4-463-9656
Email: cpf-info@vuw.ac.nz

Papers in the series can be downloaded from the following website:
http://www.victoria.ac.nz/cpf/working-papers

Also New Zealand Productivity Commission Working Paper 2017/03

# Estimating Quality-Adjusted Productivity in Tertiary Education: Methods and Evidence for New Zealand

Norman Gemmell*
Patrick Nolan†
Grant Scobie‡

Revised version: 27th March 2018

**Abstract**

This paper constructs quality adjusted productivity indices for the tertiary education sector. It proposes a number of methods for making quality adjustments to measures of labour and multifactor productivity and applies those to the public tertiary sector in New Zealand over 2000-15. Quality-adjusted productivity measures for teaching across the tertiary sector as a whole are produced as well as measures of research productivity for universities. Our evidence suggests that quality adjustment, to both inputs and outputs, can make substantial differences to conclusions about productivity trends over 2000-15. In the case of tertiary teaching productivity, adjusting student numbers for the completion of qualifications suggests positive, rather than zero, productivity growth in the sector, largely driven by an expansion in non-university providers. In the case of research productivity (universities only) weighting research output for citations amplifies measures of productivity growth following the introduction of the Performance Based Research Funding (PBRF) regime. Especially important, but rarely discussed, components of those adjustment are (i) methods of deflating financial variables within some tertiary productivity measures; and (ii) how universities allocate resources between teaching and research.

* Victoria Business School, Victoria University of Wellington

† New Zealand Productivity Commission

‡ Independent researcher

## 1. Introduction

Over the last decade or so national accounting statisticians and others have made significant progress towards developing techniques for measuring public sector productivity.[1] But, at least compared to the private or 'measured' sector, this is still a developing field with a lack of international consensus on key questions. The difficulty arises partly from a paucity of market prices in the public sector, which can act as a measure of value, or willingness to pay, and as a means of aggregating output or input volumes. The 'missing prices' mean some other approach is required to combine (or weight) diverse inputs and outputs into indices.

For many years the default position in measuring the output of the public sector assumed that the growth rate of output equals the growth of inputs, hence rendering any consideration of productivity moot. However, since the work of Atkinson (2005a, b), and the Office for National Statistics (ONS) in the UK, various developments have sought to (a) allow separate measurement of inputs and outputs; and (b) capture quality changes within productivity measures.

A recent OECD survey (Lau et al., 2017) identified that only 5 of 16 countries that measure public sector productivity make use of quality adjustment (and another 16 do not measure it at all). Hungary, Ireland, the Slovak Republic and the United Kingdom apply quality adjustments to output data, while New Zealand applies quality adjustment to some input measures (Lau, Lonti and Schultz, 2017, p. 192). Where methods to include quality dimensions have been pursued, these have mostly been for public sector health and education, the latter typically focusing on schools. Indeed, more generally, tertiary education has received much less attention than schools in measuring productivity. This in part reflects difficulties accommodating the more multi-faceted nature of tertiary output – teaching and learning at all tertiary level institutions and the research outputs of universities – as well as a variety of public and private sector inputs.

For New Zealand, the most comprehensive attempt to assess efficiency and quality effects in tertiary education is Smart (2009), covering tertiary institutions over the period to 2006. Based on data envelopment analysis (DEA), for universities he concludes: '*analysis of university productive efficiency … showed that, on average, New Zealand universities have not improved their total factor productivity at the same rate as Australian universities. Encouragingly, there were signs of improved performance in a number of New Zealand universities in the last two years of the analysis, mainly as a result of increased research output which is potentially associated with the introduction of the PBRF [Performance Based Research Framework*]' Smart (2009, p.313). For polytechnics, Smart (2009, p.11) noted that polytechnics '*that had low levels of bachelor's degree provision … achieved higher levels of*

[1] For an earlier discussion of measurement in the public sector see McGrath (1999). Dunleavy (2016) provides a concise recent overview.

*pure technical efficiency …[and] that several polytechnics could improve their technical efficiency by reducing their scale of operations*'.

Although it is often recognised that public services involve multiple hard-to-measure outputs, for school-level education, pupil attainment is commonly treated as the dominant output or outcome. Of course, 'attainment' itself may be regarded as multidimensional, but in performance statistics it is generally proxied by a single indicator such as exam performance or qualifications achieved. For university education in particular this is compounded by the additional output dimension associated with research activity which cannot be ignored.

In this paper we provide new productivity estimates across the tertiary education sector in New Zealand over the period 2000-15, based on a variety of indices of teaching and research 'quality' to adjust both output and input quantities.[2] In addition to more standard quality adjustments used in schools productivity measurement (see Gemmell et al., 2017), our approach also incorporates proxies for both teaching and research quality based on qualification completions, salary premiums and research assessment results. We also argue that the choice of price deflator for tertiary education – used for example in national account measures of real tertiary output – is not straightforward when quality changes are difficult to observe. This can have a crucial effect on estimated tertiary sector productivity trends.

Before proceeding, it is useful to recall Atkinson's (2005a) warning regarding the reliability of government sector productivity measures such as those pursued here. He noted:

> "*…the direct approach to the measurement of government output yields an implied measure of 'government productivity'. It is a residual. However, there is clearly a risk that the residual will behave in unexpected ways and that it will be dominated by the vagaries of the two measured variables. This implied measure may or may not be consistent with independent evidence on the productivity performance of the public sector. The national accounts necessarily reduce productivity measurement to a single number, and this aggregate statistic may need to be supplemented by richer information. … to obtain independent evidence on productivity, as part of a process of 'triangulation'*." (Atkinson, 2005a, p.51).

Pursuing other 'independent evidence' on tertiary sector productivity is beyond the scope of this paper, though relevant aspects for New Zealand affecting both productivity specifically and education performance more generally are discussed in New Zealand Productivity Commission (NZPC, 2017). For example, as they note, '*course and qualification completion rates, and graduate salaries and employment rates – are not reliably good indicators of provider or system performance, because they are not adjusted for differences in the student intake*' (NZPC, 2017, p.248). While such differences in student intake are clearly an important aspect of productivity measurement across institutions ('providers'), it should be less of a concern when examining the evolution of the tertiary system as a whole over time, unless the nature of the aggregate intake were to have changed substantively over the relevant period.

---

[2] In this study we focus on the measurement of productivity trends. For a discussion of the potential impacts on productivity of innovations in the tertiary sector, see New Zealand Productivity Commission (2017).

We stress at the outset that our key objective is *not* to identify 'the best' overall measure of quality or productivity in tertiary education, nor indeed to produce 'final' estimates. Rather it is to examine the sensitivity of tertiary sector productivity to the inclusion of a quality dimension, and to identify how far different quality adjustments yield similar or diverse productivity trends. Establishing such an evidence base is clearly important as a starting point for any policy advice aimed at raising tertiary sector productivity.

The remainder of the paper is organised as follows. Section 2 describes current approaches used to estimate productivity, or performance more broadly, in the education sector including those at more aggregate national accounting levels and more micro-based estimates for parts of the sector such as schools. This section also focuses on how quality adjustments in particular have been applied. The specific productivity measures we develop for the New Zealand tertiary sector are discussed in Section 3.

Sections 4 and 5 then report our estimates for 2000-15 of quality adjusted productivity in tertiary teaching-related activities and in university research activities respectively. We report values for both labour, and multifactor, productivity. The various teaching and research indices are brought together in section 6 to examine overall productivity trends in the university sector, while section 7 reports on the sensitivity of results to the choice of price deflator. Section 8 concludes.

## 2. Measuring Education Sector Productivity

### *2.1 National Accounting Measures*

At the aggregate or industry level, Statistics New Zealand (SNZ) regularly publishes estimates for two 'industries': education and training; and healthcare and social assistance, as part of their annual releases of industry productivity measures. For other public services, SNZ consider that: '*defining output in collective services, such as police or fire services, is still a difficult task*' (Tipper, 2013, p.3).

The SNZ approach follows that increasingly adopted in international practice with output measures based on a chain-volume value added approach (with annually updated component weights), designed to overcome the absence of market prices in these industries; see SNZ (2013). To the extent that there are activities within those industries which are unmeasured, growth rates are assumed to be the same as those of the measured activities. Clearly, the larger is the former relative to the latter, the less reliable this approach is likely to be. Different outputs are combined using cost weights, updated annually.[3] These weights are available for most types of education and healthcare but reflect the value placed on the good or service by the *producer* (usually government) rather than the consumer.

[3] For further discussion on the use of unit costs as weights reflecting the marginal social value of outputs see Dawson et al. (2005).

In the case of inputs, labour and capital measures are combined, with labour input reflecting hours paid, and capital input estimated via a user cost of capital concept applied to the total industry capital stock.[4] Across the New Zealand education and training sector overall, the tertiary sub-sector represents around one-third of output; the schools sector accounts for 50%; with 16% in remaining sectors (preschool; adult, community and other education).[5] These sub-sector outputs are combined based on the cost-weighted number of equivalent full-time students (EFTS) with cost weights derived from financial data on expenditures for each activity.

However, some education activities are not measured (such as research), and in these cases output growth rates are assumed to match those of measured educational activities. For universities this assumption is obviously highly material and of unknown accuracy. Indeed, our results in section 6 suggest the possibility that improvements in quality-adjusted research productivity in universities have occurred in association with concurrent declines in teaching productivity.[6] In addition, both basic and quality adjusted productivity measures that are based on student achievement as their output metric can potentially mislead because they fail to account for the 'entry level' of student learning, such that value-added cannot be identified.

### *2.2 Approaches to Education Sector Performance Measurement*

At the micro or institutional level, data envelopment analysis (DEA) and stochastic frontier analysis (SFA) techniques have increasingly been used to assess the performance of both schools and tertiary institutions. Factors studied have included ownership type, single-sex/co-education, location and scale. Alexander and Jaforullah (2005), Alexander et al. (2007), and Harrison and Rouse (2014) provide examples of DEAs for schools.

For tertiary education, Johnes and Johnes (2009) apply an SFA to UK universities, while Smart (2009, 2009a) and Margaritis and Smart (2011) apply DEA to New Zealand (NZ) universities. The latter found that productivity growth of NZ universities between 1997 and 2005 was lower than that of the G8 groups of countries and newer universities in Australia. They also argued that the introduction of the Performance Based Research Fund (PBRF) stimulated productivity improvements in the NZ university sector, mainly via increased research output.[7]

---

[4] An exogenously given rate of return of 4% is applied to all industries in estimates of the user cost of capital; see Macgibbon (2010).

[5] The market component of these services was 13% (made up of 5% in preschool education, 0% in school education, 3% in tertiary education and 5% in adult education).

[6] The extent to which teaching-learning and research are complements or substitutes and/or experience economies of scale is also subject to debate but potentially important for measures of tertiary productivity; see NZPC (2017, chapter 2) for discussion of this literature, and Barrett and Milbourne (2012) for Australian evidence.

[7] Other studies include Doucouliagos and Abbott (2007) and Abbott and Doucouliagos (2009). They showed that New Zealand enrolments of overseas students appeared to have had no effect on technical efficiency, which contrasted with evidence from Australian universities. Talukder (2011) found that private providers experienced

More recent analysis of PBRF results up to 2012 has been undertaken by Smart (2013) and Smart and Engler (2013) with the former concluding that '*although we cannot imply causation, the improvement in bibliometric performance by New Zealand tertiary education institutions has coincided with the introduction of the PBRF*' (Smart, 2013, p.27).[8] More recently, Buckle and Creedy's (2017a) analysis of the 2003-12 PBRF process examined bibliometric versus peer-reviewed based methods of assessing research output. They argue that peer-reviewed based measures of researcher quality have advantages and, in Buckle and Creedy (2017), find a marked increase in researcher quality in NZ universities which we argue is at least in part attributable to the introduction of the PBRF.

These studies contribute helpful insights into the efficiency of tertiary production technologies across institutions but, by their nature, cannot provide an overall picture of productivity in the tertiary sector, nor trends over extended periods.[9] However, their results suggest various metrics commonly associated with tertiary education performance or quality – such as qualifications gained and research bibliometrics – that could potentially be used as proxies for quality to adjust sector-wide productivity data. We pursue this in section 4. In the next sub-section we summarise existing approaches to quality measurement, most of which have been applied at the school, rather than tertiary, level.

Some basic tertiary productivity measures have been produced for New Zealand by NZPC (2017), who conducted a major inquiry in 2016-17 into the performance of the NZ tertiary sector, exploring trends and outcomes for the sector and component institutions. Using a labour productivity measure based on student and staff FTEs, and capital productivity based on a measure of 'teaching assets', NZPC (2017; see pp.226, 241) estimated productivity levels across tertiary institutions for 2015. This suggested a wide cross-institution dispersion of performance with labour productivity in the best performing institution around 4 times higher than in the least productive (and 13 times higher for capital productivity). A time-series of basic labour or capital productivity was not available however, and no formal quality adjustment to those measures was attempted.

### *2.3 Quality Adjustments and Productivity Measurement*

For the education sector in general, the presence or otherwise of quality adjustments has been shown to play an important role in the interpretation of productivity data; see Maimaiti and O'Mahony (2011). However, such adjustments can be complex and, as Schreyer and

---

larger MFP growth than public providers during 1999-2004, but experienced a sharper decline in MFP-growth over 2005-10.

[8] A somewhat different view for the economics discipline is offered by Anderson and Tressler (2013) who argue that the PBRF has been associated with undoubted increases in economics research *quantity* per capita but a decline in research *quality* per capita. Earlier studies attempting to compare the research output of economics departments based on bibliometric information such as journal rankings include Bairam (1996, 1997) and Gibson (2000).

[9] Smart (2009, p.132) does however provide evidence on output-to-input ratios for NZ polytechnics, 1996-2006.

Lequiller (2007) noted, information beyond that contained in the national accounts will generally be needed. As quality is multi-dimensional, a single index is unlikely to be adequate.

In education, key quality adjustments can relate to inputs (e.g. teacher quality or student-staff ratios), outputs (e.g. school inspectors or educational attainment) or outcomes (e.g. impact on human capital). Most of these quality adjustments have been applied to school productivity with applications to the tertiary sector much more limited; see Gemmell et al. (2017) for details. Nevertheless various approaches to adjusting schools productivity to capture quality dimensions have identified a number of variables, some of which are relevant at tertiary levels.

For example, teacher quality and class size have been suggested as important influences on students' educational progress, though the role of 'congestion' in class size effects is disputed; see, for example, Bowles et al. (2001), Rivkin et al. (2005), Hanushek and Rivkin (2006), Collesi et al (2007), Leigh and Ryan (2008), and Kimbugwe, et al. (2009). The use of school inspections and internationally comparable standardized test scores, such as PISA, have also been advocated as possible inputs into quality adjustment; see Hanushek et al. (2010), Leigh and Ryan (2011). At the tertiary level, such information is not generally available, but Huxley et al. (2017) provide a recent attempt to evaluate the impact of class size on student experience in UK universities.

An approach to quality adjustment which is equally relevant to both school and tertiary institutions, draws on a human capital framework, in which education is viewed as an investment with the payoff taking the form of higher expected future earnings. An advantage of this approach is that it captures the outcomes of the education process in a single economically interpretable form, though at the cost of excluding benefits not reflected in earnings. Examples include Murray (2007), O'Mahony and Stevens (2009), Hanushek (2011) and Barslund and O'Mahony (2012).

Of course, as Hanushek (2015) acknowledges, there are limitations to using expected earnings as a measure of the value of education. Firstly, it can be influenced by selection bias, where students enrolling in additional education are self-selecting. Secondly, historical average earnings profiles for different levels of qualification (that also ignore heterogeneity around that average) are typically used as the basis for assumed future earnings, but the past may not be a good predictor of the future. Thirdly, any earnings premium is often attributed to education when some part of this may have been due to innate ability, family background, health status, subsequent employer-based training, and so on. To mitigate this some studies have used earnings over a short, initial period (e.g. 5-10 years) following entry into the labour market.[10]

Finally, recent UK Office of National Statistics (ONS) experience illustrates the dangers of adopting particular quality adjustment measures. They found that their approach to adjusting

[10] A novel approach to assessing the quality of school education adopted by Black (1998) analysed the difference in prices for equivalent houses in the same neighbourhood in Boston but which were in different school zones. Gibson and Boe-Gibson (2014) apply a similar approach for Christchurch, New Zealand.

education outputs for quality had to be amended in response to substantive changes in the numbers of students taking different forms of exam; see ONS (2015d), Caul (2014), Bridge (2015). This had a material impact on quality-adjusted output. More generally, the significance of the contribution of quality adjustment is evident from estimates of UK education sector output growth. Over 1997-2011, Caul (2014) reports estimated education productivity growth of 2.7% per annum on average, of which quality adjustments contributed 2.5 percentage points (or 90%) of the total.

Unsurprisingly perhaps, the above review suggests that no single measure can capture the full richness of the quality dimension of education sector productivity. Indeed, UK experience indicates that quality metrics may have to adapt to changing circumstances. With a number of imperfect proxies for quality improvement available, it will be crucial to test the sensitivity of any adjustments to the particular quality metrics adopted for both inputs and outputs.

In section 4 the impacts of a number of different quality indices are therefore examined for tertiary education. For teaching these including course completions and credits, and measures of students' expected future earnings. For research, we use publication citation rates and staff input quality measures. The latter takes explicit account of PBRF-based staff quality assessments, based in part on peer-review processes. In principle citation rates also could be adjusted to capture peer-review assessments – for example by weighting citations by a measure of the quality of the publication outlet in which they appear. However, this information is neither readily available across disciplines nor uncontested within disciplines. Indeed it can be argued that the citation rate for an author's contribution is a preferable quality measure precisely because it relies on judgements by the wider research community, rather than the investigator's prior value judgements regarding the quality of the outlet in which an author's publication appears.

## 3. Constructing Labour and Multifactor Productivity Measures

As with a number of other countries, data for aggregate tertiary sector-level productivity calculations are generally available in the form of a number of output *volume* measures, e.g. student FTEs; volume measures for some inputs such as labour; 'value' or 'expenditure-based' measures (price times volume) for a wider set of inputs, and indices capturing quality dimensions to varying degrees. Where expenditure-based measures are used, or where nominal value data are used to proxy for quality – such as qualification earnings premiums – suitable deflators to derive comparable real values are also required.

Table 3.1 summarises the particular productivity measures, and the abbreviation symbols, we will use throughout later sections to identity different types of measure. Their selection from a broader conceptual group of possible measures discussed above has been dictated largely by data availability. Almost all of the data are from publicly available sources including Statistics New Zealand, the Ministry of Education (Education Counts), the Treasury and the annual reports of the universities.[11] We stress again that our key objective here is not to identify 'the best' overall measure of productivity in tertiary education, but to examine the sensitivity of alternative productivity measures to inclusion of a quality dimension, and to identify how far such adjustments yield similar or diverse productivity trends.

As Table 3.1 shows, for both teaching and research productivity measurement, we begin with a 'basic' measure of labour productivity, labelled '$Q/L_T$' or '$Q/L_R$' (where T = teaching and R = research) based on output and labour input *quantities* (volumes), from data on enrolled student (Q) and staff FTEs ($L_T$ or $L_R$). In addition, we have data on the total nominal value of public expenditure on tertiary inputs, \$E. This can be thought of as a proxy for the value of multiple inputs used in the production of tertiary output and, as such, likely mainly captures the inputs of capital (K), labour (L) and materials (M).

Hence, conceptually $\$E = wL+rK+mM$; that is, the sum of labour, L, capital, K and material, M, inputs, each weighted by their respective prices: *w*, *r* and *m*, though the available education expenditure data do not identify this decomposition. Thus, after suitable deflation of \$E to obtain real values, E, a multifactor productivity measure, 'Q/E', can be obtained by dividing output quantity by the real value of expenditure on tertiary inputs.

Subsequent productivity measures capture the quality-adjusted values of these inputs or outputs by, for example, using our quality indices to measure 'p' in the expressions 'pQ/L', 'pQ/*w*L' or 'pQ/E', where *w*L represents labour costs by adjusting labour input for 'quality' using suitable wage rates, *w*; see Diewert (2017) for detailed discussion. Labour input quality can be recognised by accounting for difference in the quality of university staff research, to yield a better measure of research human capital ($H_R$).

Table 3.1 also shows that an overall (research plus teaching) productivity measure is obtained as a weighted average of the two components, with weights given by the relative cost of the respective expenditure items. Finally, as we discuss in a section 7, the issue of price deflation of financial variables such as teaching and research expenditures, to obtain real values over time is not straightforward. In most of our empirical results we use a general consumer price index to deflate nominal values but test sensitivity of results to a tertiary education specific price index in section 7.

*Table 3.1 about here*

## 4. Teaching Productivity

This section presents estimates of teaching productivity in the tertiary sector. Initially, a range of basic measures is presented; these are then modified to illustrate the impact of quality

[11] Statistics New Zealand provided us with some additional data from the New Zealand Income Survey, and Ministry of Education provided data for earlier years for some selected variables.

adjustments. An adjustment is first made on the input side. Then outputs are adjusted for completion rates, before an adjustment for outcomes (lifetime earnings) is considered.

The tertiary sector is composed of universities, institutes of technology and polytechnics (ITPs), and wānanga.[12] For universities we recognise both a teaching and research function, whereas for ITPs and wānanga we have assumed their total activity is devoted to teaching, thereby ignoring a very small research component.[13]

### *4.1 Overall numbers of students and staff by sub-sector*

In the basic measures student FTE numbers are used as a proxy for output. These data are shown in Table 4.1. [14] For the years when student numbers were not capped (up until 2005) they rose rapidly: FTEs rising by 44% between 2000 and 2005.

*Table 4.1 about here*

For the basic measures of teaching productivity, Table 4.2 shows Ministry of Education (MoE) data on staff FTEs in the tertiary sector since 2000. A breakdown of these staff numbers for different sub-sectors can be found in Appendix Table A1. To illustrate changes in the composition of staff (as well as in the total) these data are decomposed by the MoE into separate categories of: academic staff (excluding research-only staff in universities), non-academic staff and university research staff. There are naturally limitation to this categorisation (e.g. non-university organisations may have research staff, and university 'academic' teaching staff typically undertake research). Nonetheless, the data for academic staff numbers in universities provide a reasonable basis for some basic estimates of teaching productivity shown below.

Tertiary academic staff numbers grew at 1.2% pa over 2000-2015, while non-academic staff grew at close to twice that rate (2.0%). Meanwhile, university research staff numbers increased markedly over the period (growing at 3.3%), reflecting the growing importance of research in tertiary funding. For example, Tertiary Education Commission data show that in 2015 research income accounted for 22.4% of total university income, compared to 15.1% in 2004.

Table 4.2 shows the numbers of total academic, non-academic and research staff. Teaching staff are defined as academic and non-academic staff FTEs. However in the case of universities only, a fraction of academic and non-academic staff FTEs are defined as teaching-related. This university component is described further in section 5.[15]

---

[12] Wānanga are tertiary education institutions offering learning in a Māori cultural context.

[13] MoE-sourced data on staff numbers record a designated 'research staff' category for universities but not for ITPs and wānanga.

[14] MoE definitions of student and staff FTEs are given at https://www.educationcounts.govt.nz/data-services/glossary. For students, this is 'one equivalent full-time student (EFTS) unit is defined as the student workload that would normally be carried out in a single academic year (or a 12-month period) by a student enrolled full-time'.

[15] We assume here that 50% of academic FTEs are devoted to teaching (based on the 40:40 20 model of staff time described below, but where staff administration time (20%) is allocated proportionately to teaching and research. Non-academic staff FTEs are allocated to teaching and research activities in proportion to estimated university expenditure on those activities. We test sensitivity to these allocation assumptions in section 7.

*Table 4.2 about here*

Table 4.3 provides estimates of real teaching expenditure for the three sub-sectors: universities, ITPs and Wānanga. This is treated as equivalent to total expenditure for ITPs and Wānanga, as for these sub-sectors it is assumed all expenditure relates to teaching. For universities, an estimate of their total research funding was subtracted from total expenditure, the balance providing an estimate of the teaching component. Details of this estimate are given below in Section 5.3.2.

This estimate of teaching expenditure is likely to include some university overheads potentially attributable to the research activity, such as maintenance of laboratories and other research infrastructure.

*Table 4.3 about here*

### *4.2 Basic productivity measures for tertiary teaching*

This section presents two basic measures: for labour productivity and multifactor productivity. The basic measure of labour productivity is one that has been widely used in productivity studies of education and is simply the number of student FTEs per teaching staff FTE. Student FTEs are taken as a proxy for output. It is recognised that there are significant limitations to this measure of output. Student numbers can vary with exogenous factors including the state of the labour market or changes in government policies and funding. Student FTEs per $m of teaching expenditure is treated as a basic indicator of multifactor productivity.

Table 4.4 presents annual values for the basic labour productivity index over 2000-2015.[16] Overall this suggests little change in productivity despite the earlier years being influenced by the estimates for Wānanga which started from a very low base. In general productivity growth slowed markedly after around 2009. As the data in Tables 4.1 and 4.2 on student and staff FTEs make clear, this productivity decline essentially began following the large rise in student FTEs during 2000-03, which then shrank from around 265,000 in 2004 to around 232,000 in 2015, mainly in ITPs and Wānanga. Meanwhile tertiary staff FTEs continued to rise from 26,730 in 2003 to 29,395 in 2005, much of this in universities, though staff FTEs in ITPs remained relatively constant despite student FTEs falling substantially over this period.

Table 4.4, and subsequent tables, split the fifteen year period at 2008 (after which economy-wide productivity growth rates declined). The slowdown in labour productivity is reflected in negative growth rates for 2008-15. Table 4.5 suggests that basic multifactor productivity trends were generally similar to those for labour productivity, with all three sub-sectors in this case experiencing positive (or zero), then negative, productivity growth in 2000-08 and 2008-15 respectively.

[16] NZPC (2017; ch.8) provide some evidence on basic measures of labour and capital productivity across tertiary institutions for 2015. The former is measured by student FTEs per teaching staff FTE; the latter is measured using the value of 'teaching assets'.

*Tables 4.4 and 4.5 about here*

The central question arising from these basic productivity measures is whether there has been a genuine underlying fall in productivity as might be suggested by these results, or is the apparent decline in productivity over the fifteen year period a reflection of shortcomings in the measurement of inputs and outputs. To address this the next sub-sections consider adjustments to inputs and outputs by which it is hoped that the resulting productivity indices provide more complete, but previously unmeasured, trends in productivity.

### *4.3.1 Inputs*

Ideally, teaching input should be adjusted for changes in teacher quality over time. Chalmers (2008) describes a project for the development and implementation of agreed indicators of teaching quality in Australian universities. Such metrics are an essential ingredient in any system of rewards for quality teaching.[17] However, there are no data at the aggregate level that would allow such an adjustment in the present study. Instead, the approach taken in this study is to adjust the labour input for salaries which at a minimum captures changes in labour composition between different skill or experience (salary) levels such as professors, junior lecturers, administrators etc.

Following York (2010), the approach taken was to create an adjusted teacher input defined as full-time teacher equivalents by type of tertiary institution (TI) weighted by mean teacher salary in each TI type ($\sum w_i L_i$ where $w_i$ is the mean salary in the $i^{th}$ TI type). This adjustment, involving disaggregation and cost weighting, is aimed at capturing changes over time in the qualifications and experience of teaching staff. If for example there was a decline in the number of older experienced teachers, say through retirement, and their replacement by new younger staff at lower salaries, then the labour cost index, $\sum w_i L_i$, would decline. However, the method does not capture variations in teacher quality within a TI type.

Using salaries as cost weights is a proxy for the market valuation of teaching services. As Atkinson notes (2005, p.88), the appropriate measure is the *marginal* cost, i.e., the cost of acquiring the services of an additional teacher. However, typically marginal measures are not available and in most cases average costs are employed as a substitute, as in the present case.

### *4.3.2 Output*

This section updates the basic output measure by first adding completed qualifications to the measure of output. A second adjustment is made to reflect expected incomes associated with different qualification levels.

---

[17] Similarly, the UK Professional Standards Framework (UKPSF) – which is used by the Higher Education Academy (HEA) as the basis for accreditation and professional recognition of university teachers – is attracting participation in NZ.

Completions are often seen as an important component of tertiary sector output. A tertiary institution in which a significant proportion of those enrolled fail to complete their course of study is unlikely to rank well in terms of productivity.[18] To account for completions in the measure of outputs, the sector is stratified into the three sub-sectors: universities, ITPs and Wānanga. For each sub-sector ten levels of qualification were recognised. The completion numbers for each qualification were then weighted by the number of credits assigned to each based on New Zealand Qualifications Authority (NZQA) rankings.[19]

For example, a bachelors degree represents 360 credits, whereas an honours degree represents an additional 90 credits while level 1-4 certificates (offered mainly by ITPs and Wānanga) represent 40 credits. The qualifications and their credits are set out in Table 4.6, while the number of completions for each year and the weighted total are given in Table 4.7. Of the total credit weighted qualification completions, universities represented 63%, ITPs 29% and Wānanga 8%.

*Tables 4.6 and 4.7 about here*

As noted, a further extension to the basic output measure is to account for the impact of education outputs on outcomes. The focus below is on one particular outcome: lifetime, or early career, earnings. Measures are constructed by weighting completed qualifications by an estimate of the income earned by people with these qualification levels. Earnings are thus used as an indicator of the stock of human capital; an approach that has been widely used in evaluating the returns to education.[20] Of course, there is extensive debate over whether, and how far, earnings differences observed for individuals with different qualifications can truly be attributed to that specific education. In this sense our resulting productivity estimates should be treated as measures based on quality-adjusted outcomes (earnings) *associated with* different tertiary outputs (completions). The *sources* of those outcomes may at least partially lie elsewhere.

In New Zealand, as elsewhere, returns to education qualifications are known to vary by age and gender and, sometimes by age cohort (see, for example, Maani, 1996, 1999; Maani and Malony, 2004; Zuccollo et al, 2013; MoE, 2016b). To identify possible income weights that can be used to capture qualification premiums for different graduate types, we reviewed previous relevant New Zealand and Australian studies and applied a standard earnings regression model to census data for New Zealand covering 1981 to 2013. The underlying model is described in Appendix B.

---

[18] Jia and Maloney (2015) use administrative data from a large New Zealand university to empirically estimate the determinants of both non-course completion outcomes among first year students, and non-retention outcomes in the second year. They conclude that use of the predictive modelling tools that they develop could assist in targeting students at risk of adverse outcomes and devise early intervention strategies.
[19] See: www.nzqa.govt.nz/assets/Studying-in-NZ/New-Zealand-Qualification-Framework/requirements-nzqf.pdf. NZPC (2017, p.259) discuss completion rates by course and qualification, including data for 2009-14.
[20] See for example Blundell et al. (2004).

Results are summarised in Tables 4.8 and 4.9. The data sources used and studies summarised cover a range of time periods and do not all use a consistent set of qualification categories. Furthermore, other variables are held constant to varying degrees. However, Table 4.8 suggests a fair amount of similarity across studies for approximately the same, albeit highly aggregated, qualifications, estimated over a number of years. The final column of the table shows the simple average of these estimates.

*Tables 4.8 and 4.9 about here*

In Table 4.9, the two right-hand columns show recent MoE (2016b) estimates of earnings premiums across the more detailed qualification categories for which we have completions data. The MoE data relate to incomes of employed graduates who remain in New Zealand and represent median earnings at 1, 2, 3 … 10 years following graduation. The table shows premiums for 5 and 10 years, expressed relative to median bachelors degree earnings.

Taking account of both these data and the historical estimates shown in Table 4.8, it is clear that no single set of weights takes obvious precedence, though MoE (2016b) provide the most comprehensive estimates for our qualification categories. For this reason a range of different weighting schemes was tested. These led to different *levels* of productivity, but the *growth rates* were generally unaffected. As a default weighting scheme, we apply the earnings weights shown in the left-hand column of Table 4.9, with the values in brackets examined for sensitivity. The weights were applied to the credit weighted completions for each sub-sector. [21]

In summary the results of the adjustments to teaching output are three measures: unweighted completions; credit weighted completions; and credit and income weighted completions. These measures are used in forming estimates of productivity growth rates reported in the next sub-section, which were found to be insensitive to the particular weights adopted, largely because bachelors degrees heavily dominate the completions qualification type.

### *4.4 Productivity measures for teaching incorporating quality adjustments*

The measures of teaching productivity are summarised in Tables 4.10 and 4.11 for labour and multifactor productivity, respectively.

In each case, the basic unadjusted measure of productivity growth over the study period is shown in the first row. The striking result is that without exception, the quality adjusted measures are all significantly larger. This applies across all sub-sectors and all measures,

[21] Though diplomas and degrees dominate the qualifications and completions data, especially for universities, the tertiary sector as a whole offers the full range of qualifications in Table 4.9. For example, Certificates 1-4 represent almost 50% of unweighted completions in the tertiary sector, of which 94% were obtained at ITPs or wānanga. Examining sensitivity to changes in the weights for tertiary level qualifications above bachelors degree level had very little effect on productivity outcomes largely because of the small share of qualifications above bachelors in total qualification numbers within the dataset.

underscoring the importance of quality adjustment when measuring productivity in the tertiary sector.

*Table 4.10 and 4.11 about here*

### *4.3 Accounting for grade inflation*

These estimates based on completions could be affected by grade inflation, which occurs when progressively higher grades are awarded for assignments or examinations than would have been awarded in the past for comparable performance.[22] The rate of completions could also increase by simply allowing some students of lesser quality to graduate who might otherwise have withdrawn.

Of course it is not clear that a change in the grade distribution over time necessarily provides *prima face* evidence that grade inflation has occurred. An increased share of graduates with higher average grades could be a reflection of the quality of new enrolees as indicated by their pre-tertiary academic performance. Likewise, improved methods of teaching might have led to superior performance (Bachan, 2017).

However, while there may be anecdotal evidence for grade inflation in New Zealand, we are not aware of any of research based on longitudinal evidence.[23] As a consequence, in considering the possible impact of grade inflation, in what follows we have relied on estimates from overseas studies. Obviously, this requires the untested assumption that the experience in other countries is indicative of what may have happened in New Zealand.

Notwithstanding difficulties separating grade inflation effects from other sources of change in student achievement (e.g. student intake quality, teaching efficiency), two recent studies, Johnes and Soo (2015) and Bachan (2017), have sought to distinguish grade inflation effects from efficiency changes and student intake capabilities.

Bachan (2017) reports that between 1995 and 2012, the proportion of UK students graduating with a bachelor degree who were awarded first or upper second class honours rose from 47.3% to 61.4%. After controlling for other factors, he finds a 9.6% increase in qualifications over 2006-12 years, or 1.6% per year, which they argue could substantially reflect grade inflation. Examining similar UK data for 2004-12 and using similar methods, Johnes and Soo (2015) find little or no evidence of grade inflation in general but some limited support for inflation towards the end of their period.

Anglin and Meng (2000) found that the proportion of students receiving A grades at Ontario universities rose from 16.3% in 1974 to 21.0% in 1994, an annual average rate of increase of 1.27%. And in a comprehensive study for the US covering 80 colleges and universities for an

---

[22] For an overview and discussion of consequences and remedies see Rosovsky and Hartley (2002). Kohn (2002) offers a dissenting view, arguing against the prevalence of grade inflation.

[23] Nevertheless, after analysing limited time-series evidence of increases over time in student grades at some New Zealand universities NZPC (2017, p.258) concluded that ‘it is not possible to tell from this data whether these changes result from grade inflation or from another cause such as higher entry standards or better teaching’.

extended period, Rojstaczer and Healy (2010), found that GPA scores rose by 0.39% p.a. This rate was the same for two different periods: 1935 to 2006 and 1983 to 2013. These results suggest that while it appears some grade inflation did exist the rate remained stable over a long period. Earlier, Juola (1980) found that across 180 colleges in the US, the GPA rose by 1.03% p.a. between 1960 and 1974, and this rate of increase remained largely unchanged from 1974 to 1978.

In a survey of 4,000 undergraduates in the US, Levine and Cureton (1998) reported that the proportion of A-grades or higher rose from 7% to 26% between 1967 and 1993, an annual average increase of 5.2%; in contrast grades of C or below fell from 25 to 9%. In another survey of over 52,000 students in the US, Kuh and Hu (1999) found that the GPA rose at an annual average rate of 0.77% over 1984-87 to 1995-97. The average GPA at Harvard in 1890 was 2.27; by 2004 it was 3.48, corresponding to an annual average rate of growth of 0.38%.

Summary and Weber (2012) reported that GPAs at Southern Missouri State University increased from 2.6 in 1986 to 3.1 in 2005, corresponding to an annual average rate of growth of 0.93%. But, using a frontier model with two outputs (GPAs and the information content of the grades), they found no change in efficiency.

It must be acknowledged that the above results likely represent upper bounds on the impact of grade inflation since they can only control for other factors to a limited extent. However, based on these results it is possible to consider how rates of tertiary productivity growth in New Zealand might change if we allow for possible grade inflation. From the sample of studies summarised above a lower bound of 0.3%, and an upper bound of 0.9%, average annual change would seem to encompass the range observed, but recognising that these may be *maximum* effects given difficulties excluding other sources of grade improvement.

If we were to use those results to adjust the teaching productivity growth rate in the tertiary sector of 1.8%, based on credit and income weighted completions per staff FTE (see Table 4.10), the range of this annual productivity growth rate would become from 0.9% to 1.5%. On this basis, grade inflation might account for at most half a percentage point of average teaching productivity growth rates.

Finally, it should be noted that unlike the case of inflation of prices, which (theoretically) can continue without limit, qualification grades are generally capped so the result is simply compression of the distribution. As a consequence, the factors that may have led to grade inflation in the past might become muted as compression cannot continue indefinitely. To this extent, the past may not be a good indicator of future trends.

## 5. Research Productivity

This section addresses the measurement of research productivity, and provides estimates of university research productivity growth rates in New Zealand over 2000-15. Particular attention is given to assessing the possible implications for research productivity of the introduction of the PBRF system for assessing research output and quality.

As noted earlier, it has been assumed that teaching is the principal activity of the ITPs and Wānanga. As a consequence, the analysis of research productivity is focussed on the university sector alone. To the extent that the databases on New Zealand research outputs capture research outputs across all tertiary institutions, the approach taken here will tend to somewhat overstate the level of *university* research output. However, if it is the case that that the extent of that overstatement remains approximately constant over time, then the rate of research productivity growth should be minimally affected.

The section starts by addressing the measurement of research output, and then presents estimates of the basic unadjusted research productivity measures. This is followed by the approaches taken to adjust for quality of both research inputs and outputs, and the section concludes with adjusted measures of research productivity before and after the introduction of the PBRF.

*5.1 Measuring research output*

Measuring the output of the university sector presents considerable challenges stemming from the multi-product nature of the teaching and research activities. In addition to the production of graduates (the teaching function) and the publication of new findings (the research function) Pastor *et al.* (2015) identify a third dimension they label as knowledge transfer. This arises from the contracts universities have with institutions and firms for the transfer of research findings and consulting to provide technical assistance. In the present study, we identify teaching and research outputs, leaving the third element to be subsumed in the other two.

We focus on publication numbers and citations as the primary measures of output of the research function. However, we recognise, as Wilsdon et al. (2015) argue in their wide-ranging review of research assessment processes, that '*metrics should support, not supplant, expert judgement. Peer review is not perfect, but it is the least worst form of academic governance we have, and should remain the primary basis for assessing research papers, proposals and individuals, and for national assessment exercises*' (p. viii). To the extent that there are multiple products of research, a limited 'metrics' approach risks understating the true output of research activities. For example, patenting is an important product of research not adequately captures by publications. Based on a synthesis of the literature, Pastor *et al.* (2015) conclude that the empirical evidence is that publications and patenting are positively correlated. As a result, estimates of the growth, if not the level, of productivity would not necessarily be understated.[24].

Before proceeding, it is important to recognise that there is not typically a clear delineation between the teaching and research activities; the boundary is blurred at best. To the extent that there are research elements included in the teaching function, or teaching impacts on research,

[24] The PBRF process explicitly recognises, and evaluates, other research contributions, such as contributions to the 'research environment' but these are less easily quantifiable in a way amenable to quality adjustment, have differed in scope across PBRF rounds, and are likely to be highly correlated with research outputs.

productivity estimates for research and teaching which ignore those interactions may be over- or under-stated.

New Zealand universities (other than the University of Otago) do not publish breakdowns of their total expenditure into teaching and research components. However, the MoE does publish data on income received by tertiary institutions separated into teaching-related, research and 'other' income.

We adopt the assumption that the allocation of expenditure to teaching and research activities is approximately equivalent to the income allocation between the two categories, and test sensitivity to this assumption in section 7. Specifically, MoE data on income includes 'tuition', 'student fees and charges', 'research income' and 'other income' (e.g. interest, dividends).[25] However, university staff funded from tuition and student fee income also devote time to research. We therefore redefine income for teaching purposes as 40% of tuition and student fee income. Adjusted research income is obtained by adding 40% of tuition/fee income to the MoE research income category (with the remaining 20% of tuition/fee income added to 'other income').[26] We apply the resulting percentages of teaching and 'adjusted research income' in total income to data on total university real expenditure to obtain adjusted figures for real university research and teaching expenditure. These are given in Table 5.1.

We turn now to measures of research output. Two sources have been used, both referring to research outputs of New Zealand affiliated authors; see Table 5.2. The first, SCOPUS, lists the number of citable publications, while the second, the Web of Science (WoS) covers articles, books and book chapters. The table also shows the average of these two sources which has been used in calculating research productivity.

Table 5.2 reports data from 1997 and growth rates are shown for PBRF sub-periods: pre-2003, 2002-06 and 2006-15.[27] While these data alone are insufficient to enable any conclusions to be drawn about the impact of the PBRF on the quantity of research output, there is certainly no indication here that the first PBRF (in 2003) was associated with subsequently increased output growth, whereas post-2006 growth does appear somewhat higher than 2002-06.

*Tables 5.1 - 5.4 about here*

*5.2 Basic and quality-adjusted productivity measures for university research*

Basic measures of research productivity for the university sub-sector, using both labour and multifactor productivity are shown in Tables 5.3 and 5.4 respectively. As the final row of each

---

[25] See http://www.educationcounts.govt.nz/statistics/tertiary-education/resources.

[26] This 40:40:20 allocation is used to measure academic staff time allocated to teaching, research and 'service' (or administration) respectively. It forms a common rule of thumb, advice to university academics and is supported by results from various surveys of university staff; see, for example, Sutherland (2017, pp.63-65) for evidence on the '40:40:20 model' for universities in New Zealand and overseas.

[27] We include data available back to 1997 here to increase the number of years prior to the first 2003 PBRF exercise to provide a longer perspective on pre-PBRF growth rates.

table shows, the productivity growth rates over the whole period, 2000-15, are identical for both data sources. Research productivity growth appears to have been positive throughout the period. With one exception, all measures show an acceleration in the productivity growth rate after 2006.

As in the case of teaching, we examine the effects of adjusting both inputs and outputs for quality.

### *5.2.1 Inputs*

Labour productivity is based on the number of research staff FTEs. University research FTEs are defined as 50% of academic staff FTEs plus a fraction of non-academic staff FTEs, where the latter are assumed to be engaged in supporting both teaching and research activities. The fraction used is the estimated share of research in universities' total research plus teaching expenditure. There is no simple indicator of changes in quality of research staff; a proxy therefore has to be sought. In this case we have relied on changes in the PBRF grades of university staff. If over time, a greater proportion of academics receive a higher grade, it is reasonable to assume that by some measure the 'quality' has improved. An institution where, say, 40% of its staff were graded 'A' would intuitively seem to have a higher average quality than one where only, say, 10% reached that grade.[28]

The quality adjustment of the labour input is based on the results of the three PBRF reviews (2003, 2006 and 2012) which assigned those staff active in research to one of three quality categories: A, B and C.[29] This enables a weighted measure of research FTEs to be constructed using the PBRF relative weighting scheme of A = 5, B = 3 and C = 1 (see Smart and Engler, 2013).[30] The number of research staff was derived by assuming 40% of the time, and hence cost, of 'academic staff' was devoted to research and adding the number of 'research staff'; see Table 4.2. Section 7 explores the effects of changing this time allocation.

Over time there has been a marked change in staff composition (academic and university research) as indicated by the proportions rated A, B and C; see Table 5.5. The percentage rated as C fell by almost a half, while As more than doubled. This is consistent with the stated aim of the PBRF scheme to raise the average quality of research. Furthermore, the changing composition underscores the need to incorporate a quality adjustment rather than assuming all research FTEs are identical.

*Table 5.5 about here*

---

[28] See Buckle and Creedy (2017) for discussion of the sensitivity of overall PBRF results to the quantification scheme used to allocate research individual staff to categories A, B, C. Below we discuss how awarded PBRF grades and measured research output may be inter-related.

[29] For a detailed overview of the 2012 round see Tertiary Education Commission (2014a).

[30] It is acknowledged that applying a fixed set of PBRF weights overlooks the very substantial differences in the PBRF performance evaluations across different disciplines. Boyle (2008) shows that New Zealand academics whose salaries are close to US levels (e.g. in philosophy and anthropology) have the highest performing staff in contrast to the lowest performers (e.g. accounting and finance) where there is a large gap between NZ salaries and those internationally.

### *5.2.2 Output*

Section 5.1 described the approach used to measure the volume of research output by New Zealand affiliated authors. This was based on the international datasets, Web of Science and SCOPUS. However, deriving estimates of productivity based on these raw output numbers involves the implicit assumption that there has been no change in the quality of publication over time. This sub-section relaxes that assumption.

To make this adjustment, we weight the volume of output by the average number of citations per publication. Using citations as a proxy for quality implies that more extensively cited papers make a larger contribution to the stock of knowledge than those with fewer (or no) citations.[31] An alternative measure could be based on journal weighting schemes, in which papers published in more highly cited journals are regarded as having more impact. However, there is debate over which approach is superior and journals provide just one form of peer-reviewed research output and the importance of journal article outputs differs across disciplines.

It is important to note that the distribution of citation counts can be highly skewed with a few very highly cited articles at one extreme and a long tail of articles which are rarely or never cited; see Chang et al. (2011). This is relevant as the measure of the average citation count used in this study cannot capture changes in dispersion and, where data are available, a median measure could also be used.[32]

Anderson and Tressler (2013) reviewed the limitations of journal-based weighting schemes and concluded that direct citation counts were a superior approach. In contrast, Gibson *et al.* (2014, 2015) found that the journal in which papers are published was a better predictor than citation counts of the salaries of economists in the University of Californian system. Based on the work of Bariam (1996, 1997) for departments of economics in New Zealand universities, Gibson (2000) developed a method of weighting groups of journals for differences in quality. However, this requires data on all the journals in which New Zealand authors publish and is not readily available.

In Table 5.6 the average number of citations per publication is used to create a series of citation weighted research output, 2000-15.[33] In the early years of the period, 2000-06, the average number of citations per publication rose at an annual average rate of 2.2%. This accelerated to 2.9% in the later years following the introduction of the PBRF in 2003. Despite a slightly slower growth rate of research output after 2006 (down from 6.2% to 5.6%), the

---

[31] Knox (2004) and Gush et al. (2015) use citations to assess research contributions in New Zealand. Note however, that the use of citations and the average numbers of co-authors of a publication, vary enormously across disciplines. This will affect measured productivity levels across disciplines and in aggregate, and will impact on our measured productivity growth rates if these aspects vary sufficiently over time.

[32] For example, Tressler and Anderson (2012) found that around 60 percent of papers published by New Zealand academic economists received no citations from 2000 to 2008.

[33] The annual series for citations per publication that we use is created from similar MoE data available only as five year averages for 2000-04 to 2010-14. We treat the MoE numbers as estimates for the middle year of five, and extrapolate back from 2002 to 2000 and forward from 2012 to 2015. This necessarily involves some approximation of the actual, unknown annual values and suggests these numbers should be treated with caution.

citation weighted research output grew at an annual rate of 8.6% in the later period, up slightly from 8.4%. These results underscore the point that, at least as measured by citation rates, the quality of the research output increased over time, which in turn led to a more than threefold rise in quality-adjusted research output (Figure 5.2).

*Table 5.6, 5.7 and Figure 5.1 about here*

### *5.3 Research productivity measures incorporating adjustments*

Based on the adjustments to both inputs and outputs it is possible to derive a set of productivity growth measures. These are summarised in Table 5.7.

A number of important findings emerge from these results. Firstly, the rates of research productivity growth are generally substantially above national productivity growth rates in the market sector of the economy.[34] This applies to both the labour and multifactor productivity indices. Secondly, there is an acceleration in both sets of growth rates after 2006.

Although the PBRF scheme was introduced in 2002 with the initial evaluation in 2003, in the analysis above we divided the period at 2006. By 2006 the scheme had matured, with universities having had time and experience to adapt to the new evaluation system by the time of the second PBRF 'round' in 2006 which involved a number of changes to improve the assessment process.[35] The research productivity results are consistent with the hypothesis that added incentives for research created by the PBRF scheme resulted in an increase in both the quantity and quality of research outputs and a concomitant rise in research productivity.

Thirdly, the results again underscore the important role of quality adjustments in the measurement of productivity in the tertiary education sector. Adjusting research outputs for quality based on the application of citation rates as a proxy, increases the estimated productivity growth rates substantially.

Estimates for both measures of research productivity – labour and multifactor respectively – are plotted in Figures 5.3 and 5.4. Figure 5.3 highlights that research productivity appears to trend upwards much more rapidly over the 2000-15 period as whole when citations-based quality adjustments are allowed for (compare Q/L with pQ/L). However this upward adjustment is almost entirely counteracted if staff inputs are quality adjusted to reflect their PBRF score (pQ/H). Indeed for much of the period pQ/H lies below the basic Q/L measure. That is, the improvement in labour input quality as measured by PBRF scores is essentially matched by increased citations.

*Figures 5.2 and 5.3 about here*

---

[34] For example Conway and Meehan (2013) report average measured sector (largely market-based activity) labour productivity growth over 1978-2012 of 1.9% per annum, and 0.8% for multifactor productivity.

[35] See Smart (2008, 2009, chapter 2) for more discussion of the 2006 PBRF and comparisons with 2003. Though academic were better informed about the PBRF process by 2006 it should be noted that this was a 'partial' round where staff could submit an updated research profile of simply resubmit the 2003 profile.

A natural concern with these quality adjustments for labour inputs and outputs is the potential overlap between quality adjusted outputs using citation rates and quality adjusted labour inputs based on PBRF results if the input adjustments are strongly influenced by citation rates. In this case the input and output adjustments would largely mirror each other.

While citations were one measure of research quality which research staff could include in their portfolio for assessment in the PBRF (hence some potential for an impact on both the numerator and denominator of the labour productivity measure), it represented only one relatively small, indirect input into the PBRF assessment process. Nevertheless it is known that the PBRF assessments were designed to reflect both the quantity and the quality of academic outputs which, if these are highly correlated with citations, would tend to cause both input and output quality adjustments to display similar changes over time. This can be compounded where the perceived quality or reputation of a journal is a function of the journal's citation rates, and where these influence PBRF panel judgements of individual researcher quality.

This highlights the need for caution when seeking research metrics by which to adjust quality since it may be hard to distinguish input and output quality measures that are genuinely independent. Conversely, the approximate counteracting effects on quality-adjusted research productivity observed in Figure 5.2 may indicate that improved output quality has been achieved largely by improving input quality rather than productivity.

Figure 5.3 provides similar information to Figure 5.2 but for multifactor productivity indices. Moving from a basic multifactor productivity measure (Q/E) to an adjusted multifactor measure (pQ/E) can again be seen to be associated with a substantially higher growth rate over the 2000-15 period. The figure also shows that the broad upward trend in this quality-adjusted *multifactor* measure is very similar to that of the quality-adjusted *labour* productivity index, pQ/H.

## 6. Overall University Productivity

These estimates of research productivity can now be combined with those for teaching to estimate the overall productivity, $A$, of the university sector. This requires estimating a weighted sum of teaching and research component productivities, $A_T$, and $A_R$, respectively, as $A = aA_T + (1 - a)A_R$. The weights used are cost shares based on estimates of the share of total expenditure for teaching, $a$, and research, $(1 - a)$, respectively. Values of $a$ are based on the expenditure composition discussed earlier, ranging from 0.47 (in 2001) to 0.35 (in 2015).

Broadly, this teaching cost share fell from 2001 to 2008 and remained relatively constant thereafter. More generally, these teaching share values may appear relatively low but reflect the oft-noted feature that expenditure on most university academic staff who teach implicitly funds around 40-50% of their time on research. When this fraction is added to expenditure on full-time research staff, the effective research share in total expenditure is much higher than would be inferred from designated research staff or research-related income. Equivalently, the teaching share is lower.

Table 6.1 brings together our estimate of the growth rates of the various unadjusted and quality-adjusted productivity measures for 2000-15 and the two sub-periods: 2000-06 and 2006-15. We adopt this split for both teaching and research to facilitate comparisons.

Despite the large number of estimates in Table 6.1 associated with the various teaching and research productivity measures, it is immediately clear that (a) teaching and research productivity growth can be very different; and (b) though quality adjustment is important for estimated growth rates, the particular *form* of adjustment (whether to research or teaching) can make a large difference to final outcomes. In addition all measures for teaching reveal a substantial fall in productivity growth after 2006 compared to 2000-06 but a distinct pick-up in research productivity growth between the two periods.

Figures 6.1 and 6.2 highlight the growth rates for labour and multifactor productivity measures, for both teaching and research. The results depicted incorporate all adjustments for quality. In the case of teaching this involves output measured as completions with weighting which includes adjustments for both course credits and students' expected earnings. For research, adjustment recognises the quality impact of citations. Productivity growth is shown for 2000-06 and 2006-15, using the 2006 PBRF census year as a 'break point'. There is a marked change in the productivity growth rates for the period after 2006, driven in both cases by the acceleration in the growth of research productivity.

Whereas quality-adjusted multifactor productivity growth for teaching exceeded that for research up to 2006, the reverse is observed over 2006-15, with teaching productivity growth turning negative by this measure. While causation from one to the other cannot be inferred from these results, it is noteworthy that the boost to research productivity after 2006, the year of the substantially expanded PBRF process, appears to have coincided with deteriorating growth rates in teaching productivity. This at least consistent with the hypothesis that the prioritisation of resources towards increasing research output and efficiency has been at the expenses of teaching efficiency. [36]

In fact, our discussion in section 4 of trends in student and staff FTEs, suggests that the continued increase in university staff as student FTEs fell after 2003 sheds some light on the research/teaching productivity story. Since the continued increase in university staff FTEs added to both teaching and research inputs (via the 40:40:20 allocation rule), it simultaneously increased measured research output via publication volumes and citations, but could have no similar effect on our teaching output measure: student credit weighted FTEs.

Figure 6.3 focuses on annual data on the productivity indices over 2000-15 for the same two multifactor productivity measures. It can be seen that, because of the heavier weighting towards research, overall university productivity tends to follow the research productivity path more

[36] Remler and Pema (2009) develop a theoretical framework to help explain why incentives for research have increased and the possible detriment to human capital accumulation by students.

closely. It is also clear that whereas the research and teaching indices increase similarly over 2000-07 (though by somewhat different routes), they follow quite different paths thereafter.

*Figures 6.1, 6.2 and 6.3 about here*

## 7. Some Sensitivity Testing

### *7.1 Choice of Deflators*

In producing suitable consumer price deflators for market sector goods and services statistical agencies like Statistics New Zealand (SNZ) commonly aim to account for quality improvements over time that may not be reflected in the observed prices for those items. In the technology sector, for example, quality improvements are well-known to often be associated with falling, not rising, prices.[37]

For, largely public, tertiary education, SNZ's tertiary education component of the CPI is based on tuition fees. But changes in tuition fees may not be a good guide to changes in the 'price of tertiary education'.

Firstly, these fees will generally not reflect the research dimension of tertiary output. Secondly, tuition fee increases can be expected to be related to providers' costs of tuition which in turn are composed predominantly by wage costs. Increases in these cost may reflect increased numbers of teachers or wage and salary costs per teacher. In either case, the changes could be in association with changes in quality (higher teacher/student ratios and/or more experienced or better qualified teachers) or simply changes in quantity. To the extent that improvements in quality occur over time in association with rising fees, the tertiary education subgroup of the CPI will over-state a 'true' (quality-adjusted) price increase, while deflated real quantity increases will be under-stated.

Thirdly, tertiary tuition fees are subject to various interventions by government in the form of, for example, the imposition of fee caps, and annual fee cap adjustments of variable sizes. These had differential effects across institutions, since initial fee levels differed across tertiary institutions prior to the imposition of a cap.[38] These fee arrangements also sat alongside differing annual increases in direct government subsidies to state tertiary education.

Fourthly, any price deflator, such as the consumer price index (CPI) translates nominal values into a common numeraire. In the CPI case that numeraire is an over-time constant representative basket of consumer items. When used to deflate a particular item, it represents the opportunity cost of that item in terms of the more general basket. Thus deflating tertiary education by a tertiary education consumer price provides a measure of *real* tertiary education

[37] See Brynjolfsson and Hitt (2000) for discussion of information technology evidence.
[38] In 2003, for example, annual fee increases for state tertiary institutions were limited to the overall rate of price inflation. See NZPC (2017, pp.296-300) for tuition fee and government funding trends and discussion.

where the numeraire is constant quantity units consumed of that education. Deflation by a general CPI effectively provides an alternative opportunity cost – namely how much of a general consumption basket is foregone. An interpretation of deflation by the CPI is that it measures a constant quantity of general consumer items that governments, or taxpayers, could purchase instead of the tertiary education that is actually provided.[39]

Conceptually it is clear that, in the absence of data quality concerns, nominal tertiary inputs or outputs deflated by a tertiary price index would be preferable where the objective is to establish how many additional real units of tertiary education have been provided. This is typically the case when comparing sector productivity performance over time. Indeed, in the case of government-produced, non-marketed tertiary education, a *producer* price might be preferable to a consumer price as a deflator to establish real quantities (though not for subsequent quality adjustment weighting of real quantities; see Diewert (2017).

However, given the data concerns expressed above with the tertiary price component and associated uncertainties around changes in a 'true' quality-adjusted tertiary price index, we consider that deflation by the CPI, rather than a tertiary subgroup of the CPI, provides a more reliable and more readily interpretable benchmark in this case. We therefore reported CPI-deflated values in our main tables. However in this section we consider the sensitivity to the choice of deflator. As we show below, the choice of deflator can have a non-trivial effect on some of our estimated productivity trends, especially later in the 2000-15 period, suggesting that a further practical dimension to 'quality' measurement (namely, suitable price deflation) needs careful consideration.

On the issue of allowing for tertiary quality changes, Statistics New Zealand (2010a) report that the tertiary subgroup of the CPI is obtained from information on student fees from a range of tertiary courses suitably weighted by student enrolments. SNZ attempts to allow for changes in quality by accommodating 'significant changes in course structure, duration and content'.[40] However this does not capture potential changes in quality that may give rise to changes in fees, such as increased quality of teacher or researcher inputs. To the extent, that the tertiary price subgroup overstates 'true' tertiary price increases (by undervaluing possible quality improvements) its use will lead to underestimates of real values, which can affect both outputs (better quality courses impacting student outcomes) and inputs (better quality staff).

Figure 7.1 shows that the choice of deflator is potentially important in this case. Whereas the CPI displays fairly steady annual increases during 2000-15, the tertiary component (TPI) is flat over 2000-03, rises similarly to the CPI till 2008, then rises much more rapidly than the CPI, in part reflecting policy changes on maximum tuition fees.[41]

---

[39] SNZ also produce a producer price index (PPI) for education but not for the tertiary education sub-sector.

[40] http://www.stats.govt.nz/browse_for_stats/economic_indicators/CPI_inflation/primary-secondary-tertiary-and-other-post-school-education-in-CPI.aspx

[41] For example, Smart (2009a) shows that tertiary tuition fees stabilized during 2000-03, then rose slowly to 2008 as a result of higher government subsidies to tertiary education during this period. See also Crawford (2016).

Figure 7.2 provides some evidence on the effect of the two deflators on multifactor productivity measures for university teaching and research. It can be seen that there is almost no effect on teaching productivity until the upsurge in the TPI from 2010. By contrast, research productivity is affected from 2000 to 2003 which causes the TPI-deflated series to fall by more than the CPI-deflated series. From 2010 the research productivity series can also be seen to rise more rapidly to 2015 using the TPI. This reflects the lower real growth in research expenditure (inputs) in this period when deflated with a tertiary-specific price index.

*Figures 7.1 and 7.2 about here*

The differences between the teaching and research adjustments due to the use of the TPI arise essentially because the TPI affects both the numerator (via income weighting) and the denominator (via 'adjusted teaching expenditures') of teaching productivity measures. However, indexation affects only the denominator of research productivity measures (via the 'adjusted research expenditure' inputs). For the same reasons, a labour productivity measure for research is unaffected by indexation since neither outputs nor inputs are measured in financial terms.

Nevertheless, the different price deflators do reveal quite different productivity growth patterns for research before and after 2006. For example, the multifactor research productivity indices in Figure 7.2 rose by 1.1% and 1.7% per annum over 2000-06 for the TPI and CPI deflated series respectively. From 2006-15 the equivalent growth rates were 7.8% and 5.7%. Hence the estimated upturn in research productivity growth after the major 2006 PBRF exercise is much more pronounced using a TPI-based measure. Across the whole 2000-15 period, there is also a modest difference in measured research productivity growth rates: 5.0% (TPI) versus 4.1% (CPI).

These results suggest that some caution is required when assessing quality adjustments and price deflation of financial variables used in productivity measures. It seems likely that 'true' quality-adjusted multifactor productivity growth lies somewhere between the two deflated series. TPI-based deflation attributes all tertiary cost (fee) increases to pure price change impacts while the CPI series measures tertiary inflation impacts by general price inflation, with any difference from the TPI effectively treated as measuring a real quantity change.

Finally, across the tertiary sector as a whole, deflation by the TPI instead of the CPI can lead to some substantive differences over the whole 2000-15 period and also across sub-periods, such as 2000-08 and 2008-15. Over 2000-08 for example, student FTEs per $m of staff salaries ($Q/wL$) increased at 0.8%p.a. when using a CPI index but only by 0.2%p.a. using a TPI. The reverse pattern emerges over 2008-15 (-1.2% versus +1.5%) such that for the period CPI-deflated data suggest a slight decline (-0.2%) whereas TPI-deflated data suggests a modest rise (0.8%).

This essentially reflects the apparent slower growth in real expenditure using the TPI index, especially later in the period, such that the denominator of such productivity measures grows more slowly. This is not simply the result of the 2008 break year; similar results are obtained using 2006.

These results suggest strongly that identifying how ‘real’ input and output should be measured, where these involve financial variables, can be crucial for resulting estimates of both labour and multifactor productivity growth. A case can be made for either price adjustment depending on the research question of interest. However, the limited coverage of the TPI, the nature of the indirect measures available for its construction, the impact of government policy on fee charges and the exclusion of quality changes, all suggest that the TPI is likely to be subject to greater potential for measurement error.

### *7.2 Teaching and Research Allocation*

In section 4, we examined university productivity separately for teaching and research which required total staff FTEs and expenditures to be separately estimated for teaching and research. We recognised there that academic staff in universities typically split their time between teaching, research and administration (or ‘service’), and we allocated non-academic (mainly academic support) staff FTEs to teaching and research on a pro-rata basis. This lead to a staff FTE split between teaching and research that on average over 2000-15 was around 40:60 in favour or research.

Similarly, using income sources identified in published accounts for universities to approximate expenditure allocations between teaching and research, we allocated some government tuition and student fee income to research to capture the fraction of time academic staff, funded from this income, spend on research on average. This yielded a teaching/research expenditure allocation also around 40:60 across all universities on average. In this sub-section we explore the impact of changing those assumptions on university productivity growth estimates.

To examine sensitivity we adopt the extreme alternative that all academic staff FTEs are allocated to teaching, with research FTEs obtained from the ‘research staff FTE’ category in MoE data. Similarly all tuition/student fee income is treated as teaching-related for the purposes of expenditure allocation. These two changes have the effect of changing both the teaching-to-research FTE and expenditure ratios to around 75:25, on average across 2000-15.

Table 7.1 shows the effect of these changes on growth in the multifactor productivity indices shown in Figure 6.1 for our previous assumptions. These indices incorporate quality adjustments to the maximum extent: credit and income weighted completions per $m of teaching expenditure (teaching) and citation weighted output per $m of research expenditure (research).

*Table 7.1 about here*

Table 7.1 shows that the unadjusted series display similar broad patterns to the default series – teaching productivity growth continues to be lower than research productivity growth over 2000-15, and especially over 2006-15 when teaching productivity growth remains negative.

Nevertheless, productivity growth rates in general are substantially lower with the greater allocation of resources (staff and expenditure) to teaching. This arises due to the lower productivity growth activity (teaching) now being allocated a greater share of inputs such that its productivity growth falls further, and pulls down total productivity growth. Research productivity growth also appears lower, however, in the unadjusted case.[42]

Overall, the results of assuming a much more heavily weighted allocation of university resources towards teaching suggest that productivity growth is substantially lower than it would appear to be with a more research-weighted allocation. And, while quality-adjustment generally continues to produce faster productivity growth outcomes than basic measures, both those measures are lower with greater input allocation to teaching.

## 8. Conclusions

This paper has examined how quality adjusted productivity indices for the tertiary education sector may be constructed, and proposed a number of methods for making quality adjustments to 'basic' measures of the growth rates of labour and multifactor productivity. We then applied those to public sector tertiary productivity in New Zealand over 2000-15. Quality adjusted productivity measures for teaching across the tertiary sector as a whole were produced. In addition we reported measures of research productivity for New Zealand universities, where the vast majority of publicly-funded research in the tertiary sector is undertaken. We argue that the adjustments we propose are sufficiently general that they should be readily applicable to other countries with similar data.

Our evidence suggests that quality adjustment to both inputs and outputs can make substantial differences to conclusions about productivity growth trends over 2000-15 compared with basic, unadjusted indices. Across a variety of methods for adjusting productivity (both teaching and research) quite different trends emerge such that the choice of specific quality-adjustment adopted can be important for outcomes.

A particularly striking result is that most quality adjustments lead to estimates of substantially faster productivity growth in New Zealand tertiary education than simple unadjusted measures would suggest. For example, as the summary in Table 6.1 for the university sector revealed, for teaching, basic measures of labour and multifactor productivity growth over 2000-15 averaged 0.0% and -1.2% per year respectively. However when credit weighted completions are used to adjust teaching productivity measures, these growth rates become 1.4% and 0.2% respectively. These rise to 1.6% and 0.4% when income is added as an outcome measure to the credit weighted completions. For research, comparable productivity measures for labour and multifactor productivity respectively rise from 3.7% and 2.2% (basic) to 6.4% and 4.8% when citation weighted research output is used.

---

[42] This feature – of growth rates falling for indices of both teaching and research productivity – arises in part because, after some inputs are reallocated to teaching from research, the indices for both teaching and research are set to 100 in the initial year (e.g. 2000) in both the default and unadjusted cases.

An especially important component of the quality adjustment when financial variables form part of the productivity measures is the method of price deflation to obtain real values; specifically, whether a general consumer price index, or tertiary-specific consumer price index, is used. In particular Statistics New Zealand price indices for tertiary education rise much faster over 2010-15 than an a general consumer price index and affect resulting measures of real tertiary outputs and inputs. Given the way the tertiary price index is calculated (from student fee income), it is likely that it ignores a number of sources of quality improvement within the tertiary sector.

More generally, the results of this study highlight the need for careful measurement of tertiary productivity trends. Measures unadjusted for quality are unlikely to provide sufficiently robust signals about changes in productivity performance in the tertiary sector on which policy advice could be built. Similarly, our results for quality adjusted productivity suggest the potential for wide variations in conclusions regarding productivity trends that depend on the particular quality metrics available. Hence, as we noted in the Introduction, our key objective was *not* to identify definitive estimates of productivity growth in tertiary education. Rather it was to establish how various measures of tertiary education quality (for both inputs and outputs) could be used to estimate trends in productivity, and the sensitivity of those to the different quality measures.

In should be stressed also that our results identify *changes* of productivity; they do not address the issue of the absolute *levels* of tertiary productivity since all measures have been based on an index set at 100 in 2000. It is conceivable that productivity growth could appear favourable when compared to other sectors, while at the same time *levels* of productivity remain below par. When going beyond national account definitions of productivity for the tertiary sector by incorporating quality dimensions, cross-sector level comparisons typically become impossible.

In addition, high productivity growth rates do not necessarily imply either technical or allocative efficiency, and our results do not relate to the overall performance of the tertiary sector. Performance has many dimensions including contributions to the wider society, with productivity representing but one element.

Finally, to develop an initial overview of tertiary and university sector productivity we chose to base the analysis on data that are largely in the public domain. More detailed data would allow disaggregation across individual institutions, and between faculties and departments within institutions. It is reasonable to expect differing productivity trends in both contexts. Greater use of data at the level of the individual staff member, such as that undertaken specifically for the New Zealand PBRF by Buckle and Creedy (2017a), allows deeper insights into the characteristics and institutional heterogeneity of research productivity. This would complement the sector averages presented here.

## References


Abbott, M. (2000) The development of vocational education and training in New Zealand. *Education Research and Perspectives*, 27(1): 90-108.

Abbott, M., and Doucouliagos, C. (2000) Technical and scale efficiency of vocational education and training institutions: the case of the New Zealand polytechnics. *New Zealand Economic Papers*, 34(1): 1-23.

Abbott, M., and Doucouliagos, C. (2003) The efficiency of Australian universities, a data envelopment analysis', *Economics of Education Review*, 22(1): 89-97.

Abbott, M., and Doucouliagos, C. (2004) A long run appraisal of the economics of government provided tertiary education and training in New Zealand. *Auckland Centre of Research in International Education Occasional Paper* No 2. Available at: http://www.crie.org.nz/research_paper/m_abbott_op2.pdf.

Abbott, M., and Doucouliagos, C. (2007) Competition and efficiency: Overseas students and technical efficiency in Australian and New Zealand universities. *Faculty of Business and Law, School Working Paper* No. 2007/09, Deakin University.

Abbott, M. and Doucouliagos, C. (2009). Competition and efficiency: overseas students and technical efficiency in Australian and New Zealand universities. *Education Economics*, 17(1): 31-57.

Afonso, A. and St. Aubyn, M. (2005). Non-parametric approaches to education and health efficiency in OECD countries. *Journal of Applied Economics*, 8(2): 227-246.

Alexander, W. and Jaforullah, M. (2005). Scale and pure efficiencies of New Zealand secondary schools. *University of Otago Economics Discussion Papers* No. 0501.

Alexander, W., Haug, A. and Jaforullah, M. (2007). A two-stage double-bootstrap data envelopment analysis of efficiency differences of New Zealand secondary schools. *University of Otago Economics Discussion Papers* No. 0714.

Anderson, D.L. and Tressler, J. (2008a). Research output in New Zealand economics departments 2000–2006. *New Zealand Economic Papers*, 42(2): 155–189.

Anderson, D.L. and Tressler, J. (2008b). An analysis of New Zealand economists' research output 2000–2006. *Department of Economics, University of Waikato Working Papers in Economics* No. 20/08.

Anderson, D.L. and Tressler, J. (2011). Ranking economics departments in terms of residual productivity: New Zealand economics departments, 2000-2006. *Australian Economic Papers*, 50(4): 157-168.

Anderson, D.L. and Tressler, J. (2013). The relevance of the "h-" and "g-" index to economics in the context of a nation-wide research evaluation scheme: The New Zealand case. *Economic Papers*, 32(1): 81-94.

Anderson, D.L. and Tressler, J. (2013a). The New Zealand Performance Based Research Fund and its impact on publication activity in economics. *Department of Economics, University of Waikato, Working Paper* No. 3/13.

Anglin, P. and Meng, R. (2000). Evidence on grade inflation at Ontario's universities. *Canadian Public Policy*, 26(3): 361-368.

Atkinson. A. (2005a). *Measurement of Government Output and Productivity for the National Accounts*. New York: Palgrave Macmillan.

Atkinson. A. (2005b). Measurement of UK government output and productivity for the national accounts. *Journal of the Statistical and Social Inquiry Society of Ireland*, 34: 152-160.

Bachan, R. (2017). Grade inflation in UK higher education. *Studies in Higher Education*, 42: 1580-1600.

Bairam, E. (1996). Research productivity in New Zealand university economics departments, 1988-1995. *New Zealand Economic Papers*, 30(2): 229-241.

Bairam, E. (1997). Corrigendum: research productivity in New Zealand university economics departments, 1988-1995. *New Zealand Economic Papers*, 31(1): 133-134.

Baker, B. and Kelly, P. (2008). *A Primer on the BEA's Government Accounts*. BEA Briefing. Washington, DC: Bureau of Economic Analysis.

Barrett, G. and Milbourne, R. (2012). Do excellent research environments produce better learning and teaching outcomes? *Economic Record,* 88 (Special Issue, June): 70–77.

Barslund, M. and O'Mahony, M. (2012). *Output and productivity in the education sector*. Indicators for Evaluating International Performance in Service Sectors (INDICSER). Discussion Paper 39, Research Directorate General, European Commission, Brussels.

Black, S. (1998). Measuring the value of better schools. *Federal Reserve Bank of New York, Economic Policy Review*, 4(1): 87-94.

Blundell, R., Dearden, L. and Sianesi, B. (2004). *Evaluating the impact of education on earnings in the UK: Models, methods and results from the NCDS*. Working Paper WP03/20. The Institute for Fiscal Studies, London.

Bowles, S., Gintis, H. and Osborne, M. (2001). The determinants of earnings: a behavioral approach. *Journal of Economic Literature*, 9(4): 1137-1176.

Boyle, G. (2008). Pay peanuts and get monkeys? Evidence from academia. *The B.E. Journal of Economic Analysis and Policy*, 8(1), Article 21.

Boyle, R. (2007). Public sector productivity measurement: an impossible task? In Aylward, C. and O'Toole, R. (eds). *Perspectives on Irish Productivity*. Dublin: Forfas.

Bridge, M. (2015). Methods change in public service productivity estimates: education 2013. Information Note. London: Office for National Statistics.

Buckle, R. and Creedy, J. (2017). *The evolution of research quality in New Zealand universities as measured by the Performance Based Research Fund process. Working Papers in Public Finance*, No. 11/2017. Victoria Business School, Victoria University of Wellington.

Buckle, R. and Creedy, J. (2017a). *An evaluation of metrics used by the Performance-Based Research Fund process in New Zealand. Working Papers in Public Finance*, No. 16/2017. Victoria Business School, Victoria University of Wellington.

Burgess, S. (2016). Human capital and education: The state of the art in the economics of education, *Institute for the Study of Labour (IZA) Discussion Paper* No. 9885, Bonn.

Brynjolfsson, E. and Hitt, L.M. (2000) Beyond computation: information technology, organizational transformation and business performance. *Journal of Economic Perspectives*, 14 (4): 23-48.

Caplan, D. (1998). Measuring the output of non-market services. *Economic Trends*, 539: 45-49.

Caul, S. (2014). *Public service productivity estimates: Education 2012*. London: UK Office for National Statistics.

Chalmers, D. (2008). *Teaching and learning quality indicators in Australian universities*. Paper presented to the General Conference of the Programme on Institutional Management in Higher Education (IMHE). Paris: OECD.

Chetty, R., Friedman, J. and Rockoff, J. (2014). Measuring the impacts of teachers I: evaluating bias in teacher value-added estimates. *American Economic Review*, 104(9): 2593-2632.

Conway, P. (2016). *Achieving New Zealand's Productivity Potential*. New Zealand Productivity Commission, Wellington.

Conway, P. and Meehan, L. (2013). Productivity by the numbers: The New Zealand experience, *New Zealand Productivity Commission Research Paper* No. 2013/0.

Crawford, R. (2016) *History of Tertiary Education Reforms in New Zealand*. Research Note 2016/1 (January). New Zealand Productivity Commission.

Cullen, D. and Ergas, H. (2014). *Efficiency and Productivity in the Australian Health Care Sector*. A report submitted to the AHMAC CEOs Strategic Discussion 10 April. Australia: Commonwealth Department of Health.

Dawson, D., Gravelle, H., O'Mahony, M., Street, A., Weale, M., Castell, A., Jacobs, R., Kind, P., Loveridge, P., Martin, S., Stevens, P. and Stokes, L. (2005). *Developing New Approaches to Measuring NHS Outputs and Productivity*. University of York: Centre for Health Economics.

Department of Education and Skills (2005). *Measuring Government Education Output in the National Accounts: An Overview of Several Methods Developed as Part of the Atkinson Review*. London: DES.

Diewert, W.E. (2017) *Productivity Measurement in the Public Sector: Theory and Practice*. Vancouver School of Economics, University of British Columbia. Discussion Paper 17-01.

Doucouliagos, H. and Abbott, M. (2007). *Competition and Efficiency: Overseas Students and Technical Efficiency in Australian and New Zealand Universities*. Retrieved from http://dx.doi.org/10.2139/ssrn.1014277

Dunleavy, P. (2016) *Public Sector Productivity. Measurement Challenges, Performance Information and Prospects for Improvement*. 12th Annual Meeting of the OECD Senior Budget Officials Performance and Results Network. Paris: OECD.

Dutu, R. and Sicari, P. (2016). Public spending efficiency in the OECD: benchmarking health care, education and general administration. *OECD Economics Department Working Papers*, No. 1278. Paris: OECD. Retrieved from http://dx.doi.org/10.1787/5jm3st732jnq-en

Gemmell, N., Nolan, P. and Scobie, G. (2017) Public sector productivity. Quality adjusting sector-level data on New Zealand schools. *New Zealand Productivity Commission Working Paper* No. 2017/2 (May).

Gibson, J. and Boe-Gibson, G. (2014). Capitalizing performance of 'free' schools and the difficulty of reforming school attendance boundaries. *Department of Economics University of Waikato Working Paper* No. 8/14.

Gibson, J. (2000). Research productivity in New Zealand university economics departments: comment and update. *New Zealand Economic Papers*, 34(1): 73-87.

Gibson, J. (2014). Returns to articles versus pages in academic publishing: do salary-setters show 'article illusion'? *Economic Letters*, 125(3): 343-346.

Gibson, J. and Boe-Gibson, G. (2014). Capitalizing performance of ‘free’ schools and the difficulty of reforming school attendance boundaries. *Department of Economics, University of Waikato Working Paper* No. 8/14.

Gibson, J., Sabel, C., Boe-Gibson, G. and Kim, B. (2007). *House prices and school zones: does geography matter?* Paper presented to a conference of the Spatial Econometrics Association, Cambridge.

Gibson, J., Anderson, D. and Tressler, J. (2014). Which journal rankings best explain academic salaries: evidence from the University of California. *Economic Inquiry,* 52(4): 1332-1340.

Gibson, J., Anderson, D. and Tressler, J. (2015). Citations or journal quality: which is rewarded more in the academic labour market. *Department of Economics, University of Waikato Working Paper* No. 13/15.

Gordon, J., Zhao, S. and Gretton, P. (2015). *On Productivity: Concepts and Measurement*. Australian Productivity Commission Staff Research Note, Canberra, February.

GradeInflation.com (2016). *Recent GPA trends nationwide four-year colleges and universities*. Retrieved from www.gradeinflation.com on 02-11-17.

Gush, J., Jaffe, A.B., Larsen, V. and Laws, A. (2015). The effect of public funding on research output: the New Zealand Marsden fund. *Motu Working Paper* No. 15-12 (October). Wellington: Motu Economic and Public Policy Research.

Hanushek, E. (2010). The economic value of higher teacher quality. *NBER Working Paper* No. 16606.

Hanushek, E. (2011). The economic value of higher teacher quality. *Economics of Education Review*, 30: 466-479.

Hanushek, E. (2015). Why standard measures of human capital are misleading. *KDI Journal of Economic Policy*, 37(2): 22-39.

Hanushek, E. (2016). What matters for achievement: updating Coleman on the influence of families and schools. *Education Next*, 16(2): 22-30.

Hanushek, E., Kain, J. and Rivkin, S. (1998). Teachers, schools and academic achievement. *NBER Working Paper* No. 6691.

Hanushek, E. and Kimko, D. (2000) Schooling, labor force quality and the growth of nations. *American Economic Review*, 90: 1184-1208.

Hanushek, E. and Rivkin, S. (2006). Teacher quality. In Hanushek, E. and Welsh, F. (eds). *Handbook of the Economics of Education: Vol.2*. Amsterdam: North Holland.

Hanushek, E. and Ettema, E. (2015). *Defining Productivity in Education: Issues and Illustrations*. Hoover Institution Stanford, CA: Stanford University. Retrieved from http://hanushek.stanford.edu/publications/defining-productivity-education-issues-and-illustrations.

Hanushek, E., Woessmann, L., Schleicher, A., Duval, R. and Jakubowski, W. (2010). *The High Cost of Low Educational Performance: the Long-run Impact of Improving PISA Outcomes*. Paris: OECD.

Harrison, J. and Rouse, P. (2014). Competition and public high school performance. *Socio-Economic Planning Sciences*, 48(1):10-19.

Hattie, J. and Marsh, H. (1996). The relationship between research and teaching: a meta-analysis. *Review of Educational Research*, 66(4): 507-542.

Huxley, G., Mayo, J., Peacey, M.W. and Richardson, M. (2017) Class size at university. *Fiscal Studies*. Available online at DOI: 10.1111/j.1475-5890.2017.12149.

Jaforullah, M. (2010). Productivity change in New Zealand secondary schools. *Journal of New Business Ideas and Trends*, 8(2): 14-26.

Jensen, B. (2010). *Measuring What Matters: Student Progress*. Grattan Institute Report No. 2010-1, Melbourne.

Jia, P. and Maloney, T. (2015). Using predictive modelling to identify students at risk of poor university outcomes. *Higher Education*, 70: 127-149.

Johnes, G and Johnes, J. (2009). Higher education institutions' costs and efficiency: taking the decomposition a further step. *Economics of Education Review*, 28: 107-113.

Johnes, G. and Soo, K.T. (2015). *Grades Across Universities Over Time*. Unpublished paper Lancaster University (revised June 2015).

Jorgenson, D. and Fraumeni, B. (1992). The output of the education sector. In Griliches, Z. (ed). *Output Measurement in the Service Sector*. Chicago: National Bureau of Economic Research, Studies in Income and Wealth, Volume 56, University of Chicago Press.

Juola, A. (1980). *Grade Inflation in Higher Education - 1979. Is it Over?* Learning and Evaluation Service, Michigan State University, East Lansing, MI. (ERIC Document Reproduction Service No 189 129).

Kimbugwe, K., Lewis, R. and James, N. (2009). Labour inputs in public sector productivity: methods, issues and data. *Office for National Statistics Economic and Labour Market Review*, 3(4): 52-59.

Knox, A. (2004). *The Impact of Marsden-Funded Research: A Bibliometric Assessment of Marsden Funded Publications, 1997-2001*. The Royal Society of New Zealand.

Kocher, M., Luptacik, M. and Sutter, M. (2006). Measuring productivity of research in economics: A cross-country study using DEA. *Socio-economic Planning Sciences*, 40(4): 314–332.

Kohn, A. (2002). The dangerous myth of grade inflation. *The Chronicle of Higher Education*, 49(11): B7-14.

Kuh, G. and Hu, S. (1999). Unravelling the complexity of the increase in college grades from the mid-1980s to the mid-1990s. *Educational Evaluation and Policy Analysis*, Fall 1999: 297–320.

Lau, E., Lonti, Z. and Schultz, R. (2017) Challenges in the measurement of public sector productivity in OECD countries. *International Productivity Monitor*, 32: 180-195

Le, T., Gibson, J. and Oxley, L. (2005). Measuring the stock of human capital in New Zealand. *Mathematics and Computers in Simulation*, 68: 485-498.

Leigh, A. and Ryan, C. (2008). How and why has teacher quality changed in Australia? *The Australian Economic Review*, 41(2): 141–159.

Leigh, A. and Ryan, C. (2011). Long-run trends in school productivity: evidence from Australia. *Education Finance and Policy*, 6(1): 105-135.

Levine, A. & Cureton, J. (1998). *When Hope and Fear Collide: A Portrait of Today's College Student*. San Francisco: Jossey-Bass.

Maani, S. A. (1996). Private and social rates of return to secondary and higher education in New Zealand: evidence from the 1991 census. *Australian Economic Review*, 29 (1): 82-100.

Maani, S. A. (1999). Private and public rates of returns to investments in secondary and higher education in New Zealand over time: 1981-1996. *New Zealand Treasury Working Paper* No. 99/2. Wellington: The Treasury.

Maani, S. and Maloney, T. (2004). *Returns to Post-School Qualifications: New Evidence Based on the HLFS Income Supplement (1997-2002)*. Report to the Labour Market Policy Group, Department of Labour, Wellington.

Macgibbon, N. (2010). Exogenous vs endogenous rates of return: The user cost of capital in Statistics New Zealand's multifactor productivity measures. *Statistics New Zealand Working Paper* No. 10-03, Wellington.

Maimaiti, Y. and O'Mahony, M. (2011). *Quality Adjusted Education Output in the E.U.* Indicators for Evaluating International Performance in Service Sectors (INDICSER). Discussion Paper 37. Research Directorate General, European Commission, Brussels.

Mamun, S. and Rahman, M. (2016). An investigation on allocative efficiency and implications of new funding plans for Australian universities. *Education Research for Policy and Practice*, 15: 71-82.

Margaritis, D. and Smart, W. (2011). *Productivity change in Australasian universities 1997-2005: A Malmquist analysis*. Paper presented to the annual conference of the New Zealand Association of Economists, Wellington. Retrieved from http://nzae.org.nz/wp-content/uploads/2011/Session5/54_Smart.pdf.

McGrath, M. (1999). *Non-Market Services: New Zealand Experience in Measurement*. Wellington: Statistics New Zealand.

Melbourne Institute (2015). *Household Income and Labour Dynamics Survey (HILDA): Selected Findings Waves 1-12*. Melbourne, Australia.

Ministry of Education (2015). *Profile and Trends: Tertiary education outcomes and qualification completions.* Wellington: Ministry of Education.

Ministry of Education (2017). *Financial Performance of Tertiary Education Institutions*. Wellington: Ministry of Education. Retrieved from: http://www.educationcounts.govt.nz/statistics/tertiary-education/financial_performance

Ministry of Education (2016a). *Tertiary Education Statistics*. Wellington: Ministry of Education. Retrieved 06 November 2017 from www.educationcounts.govt.nz/statistics/tertiary-education.

Ministry of Education (2016b) *Life after Study*. *Income Statistics*. Wellington: Ministry of Education. Retrieved from http://www.educationcounts.govt.nz/statistics/tertiary-education/life_after_study

Mortensen, J., O'Mahony, M., Pastor, J., Serrano, L. and Stokes, L. (2011). *Measuring education input, output and outcomes: State of the art and data availability*. Indicators for Evaluating International Performance in Service Sectors (INDICSER) Review Paper 4. Research Directorate General, European Commission, Brussels.

Murray, R. (2007). *Developing a quality adjusted output measure for the Scottish education system*. Paper presented at a Workshop on Measuring Education and Health Volume. National Accounts and Financial Statistics Division, Statistics Directorate, OECD, Paris. Retrieved from www.oecd.org/std/na/38641867.pdf

New Zealand Productivity Commission (2017). *New Models of Tertiary Education: Final Report*. Wellington: New Zealand Productivity Commission (March).

O'Mahony, M and Stevens, P. (2009). Output and productivity growth in the education sector: Comparisons for the US and UK. *Journal of Productivity Analysis*, 31: 177–194.

O'Mahony, M. and Stevens, P. (2006). International comparisons of output and productivity in public service provision: A review. In Boyne, G., Meier, K., O'Toole, L. and Walker, R. (eds.) (2006). *Public Sector Performance: Perspectives on Measurement and Management*. Cambridge: Cambridge University Press.

O'Mahony, M., Pastor, J., Peng, F., Serrano, L. and Hernández, L. (2012). *Output growth in the post-compulsory education sector: the European experience.* Indicators for Evaluating International Performance in Service Sectors (INDICSER). Discussion Paper 32. Research Directorate General, European Commission, Brussels.

Office for National Statistics (2005). Improvements in the methodology for measuring government output. *Economic Trends*, 622: 35-45.

Office for National Statistics (2006). Public service productivity: Education. *Economic Trends*, 626: 13-37.

Office for National Statistics (2013). *Sources and Methods: Public Service Productivity Estimates: Healthcare*. London: ONS.

Office for National Statistics (2013b). *Quality and Methodology Information Report; Public Service Productivity Estimates: Healthcare.* London: ONS.

Office for National Statistics (2015a). *Public Service Productivity Estimates: Total Public Services 2012*. London: ONS.

Office for National Statistics (2015b). *Public Service Productivity Estimates: Healthcare 2012*. London: ONS.

Office for National Statistics (2015c). *Public Service Labour Productivity*. London: ONS.

Office for National Statistics (2015d). *Public Service Productivity Estimates: Education 2013*. London: ONS.

Oreopoulos, P. and Salvanes, K. (2011). Priceless: the nonpecuniary benefits of schooling. *Journal of Economic Perspectives*, 25(1): 159-184.

Pastor, J.M., Serrano, L. and Zaera, I. (2015). The research output of European higher education institutions. *Scientometrics*, 102: 1867-1893.

Phelps, M. (2010). *Comparing the Different Estimates of Productivity Produced by the Office for National Statistics*. UK Centre for the Measurement of Government Activity.

Phelps, M, Kamarudeen, S., Mills, K. and Wild, R. (2010). *Total Public Service Output, Inputs and Productivity*. UK Centre for the Measurement of Government Activity.

Remler, D and Pema, E. (2009). Why do institutions of higher education reward research while selling education? *NBER Working Paper* No. 14974.

Rivkin, S., Hanushek, E. and Kain, J. (2005). Teachers, schools and academic achievement. *Econometrica*, 73(2): 417-458.

Rojstaczer, S. and Healy, C. (2010). Grading in American colleges and universities. Teachers College Record. Retrieved from www.tcreord.org/PrintContent.asp?ContentID=15982

Rosovsky, H. and Hartley, M. (2002). *Evaluation and the Academy: Are we Doing the Right Thing? Grade Inflation and Letters of Recommendation*. American Academy of Arts and Sciences, Cambridge. Retrieved from www.amacad.org/publications/monographs/Evaluation_and_the_Academy.pdf.

Schreyer, P. (2010). Toward measuring the volume of output in health and education services: A handbook. *OECD Statistics Working Papers*, No. 2010/02, Paris. Retrieved from http://dx.doi.org/10.1787/5kmd34g1zk9x-en.

Schreyer, P. (2012). Output, outcome and quality adjustment in measuring health and education services. *Review of Income and Wealth*, 58(2): 257-278.

Schreyer, P. (2014). Priorities and directions for future productivity research: An OECD perspective. *International Productivity Monitor*, 27: 7-9.

Schreyer, P. and Lequiller, F. (2007). *Terminology and Concepts*. Paper presented at a Workshop on Measuring Education and Health Volume. National Accounts and Financial Statistics Division, Statistics Directorate, OECD, Paris. Retrieved from www.oecd.org/std/na/38597417.pdf

Smart, W. (2008). *Trends in Measured Research Quality. An Analysis of PBRF Quality Evaluation Results.* Wellington: Ministry of Education (July).

Smart, W. (2009). *The Measurement of the Performance of New Zealand Tertiary Education Institutions and the Demand for their Services.* A thesis submitted to Auckland University of Technology in fulfilment of the requirements for the degree of Doctor of Philosophy (PhD).

Smart, W. (2009a). The impact of the performance-based research fund on the research productivity of New Zealand universities. *Social Policy Journal of New Zealand*, 34 (April): 36-151.

Smart, W. (2013). *Analysing the Impact of the PBRF. Interim Findings*. Wellington: Ministry of Education, Wellington (February).

Smart, W. and Engler, R. (2013). *In Pursuit of Excellence: Analysing the Results of New Zealand's PBRF Quality Evaluations*. Wellington: Ministry of Education (June).

Statistics New Zealand (2010). *Measuring Government Sector Productivity in New Zealand: A Feasibility Study*. Wellington: Statistics New Zealand. Retrieved from www.stats.govt.nz/browse_for_stats/economic_indicators/productivity/measuring-govt-productivity.aspx.

Statistics New Zealand (2010a) *Price Index News: July 2010.* Available at: http://www.stats.govt.nz/tools_and_services/newsletters/price-index-news/jul-10.aspx

Statistics New Zealand (2013). *Measuring Value Added in the Education and Health Industries*. Wellington: Statistics New Zealand.

Statistics New Zealand (2015). *Productivity Statistics 1978-2014*. Wellington: Statistics New Zealand.

Statistics New Zealand (2016). *Productivity Statistics 1978-2015*. Wellington: Statistics New Zealand.

Stevens, P., Stokes, L. and O'Mahony, M. (2006). Metrics, Targets and Performance. *National Institute Economic Review*, 197(1): 80-92.

Summary, R. and Weber, W. (2012). Grade inflation or productivity growth? An analysis of changing grade distributions at a regional university. *Journal of Productivity Analysis*, 38: 95-107.

Sutherland, D., Price, R., Joumard, I. and Nicq, C. (2007). Performance indicators for public spending efficiency in primary and secondary education. *OECD Economics Department Working Paper*, No. 546. Paris: OECD.

Sutherland, K.A. (2017) *Early Career Academics in New Zealand: Challenges and Prospects in Comparative Perspective*. Cham, Switzerland: Springer International.

Schwellnus, C. (2009) Achieving higher performance: enhancing spending efficiency in health and education in Mexico. *OECD Economics Department Working Paper* No. 732. Paris: OECD.

Talukder, D. (2011). *Are Private Providers more Productive and Efficient than Public Providers of International Education? Evidence from New Zealand.* Paper presented to the annual conference of the New Zealand Association of Economists, Wellington.

Tertiary Education Commission (2014a). *2012 Performance-Based Research Fund. Annual Report*. Wellington: Tertiary Education Commission.
Retrieved from http://pbrfar2012.publications.tec.govt.nz/

Tertiary Education Commission (2014b). *2012 Educational Performance Indicators: Definitions and Methodology*. Wellington: Tertiary Education Commission. Retrieved from www.tec.govt.nz/Tertiary-Sector/Performance-information/Educational-performance/.

Tipper, A. (2013). *Output and Productivity in the Education and Health Industries*. Paper presented at the 54th Conference of the New Zealand Association of Economists, Wellington, New Zealand.

Tressler, J. and Anderson, D. (2012). Using citations to measure research output in New Zealand economic departments: the problem of long and variable lags. *Agenda*, 19(1): 17-37.

Verhoeven, M., Gunnarsson, V. and Carcillo, S. (2007). Education and health in G7 countries: achieving better outcomes with less spending. *IMF Working Papers*, No. 07/263. Washington, DC: IMF.

Wilsdon, J., Allen, L., Belfiore, E., Campbell, P., Curry, S., Hill, S., Jones, R., Kain, R., Kerridge, S., Thelwall, M., Tinkler, J., Viney, I., Wouters, P., Hill, J. and Johnson, B. (2015) *The Metric Tide Report of the Independent Review of the Role of Metrics in Research Assessment and Management*. DOI: 10.13140/RG.2.1.4929.1363.

York, J. (2010). *The devil is in the Details: Demonstrating the Impact of Measurement Choices on Inputs to Government Sector Productivity*. Paper presented to the 51st New Zealand Association of Economists Conference, Auckland, New Zealand.

Zuccollo, J., Maani, S., Kaye-Blake, B. and Zend, L. (2013). Private returns to tertiary education. How does New Zealand compare to the OECD. *New Zealand Treasury Working Paper* No. 13/10. Wellington: The Treasury.

**Acknowledgements**: This paper forms part of a larger research project on measuring public sector productivity. The authors are grateful to a large number of people who have assisted in providing data and/or guidance for that project.

Special acknowledgement is due to the following:

*At the New Zealand Productivity Commission*: Paul Conway, Sally Davenport, Dave Heatley, Matthew Horwell, Judy Kavanagh, Geoff Lewis, Lisa Meehan, Amy Russell, Graham Scott, Murray Sherwin, Simon Wakeman and Guanyu Zheng.

*At the Ministry of Education*: David Earle, Jasmine Ludwig, Cyril Mako, Shona Ramsay, Warren Smart and Philip Stevens.

*At the Tertiary Education Commission*: Kirralee Mahony.

*At Statistics New Zealand*: Cameron Adams, Dean Edwards, Ewan Jonasen, David Lum, Paul Pascoe, Evelyn Ocansey and Adam Tipper.

*At Victoria University of Wellington*: Bob Buckle and John Creedy.

*At the Grattan Institute*: John Daley, Peter Goss, Jordana Hunter and Jim Minifie.

*At the Australian Productivity Commission*: Jenny Gordon, Anna Heaney, Patrick Jomani, Ralph Lattimore, Greg Murgouth and John Salarian.

*At the Australian Bureau of Statistics*: Jason Annabel, Derek Burnell, Ian Ewing, David Hansell, Stephen Howe, Jennifer Humphrys, Katherine Keenan, Ben Loughton, David Stewart, Hui Wei, Peter Williams and Shiji Zhao.

*Thanks also to*: Jason Gush, Royal Society of New Zealand; Eric Hanushek, Stanford Institute; Trinh Le, Motu; Dimitris Margaritis and Paul Rouse, University of Auckland; Bryce Wilkinson, New Zealand Initiative.

## Tables and Charts

### Table 3.1 Summary of Tertiary Education Productivity Measures

| Measure | Data | Symbol |
|---|---|---|
| | **Teaching productivity (All Tertiary)** | |
| Basic labour productivity | Total student places / Teaching staff FTEs | $Q/L_T$ |
| Basic multifactor productivity | Total student places / Total real teaching expenditure ($E_T$) | $Q/E_T$ |
| Labour productivity based on wage-adjusted labour input | Total student places / Teaching staff salaries | $Q/wL_T$ |
| Labour productivity based on adjusted output: completions (a) | Total student places weighted by NZQA credit-weighted completions / Teaching staff FTEs | $p_aQ/L_T$ |
| Multifactor productivity based on adjusted output: completions (a) | Total student places weighted by NZQA credit-weighted completions / Total real teaching expenditure ($E_T$) | $p_aQ/E_T$ |
| Labour productivity based on adjusted output: earnings (b) | Total student places weighted by earnings and qualifications / Teaching staff FTEs | $p_bQ/L_T$ |
| Multifactor productivity based on adjusted output: earnings (b) | Total student places weighted by earnings and qualification / Total real teaching expenditure ($E_T$) | $p_bQ/E_T$ |
| | **Research productivity (Universities only)** | |
| Basic research productivity per staff FTE (c) | Index of research volume / Total research staff FTEs ($L_R$) | $Q/L_R$ |
| Citation-adjusted research productivity per staff FTE | Index of research volume weighted by citation rates / Total research staff FTEs ($L_R$) or quality-adjusted research staff FTEs ($H_R$) | $pQ/L_R$ or $pQ/H_R$ |
| Basic research productivity per research expenditure | Alternate indices of research volume / Research expenditure ($E_R$) | $Q/E_R$ |
| Citation-adjusted research productivity per research expenditure | Index of research volume weighted by citation rates / Research expenditure ($E_R$) | $pQ/E_R$ |
| Overall university productivity | Combined estimates of teaching (T) and research (R) productivity, A, based on expenditure weights, $\alpha_T$ | $A = \propto_T A_T + (1-\propto_T)A_R$ |

Note: (a) Quality adjustment ($p_a$) uses credit weighting only. (b) Quality adjustment ($p_b$) uses credit and earnings weighting. (c) Total research staff FTEs ($L_R$) are 0.4 *x* Academic staff FTEs plus Research staff FTEs. Quality adjusted research staff ($H_R$) are weighted by PBRF ranking.

Table 4.1 Student FTE numbers in the tertiary sector: 2000-15

| Year | Student FTEs | Year | Student FTEs |
|---|---|---|---|
| 2000 | 177,651 | 2008 | 227,920 |
| 2001 | 192,054 | 2009 | 242,995 |
| 2002 | 223,227 | 2010 | 249,091 |
| 2003 | 263,480 | 2011 | 240,177 |
| 2004 | 267,111 | 2012 | 243,969 |
| 2005 | 256,928 | 2013 | 239,180 |
| 2006 | 236,142 | 2014 | 237,959 |
| 2007 | 233,392 | 2015 | 232,250 |

*Sources* For 2000-15 data are from Ministry of Education, Financial performance of tertiary education institutions.
*Notes*: Student numbers in tertiary sub-sectors are given in Appendix Table A2. MoE definitions of student and staff FTEs are given at https://www.educationcounts.govt.nz/data-services/glossary.

Table 4.2 Fulltime equivalent staff numbers in the tertiary sector: 2000-15

| Year | Academic | Non-academic | Research | Total |
|---|---|---|---|---|
| 2000 | 10,653 | 11,223 | 1,099 | 22,975 |
| 2001 | 10,814 | 11,489 | 1,100 | 23,403 |
| 2002 | 11,351 | 11,369 | 1,047 | 23,767 |
| 2003 | 12,057 | 13,433 | 1,244 | 26,734 |
| 2004 | 12,570 | 13,711 | 1,305 | 27,586 |
| 2005 | 12,581 | 14,136 | 1,422 | 28,139 |
| 2006 | 12,304 | 13,947 | 1,435 | 27,686 |
| 2007 | 12,178 | 14,043 | 1,485 | 27,706 |
| 2008 | 11,887 | 13,907 | 1,591 | 27,385 |
| 2009 | 11,915 | 14,459 | 1,729 | 28,103 |
| 2010 | 12,118 | 14,645 | 1,774 | 28,537 |
| 2011 | 12,092 | 14,814 | 1,758 | 28,664 |
| 2012 | 12,246 | 15,271 | 1,673 | 29,190 |
| 2013 | 12,324 | 15,460 | 1,631 | 29,415 |
| 2014 | 12,320 | 15,265 | 1,696 | 29,281 |
| 2015 | 12,495 | 15,110 | 1,790 | 29,395 |
| Ave. growth rate (%p.a.) | 1.2 | 2.1 | 3.7 | 1.8 |

*Source*: Ministry of Education, Resources: Human Resources.
*Notes*: Research staff includes research support staff.

Table 4.3 Tertiary sector real teaching expenditure (in 2006 $m), 2000-15

| Year | Universities | ITPs | Wānanga | Total |
|---|---|---|---|---|
| 2000 | 728 | 673 | 27 | 1,428 |
| 2001 | 794 | 691 | 56 | 1,541 |
| 2002 | 834 | 733 | 120 | 1,687 |
| 2003 | 887 | 832 | 205 | 1,924 |
| 2004 | 914 | 876 | 234 | 2,025 |
| 2005 | 959 | 859 | 220 | 2,038 |
| 2006 | 916 | 841 | 176 | 1,933 |
| 2007 | 899 | 876 | 148 | 1,923 |
| 2008 | 864 | 855 | 152 | 1,871 |
| 2009 | 892 | 869 | 168 | 1,929 |
| 2010 | 932 | 898 | 172 | 2,002 |
| 2011 | 912 | 863 | 165 | 1,940 |
| 2012 | 944 | 890 | 159 | 1,994 |
| 2013 | 956 | 873 | 161 | 1,990 |
| 2014 | 961 | 877 | 158 | 1,997 |
| 2015 | 1,004 | 898 | 154 | 2,056 |

*Source*: Ministry of Education
*Notes*: For ITPs and Wānanga it assumed that all expenditure relates to teaching. For universities, teaching expenditure is the difference between total expenditure minus estimated research expenditure. Figures are deflated using Statistics New Zealand's CPI deflator.

Table 4.4 Basic measure of labour productivity in the tertiary sector: 2000-15

| Year | Universities | ITPs | Wānanga | Total |
|---|---|---|---|---|
| 2000 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2001 | 100.2 | 111.9 | 180.8 | 106.0 |
| 2002 | 105.1 | 132.5 | 238.7 | 121.0 |
| 2003 | 104.0 | 143.5 | 240.2 | 127.3 |
| 2004 | 103.9 | 144.6 | 201.5 | 125.1 |
| 2005 | 99.4 | 137.5 | 184.8 | 118.4 |
| 2006 | 97.5 | 121.5 | 182.3 | 110.8 |
| 2007 | 96.9 | 118.9 | 196.7 | 109.6 |
| 2008 | 94.7 | 119.2 | 222.8 | 108.8 |
| 2009 | 98.7 | 126.3 | 200.3 | 113.4 |
| 2010 | 100.0 | 126.7 | 198.5 | 114.6 |
| 2011 | 96.2 | 121.3 | 184.3 | 109.9 |
| 2012 | 95.3 | 119.8 | 194.4 | 109.2 |
| 2013 | 92.7 | 116.0 | 185.6 | 106.0 |
| 2014 | 92.7 | 117.4 | 184.0 | 106.2 |
| 2015 | 92.3 | 110.8 | 184.9 | 103.6 |
| Annual average productivity growth rates (%) | | | | |
| 2000-2008 | -0.7 | 2.2 | 10.5 | 1.1 |
| 2008-2015 | -0.4 | -1.0 | -2.6 | -0.7 |
| 2000-2015 | -0.5 | 0.7 | 4.2 | 0.2 |

Note: In all cases the output measure is student FTEs. In the case of universities the input measure is teaching staff FTEs while for the other sub-sectors it is total staff FTEs.

Table 4.5 Basic measure of multifactor productivity in the tertiary sector: Student FTEs per $m of teaching expenditure, 2000-15

| Year | Universities | ITPs | Wānanga | Total |
|---|---|---|---|---|
| 2000 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2001 | 94.8 | 105.9 | 134.4 | 100.2 |
| 2002 | 95.2 | 113.5 | 183.2 | 106.4 |
| 2003 | 95.9 | 122.8 | 171.5 | 110.1 |
| 2004 | 94.8 | 122.8 | 135.5 | 106.1 |
| 2005 | 88.8 | 119.4 | 130.5 | 101.4 |
| 2006 | 90.5 | 108.7 | 125.0 | 98.2 |
| 2007 | 92.0 | 103.3 | 139.1 | 97.6 |
| 2008 | 94.3 | 100.3 | 138.7 | 97.9 |
| 2009 | 96.6 | 105.4 | 139.7 | 101.3 |
| 2010 | 94.3 | 105.4 | 139.5 | 100.0 |
| 2011 | 92.6 | 106.7 | 139.6 | 99.6 |
| 2012 | 90.5 | 106.1 | 144.7 | 98.4 |
| 2013 | 88.0 | 104.3 | 144.6 | 96.6 |
| 2014 | 87.2 | 103.5 | 144.8 | 95.8 |
| 2015 | 83.2 | 96.7 | 137.5 | 90.8 |
| | Annual average productivity growth rates (%) | | | |
| 2000-2008 | -0.7 | 0.0 | 4.2 | -0.3 |
| 2008-2015 | -1.8 | -0.5 | -0.1 | -1.1 |
| 2000-2015 | -1.2 | -0.2 | 2.1 | -0.6 |

*Note*: In all cases the output measure is student FTEs. In the case of universities the input measure is teaching expenditure while for the other sub-sectors it is total expenditure given all their activity is assumed to be related to teaching.

Table 4.6 Tertiary qualifications and credits

| Qualification | Credits | Qualification | Credits |
|---|---|---|---|
| Certificate Level 1 | 40 | Bachelor degrees | 360 |
| Certificate Level 2 | 40 | Graduate certificates and diplomas | 90 |
| Certificate Level 3 | 40 | Honours and post-graduate Cert./Dip. | 90 |
| Certificate Level 4 | 40 | Masters degrees | 240 |
| Diplomas 5-7 | 120 | Doctorates | 360 |

*Source*: New Zealand Qualifications Authority (undated), The New Zealand Qualifications Framework

*Notes*: As the data on completions is in some cases more aggregated than the NZQA specifications, the credits for categories 7 and 8 reflect an average weighting.

Table 4.7 Total tertiary completions, 2000-15

| Year | Unweighted Qualifications | Weighted by NZQA Credits |
|---|---|---|
| 2000 | 58,395 | 10,025,950 |
| 2001 | 59,760 | 9,993,050 |
| 2002 | 68,330 | 10,269,900 |
| 2003 | 86,110 | 11,530,200 |
| 2004 | 88,162 | 12,368,730 |
| 2005 | 112,100 | 14,127,500 |
| 2006 | 102,095 | 14,669,600 |
| 2007 | 94,245 | 13,334,500 |
| 2008 | 103,825 | 14,391,800 |
| 2009 | 112,615 | 14,783,200 |
| 2010 | 117,185 | 14,914,200 |
| 2011 | 121,195 | 16,151,300 |
| 2012 | 126,910 | 17,027,050 |
| 2013 | 125,000 | 17,141,250 |
| 2014 | 120,955 | 16,900,550 |
| 2015 | 119,085 | 16,765,150 |

*Source*: Ministry of Education.

Table 4.8 Summary of estimated earnings weights by qualification level

| | NZ Census 1981-2013 | | Min. of Education 2000-15 (ave.) | Min. of Education 1997-2002 | Maani and Maloney (2004) | Australia: HILDA Survey 2012 | Simple average |
|---|---|---|---|---|---|---|---|
| | NPV: lifetime incomes | NPV: age 30-60 incomes | | | | | |
| No qualification | 0.59[a] | 0.55[a] | 0.60 | | 0.61 | | 0.59 |
| Lower secondary | | | 0.63 | | 0.71 | 0.72 | 0.69 |
| Upper secondary | | | | | 0.81 | 0.85 | 0.76 |
| Post-school Cert/Dip. | 0.75[b] | 0.72[b] | 0.77 | 0.24 | 0.80 | 0.83 | 0.69 |
| Bachelor | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Graduate diploma | 1.17[c] | 1.15[c] | | 1.37 | | 1.03 | 1.20 |
| Masters | | | | 1.54 | 1.10 | 1.12 | 1.22 |
| Doctorate | | | | 1.59 | | | 1.59 |
| Overall postgrad. Ave. | | | | | | | 1.20 |

*Sources*: Statistics New Zealand; Maani and Maloney (2004, Tables C.1 and C.2): average for male and female, 1997-2002. School Certificate and 6th Form Certificate assigned to lower and upper secondary respectively; Ministry of Education (2015), (2016b); Melbourne Institute (2015, Table 7.4): average for male and female; Authors' estimates based on the New Zealand Census.

*Note*: [a] NCEA level 1 qualification or less; [b] other (school) qualification; [c] average of all postgrad qualifications.

Table 4.9 Income weights by qualification level applied to student completions

| Qualification | Relative Income weight | MoE (2016): After 5 years | MoE (2016): After 10 years |
|---|---|---|---|
| Certificate Levels 1-3 | 0.5 (0.6) | 0.70 | 0.69 |
| Certificate Level 4 | 0.6 (0.7) | 0.71 | 0.70 |

| | | | |
|---|---|---|---|
| Diploma Levels 5-7 | 0.7 (0.8) | 0.76 | 0.77 |
| Bachelors | 1.0 (1.0) | 1.00 | 1.00 |
| Graduate certificates and diplomas | 1.1 (1.1) | 1.12 | 1.13 |
| Honours and post-grad. certificates | 1.2 (1.1) | 1.14 | 1.17 |
| Masters | 1.3 (1.2) | 1.15 | 1.18 |
| Doctorates | 1.4 (1.6) | 1.42 | 1.37 |

*Source*: Authors' estimates and MoE (2016).
*Note*: MoE (2016) data relate median earnings in 2015by qualification level.

Table 4.10 Tertiary teaching: Average labour productivity growth (%p.a.), 2000-15

| | Universities | ITPs | Wānanga | Total Tertiary |
|---|---|---|---|---|
| | Based on teaching staff FTE | | | |
| Student FTEs/Staff FTE | -0.5 | 0.7 | 4.2 | 0.2 |
| Completions/Staff FTE | 0.6 | 4.4 | 8.4 | 3.3 |
| Credit weighted completions/Staff FTE | 0.9 | 3.9 | 5.0 | 1.9 |
| Credit and income weighted completions/Staff FTE | 1.1 | 4.0 | 4.0 | 1.8 |
| | Based on teaching salaries | | | |
| Student FTEs/Staff salaries | -1.4 | 0.0 | 1.0 | -0.6 |
| Completions/Staff salaries | -0.3 | 3.7 | 5.1 | 2.3 |
| Credit weighted completions/Staff salaries | 0.0 | 3.1 | 1.8 | 1.0 |
| Credit and income weighted completions/Staff salaries | 0.2 | 3.2 | 0.8 | 0.9 |

*Notes*: 'Staff FTE' refers to academic teaching staff (or staff 'teaching component' for university staff).

Table 4.11 Tertiary teaching: Average multifactor productivity growth (%p.a.), 2000-15

| | Universities | ITPs | Wānanga | Total Tertiary |
|---|---|---|---|---|
| Student FTEs/$m | -1.2 | -0.2 | 2.1 | -0.6 |
| Completions/$m | -0.1 | 3.4 | 6.3 | 2.3 |
| Credit weighted completions/$m | 0.2 | 2.9 | 2.9 | 1.0 |
| Credit and income weighted completions/$m | 0.4 | 3.0 | 2.0 | 0.9 |

*Notes*: $m refers to total expenditure in ITPs and Wānanga and estimated teaching expenditure in universities.

Table 5.1 University research and teaching real expenditure ($m, 2006 prices), 2000-15

| Year | Research Expenditure | Teaching Expenditure | Total Expenditure |
|---|---|---|---|
| 2000 | 1,127.6 | 727.8 | 1,855.4 |
| 2001 | 1,124.5 | 793.8 | 1,918.3 |
| 2002 | 1,220.0 | 834.3 | 2,054.3 |
| 2003 | 1,304.5 | 887.4 | 2,191.9 |
| 2004 | 1,402.5 | 914.5 | 2,317.0 |
| 2005 | 1,522.5 | 959.2 | 2,481.6 |
| 2006 | 1,484.3 | 915.8 | 2,400.1 |
| 2007 | 1,610.2 | 899.1 | 2,509.3 |
| 2008 | 1,710.0 | 864.0 | 2,574.0 |
| 2009 | 1,766.5 | 892.4 | 2,658.9 |
| 2010 | 1,807.3 | 931.7 | 2,738.9 |
| 2011 | 1,778.8 | 911.8 | 2,690.6 |
| 2012 | 1,781.7 | 944.1 | 2,725.7 |
| 2013 | 1,797.8 | 956.3 | 2,754.1 |
| 2014 | 1,820.8 | 961.5 | 2,782.3 |
| 2015 | 1,902.8 | 1,004.0 | 2,906.9 |

*Source*: Calculated from Ministry of Education sources: Research Financing, and Financial Resources, at http://www.educationcounts.govt.nz/statistics/tertiary-education.

*Notes:* MoE data for teaching and research expenditure cover 2004-15. For 2000-03, the average ratio of Vote Education funding for research plus university contract research funding to total reported research funding was calculated. This was then used to interpolate the components of total research expenditure for the missing earlier years.

Table 5.2 Reported research outputs for New Zealand: 1996-2015

| Year | SCOPUS | Web of Science | Average |
|---|---|---|---|
| 1997 | 5,006 | 3,864 | 4,435 |
| 1998 | 5,215 | 4,194 | 4,705 |
| 1999 | 5,464 | 4,221 | 4,843 |
| 2000 | 5,363 | 4,283 | 4,823 |
| 2001 | 5,441 | 4,359 | 4,900 |
| 2002 | 5,597 | 4,374 | 4,986 |
| 2003 | 6,247 | 4,489 | 5,368 |
| 2004 | 6,940 | 4,785 | 5,863 |
| 2005 | 7,907 | 5,232 | 6,570 |
| 2006 | 8,323 | 5,478 | 6,901 |
| 2007 | 8,927 | 5,786 | 7,357 |
| 2008 | 9,383 | 6,188 | 7,786 |
| 2009 | 10,046 | 6,385 | 8,216 |
| 2010 | 10,640 | 7,214 | 8,927 |
| 2011 | 11,799 | 7,763 | 9,781 |
| 2012 | 12,071 | 8,101 | 10,086 |
| 2013 | 12,295 | 8,445 | 10,370 |
| 2014 | 12,862 | 8,568 | 10,715 |
| 2015 | 12,499 | 9,971 | 11,235 |
| | | Annual average growth rates (%) | |
| 1997-2002 | 2.5 | 2.3 | 2.5 |
| 2002-2006 | 5.8 | 10.4 | 5.8 |
| 2006-2015 | 6.9 | 4.6 | 6.9 |
| 1997-2015 | 5.8 | 5.8 | 5.8 |

*Sources*: SCOPUS data based on number of citable publications by New Zealand affiliated authors. Elsevier. (2017). Scopus [Database]. Retrieved 7 September 2017 from www.scopus.com . Web of Science data based on articles, books and book chapters by NZ affiliated authors across all disciplines http://apps.webofknowledge.com/WOS_AdvancedSearch_input.do?SID=P2wUXelNdAI9RUhKoODandproduct=WOSandsearch_mode=AdvancedSearch (Accessed on 18-09-17).

Table 5.3 Labour productivity: Publications per research staff FTE, 2000-15

| Year | SCOPUS | Web of Science | Average |
|---|---|---|---|
| 2000 | 100.0 | 100.0 | 100.0 |
| 2001 | 100.5 | 100.8 | 100.6 |
| 2002 | 103.0 | 100.8 | 102.0 |
| 2003 | 104.5 | 94.0 | 99.9 |
| 2004 | 112.5 | 97.1 | 105.7 |
| 2005 | 123.0 | 101.9 | 113.6 |
| 2006 | 129.5 | 106.7 | 119.3 |
| 2007 | 135.0 | 109.5 | 123.7 |
| 2008 | 136.7 | 112.9 | 126.2 |
| 2009 | 142.7 | 113.6 | 129.8 |
| 2010 | 150.2 | 127.5 | 140.1 |
| 2011 | 166.6 | 137.3 | 153.6 |
| 2012 | 169.3 | 142.3 | 157.3 |
| 2013 | 171.2 | 147.3 | 160.6 |
| 2014 | 178.6 | 149.0 | 165.4 |
| 2015 | 172.0 | 171.8 | 171.9 |
| | Annual average productivity growth rates (%) | | |
| 2000-2006 | 4.4 | 1.1 | 3.0 |
| 2006-2015 | 3.2 | 5.4 | 4.1 |
| 2000-2015 | 3.7 | 3.7 | 3.7 |

Table 5.4 Multifactor productivity: Publications per $m research expenditure, 2000-15

| Year | SCOPUS | Web of Science | Average |
|---|---|---|---|
| 2000 | 100.0 | 100.0 | 100.0 |
| 2001 | 101.7 | 102.1 | 101.9 |
| 2002 | 96.5 | 94.4 | 95.5 |
| 2003 | 100.7 | 90.6 | 96.2 |
| 2004 | 104.0 | 89.8 | 97.7 |
| 2005 | 109.2 | 90.5 | 100.9 |
| 2006 | 117.9 | 97.2 | 108.7 |
| 2007 | 116.6 | 94.6 | 106.8 |
| 2008 | 115.4 | 95.3 | 106.4 |
| 2009 | 119.6 | 95.2 | 108.7 |
| 2010 | 123.8 | 105.1 | 115.5 |
| 2011 | 139.5 | 114.9 | 128.6 |
| 2012 | 142.4 | 119.7 | 132.3 |
| 2013 | 143.8 | 123.7 | 134.9 |
| 2014 | 148.5 | 123.9 | 137.6 |
| 2015 | 138.1 | 138.0 | 138.0 |
| | Annual average productivity growth rates (%) | | |
| 2000-2006 | 2.8 | -0.5 | 1.4 |
| 2006-2015 | 1.8 | 4.0 | 2.7 |
| 2000-2015 | 2.2 | 2.2 | 2.2 |

Table 5.5 PBRF weighted research FTEs, 2000-15

| | % of Research FTEs | | | Number of Research FTEs | |
|---|---|---|---|---|---|
| | A | B | C | Unadjusted | PBRF rank weighted |
| *2003* | *9.74* | *39.07* | *51.19* | | |
| *2006* | *13.49* | *45.69* | *40.81* | | |
| *2012* | *16.33* | *48.64* | *35.02* | | |
| | (1) | (2) | (3) | (4) | (5) |
| 2000 | 6.0 | 32.4 | 61.6 | 9,145 | 17,273 |
| 2001 | 7.2 | 34.7 | 58.1 | 9,235 | 18,312 |
| 2002 | 8.5 | 36.9 | 54.6 | 9,270 | 19,254 |
| 2003 | 9.7 | 39.1 | 51.2 | 10,193 | 22,132 |
| 2004 | 11.0 | 41.3 | 47.7 | 10,520 | 23,831 |
| 2005 | 12.2 | 43.5 | 44.3 | 10,964 | 25,870 |
| 2006 | 13.5 | 45.7 | 40.8 | 10,963 | 26,899 |
| 2007 | 14.0 | 46.2 | 39.8 | 11,279 | 27,999 |
| 2008 | 14.4 | 46.7 | 38.9 | 11,701 | 29,381 |
| 2009 | 14.9 | 47.2 | 37.9 | 12,004 | 30,488 |
| 2010 | 15.4 | 47.7 | 37.0 | 12,081 | 31,032 |
| 2011 | 15.9 | 48.2 | 36.0 | 12,075 | 31,364 |
| 2012 | 16.3 | 48.6 | 35.0 | 12,160 | 31,934 |
| 2013 | 16.8 | 49.1 | 34.1 | 12,245 | 32,509 |
| 2014 | 17.3 | 49.6 | 33.1 | 12,281 | 32,958 |
| 2015 | 17.8 | 50.1 | 32.1 | 12,392 | 33,614 |

*Notes*: The percentages of PBRF rankings (A, B and C) at the top of the table in italics are from The Ministry of Education: www.educationcounts.govt.nz/statistics/tertiary_education/research Research Performance.

Columns (1) to (3) are derived by interpolating and extrapolating from the three fixed data points for the years 2003, 2006 and 20012. Column (4) is (0.5*Academic staff) + Research Staff + Share of non-academic staff allocated to reserach. Column (5) is the weighted sum of FTEs in each category with relative weights: A=5, B=3 and C=1 following Smart and Engler (2013, p.5).

Table 5.6 Citation-adjusted research output, 2000-2015

| Year | Ave. citations per publication | | Research output | | |
|---|---|---|---|---|---|
| | Number | Index | Unadjusted (volume) | Adjusted by citations | Index |
| 2000 | 0.92 | 100.0 | 4,823 | 4,431 | 100.0 |
| 2001 | 0.95 | 103.1 | 4,900 | 4,643 | 104.8 |
| 2002 | 0.98 | 106.2 | 4,986 | 4,867 | 109.8 |
| 2003 | 0.96 | 104.3 | 5,368 | 5,145 | 116.1 |
| 2004 | 1.00 | 109.0 | 5,863 | 5,874 | 132.5 |
| 2005 | 1.02 | 111.0 | 6,570 | 6,700 | 151.2 |
| 2006 | 1.04 | 113.7 | 6,901 | 7,206 | 162.6 |
| 2007 | 1.10 | 119.5 | 7,357 | 8,077 | 182.3 |
| 2008 | 1.12 | 121.7 | 7,786 | 8,708 | 196.5 |
| 2009 | 1.14 | 124.2 | 8,216 | 9,379 | 211.6 |
| 2010 | 1.17 | 127.4 | 8,927 | 10,453 | 235.9 |
| 2011 | 1.22 | 133.3 | 9,781 | 11,976 | 270.2 |
| 2012 | 1.26 | 137.5 | 10,086 | 12,741 | 287.5 |
| 2013 | 1.29 | 140.6 | 10,370 | 13,398 | 302.3 |
| 2014 | 1.32 | 143.7 | 10,715 | 14,151 | 319.3 |
| 2015 | 1.35 | 146.9 | 11,235 | 15,160 | 342.1 |
| | | | Annual average growth rates (%) | | |
| 2000-06 | 2.2 | | 6.2 | 8.4 | |
| 2006-15 | 2.9 | | 5.6 | 8.6 | |
| 2000-15 | 2.6 | | 5.8 | 8.5 | |

*Notes:* Column (1) An annual series derived from Ministry of Education. www.educationcounts.govt.nz/statistics/tertiary_education/research, Research Performance, Table RSP.11. This is the number of citations divided by the number of publications. In this case, the results are normalised to take into account the different rates of citation between subject areas. A value of 1 indicates that the impact of the research is equal to the world average, and based on a weighted average of 22 subject areas categorised by Thomson Reuters. Column (2) = index of Column (1) with 2000 =100. Column (3) from Table 5.2. Column (4) = Column (3)*(Column (2)/100). Column (5) = index of Column (4) with 2000 =100.

Table 5.7 Measures of research productivity: annual average growth rates (%)

| | 2000-06 | 2006-15 | 2000-15 |
|---|---|---|---|
| | Labour productivity: *Output per Research Staff FTE* | | |
| Unadjusted | 3.0 | 4.1 | 3.7 |
| Citation weighted output | 5.2 | 7.1 | 6.4 |
| Citation weighted and PBRF-adjusted staff FTEs | 0.7 | 6.0 | 3.8 |
| | Multifactor productivity: *Output per $m research expenditure* | | |
| Unadjusted | 1.4 | 2.7 | 2.2 |
| Citation weighted output | 3.6 | 5.7 | 4.8 |

Table 6.1 Annual average productivity growth rates in the university sector (%)

| **Teaching** | | | **Research** | | | **Overall** |
|---|---|---|---|---|---|---|
| | | | *Labour productivity* | | | |
| Student FTEs per Teaching staff FTE | 2000-2006 | -0.1 | Research output per Research staff FTE | 2000-2006 | 3.0 | 1.9 |
| | 2006-2015 | 0.1 | | 2006-2015 | 4.1 | 3.1 |
| | **2000-2015** | **0.0** | | **2000-2015** | **3.7** | **2.6** |
| Credit weighted completions per Teaching staff FTE | 2000-2006 | 3.3 | Citation weighted research output per Research staff FTE | 2000-2006 | 5.2 | 4.5 |
| | 2006-2015 | 0.2 | | 2006-2015 | 7.1 | 5.3 |
| | **2000-2015** | **1.4** | | **2000-2015** | **6.4** | **5.0** |
| Credit and income weighted completions per Teaching staff FTE | 2000-2006 | 3.4 | Citation weighted research output per PBRF adjusted Research staff FTE | 2000-2006 | 0.7 | 1.8 |
| | 2006-2015 | 0.4 | | 2006-2015 | 6.0 | 4.0 |
| | **2000-2015** | **1.6** | | **2000-2015** | **3.8** | **3.1** |
| | | | *Multifactor productivity* | | | |
| Student FTEs per $m teaching expenditure | 2000-2006 | -1.6 | Research output per $m research expenditure | 2000-2006 | 1.4 | 0.3 |
| | 2006-2015 | -0.9 | | 2006-2015 | 2.7 | 1.8 |
| | **2000-2015** | **-1.2** | | **2000-2015** | **2.2** | **1.2** |
| Credit weighted completions per $m teaching expenditure | 2000-2006 | 1.8 | Citation weighted research output per $m research expenditure | 2000-2006 | 3.6 | 2.9 |
| | 2006-2015 | -0.8 | | 2006-2015 | 5.7 | 4.0 |
| | **2000-2015** | **0.2** | | **2000-2015** | **4.8** | **3.5** |
| Credit and income weighted completions per $m teaching expenditure | 2000-2006 | 1.8 | Citation weighted research output per $m research expenditure | 2000-2006 | 3.6 | 2.9 |
| | 2006-2015 | -0.6 | | 2006-2015 | 5.7 | 4.0 |
| | **2000-2015** | **0.4** | | **2000-2015** | **4.8** | **3.6** |

Table 7.1 University productivity growth rates: testing sensitivity to allocation assumptions

| | *Adjusted (default*):* | | | *Unadjusted:* | | |
|---|---|---|---|---|---|---|
| | Teaching | Research | **Total** | Teaching | Research | **Total** |
| | Quality adjusted multifactor productivity ** | | | | | |
| 2000-2006 | 1.8 | 3.6 | 2.9 | 1.5 | -0.5 | 1.1 |
| 2006-2015 | -0.6 | 5.7 | 4.0 | 1.3 | 5.1 | 2.2 |
| 2000-2015 | **0.4** | **4.8** | **3.6** | 1.4 | 2.8 | 1.8 |
| | Basic labour productivity *** | | | | | |
| 2000-2006 | -0.1 | 3.0 | 1.9 | -0.2 | 1.2 | 0.1 |
| 2006-2015 | 0.1 | 4.1 | 3.1 | -0.3 | 2.5 | 0.6 |
| 2000-2015 | **0.0** | **3.7** | **2.6** | -0.2 | 2.0 | 0.4 |

* The adjusted results are used throughout except where indicated

**Teaching: credit and income weighted completions per $m teaching expenditure; Research: Citation weighted research output per $m research expenditure.

***Teaching: Student FTEs per teaching staff FTE; Research: Publications per research FTE;

Figure 5.1 Quality Adjusted Research Output, 2000-15

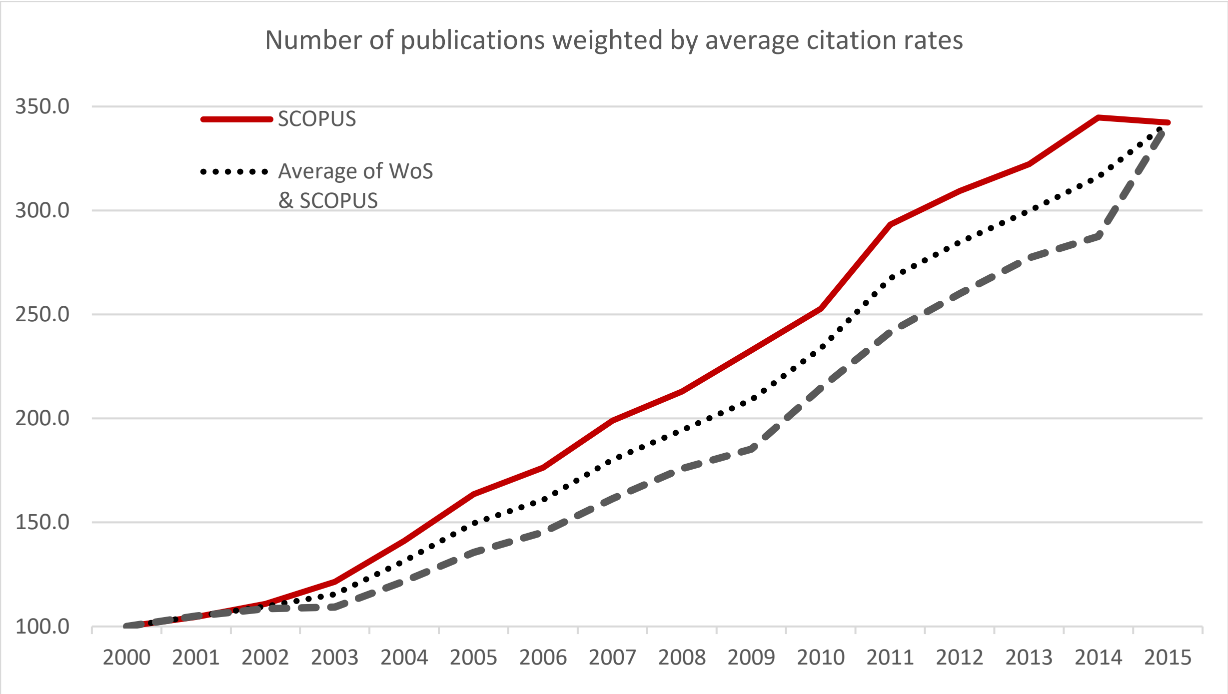



Figure 5.2: Research: labour productivity

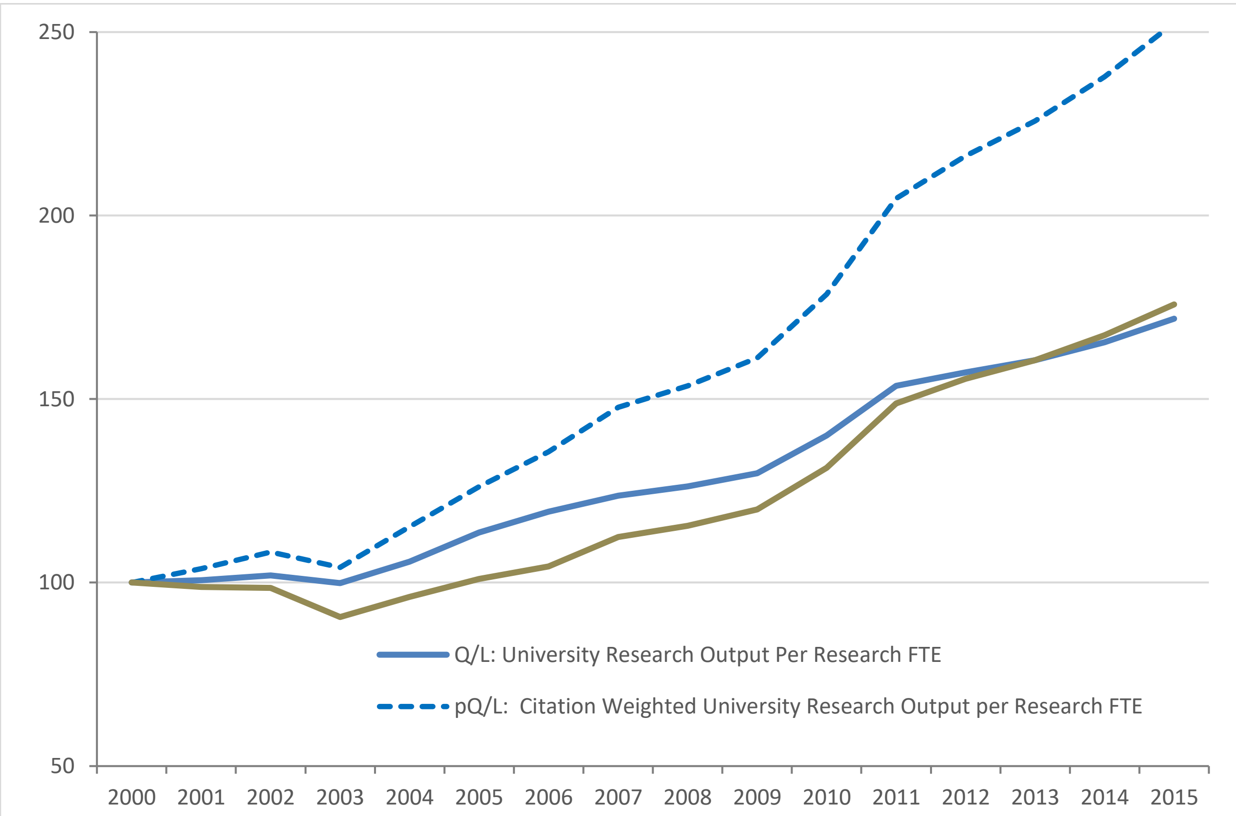


Figure 5.3: Research: multifactor productivity

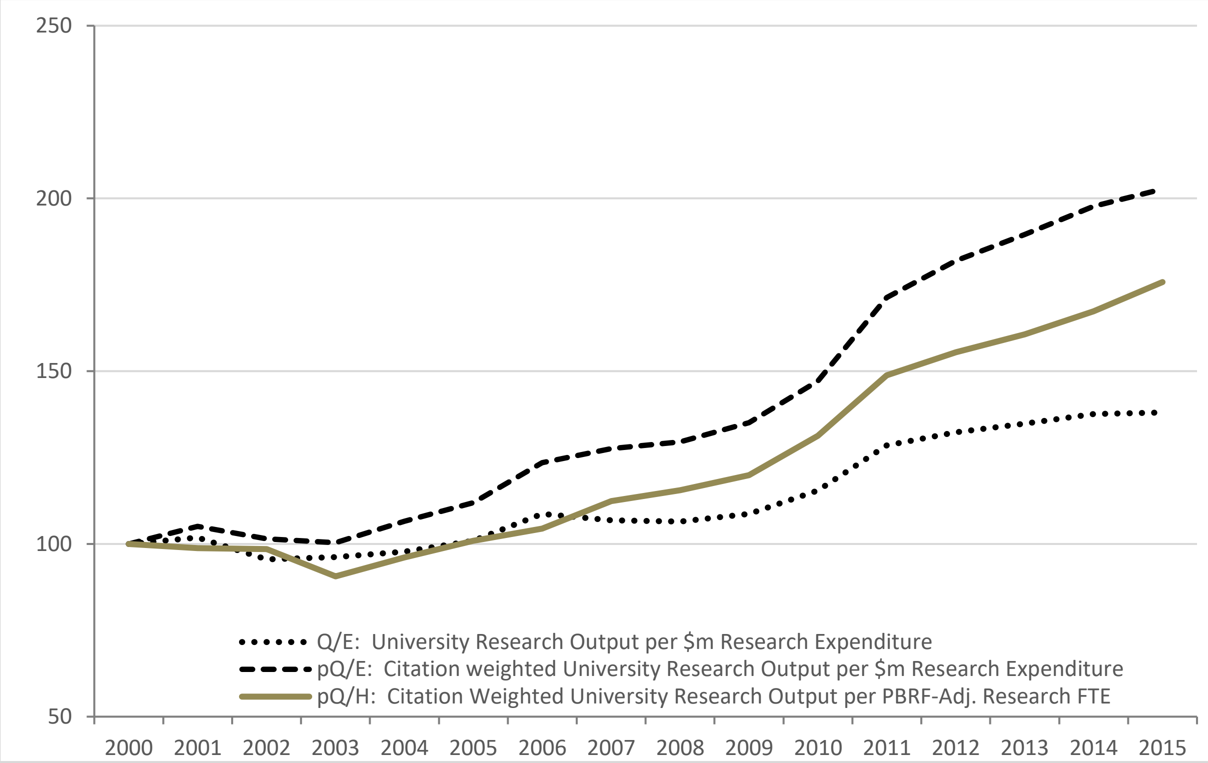



Figure 6.1 Labour productivity growth rates in universities: Teaching versus research

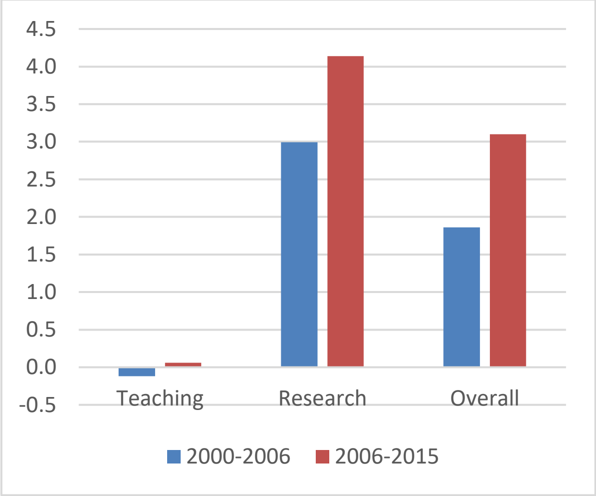


Figure 6.2 Multifactor productivity growth rates in universities: Teaching versus research

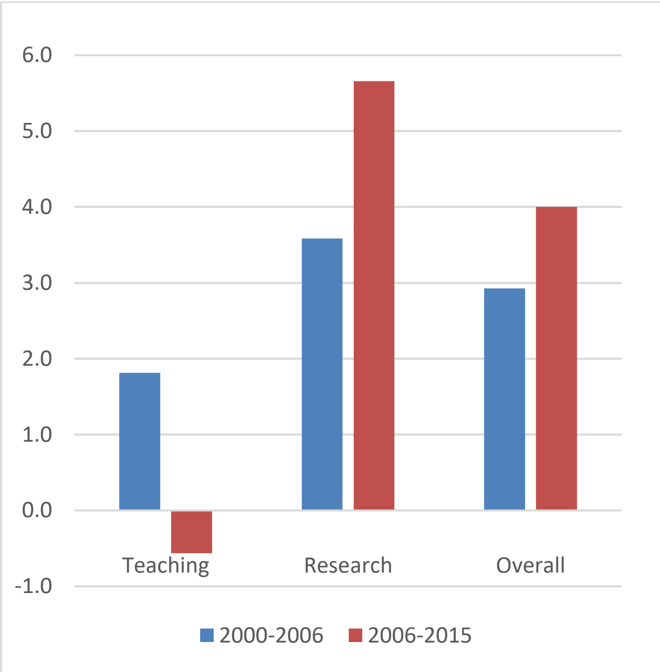



Figure 6.3 Trends in university productivity, 2000-15

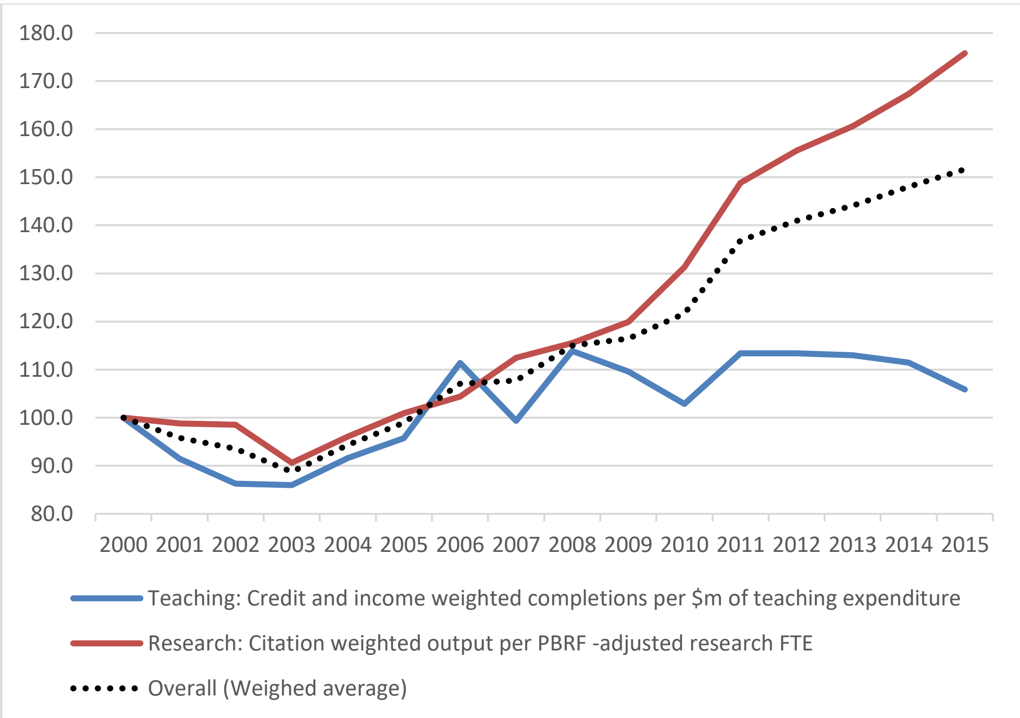


Figure 7.1 General consumer and tertiary education price indices, 2000-15

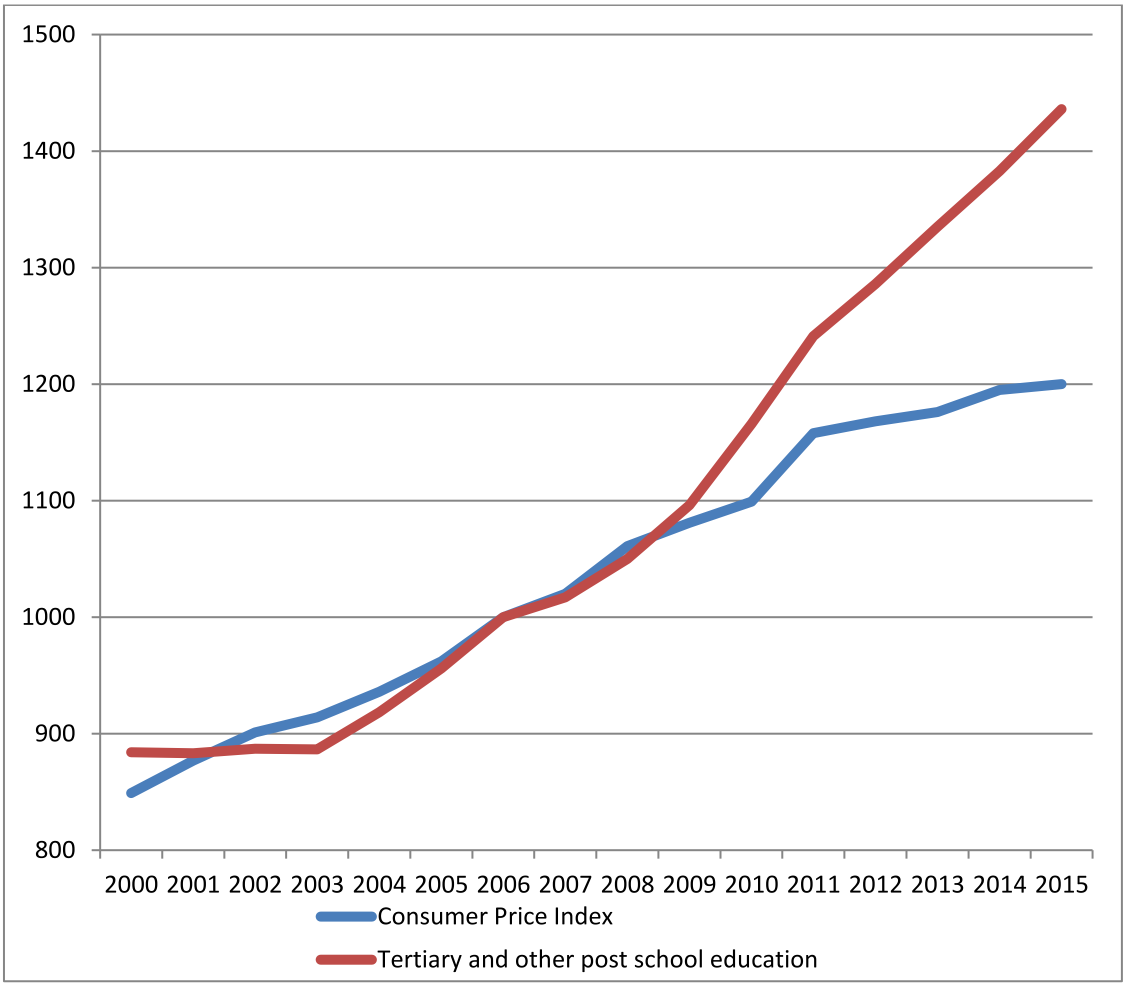
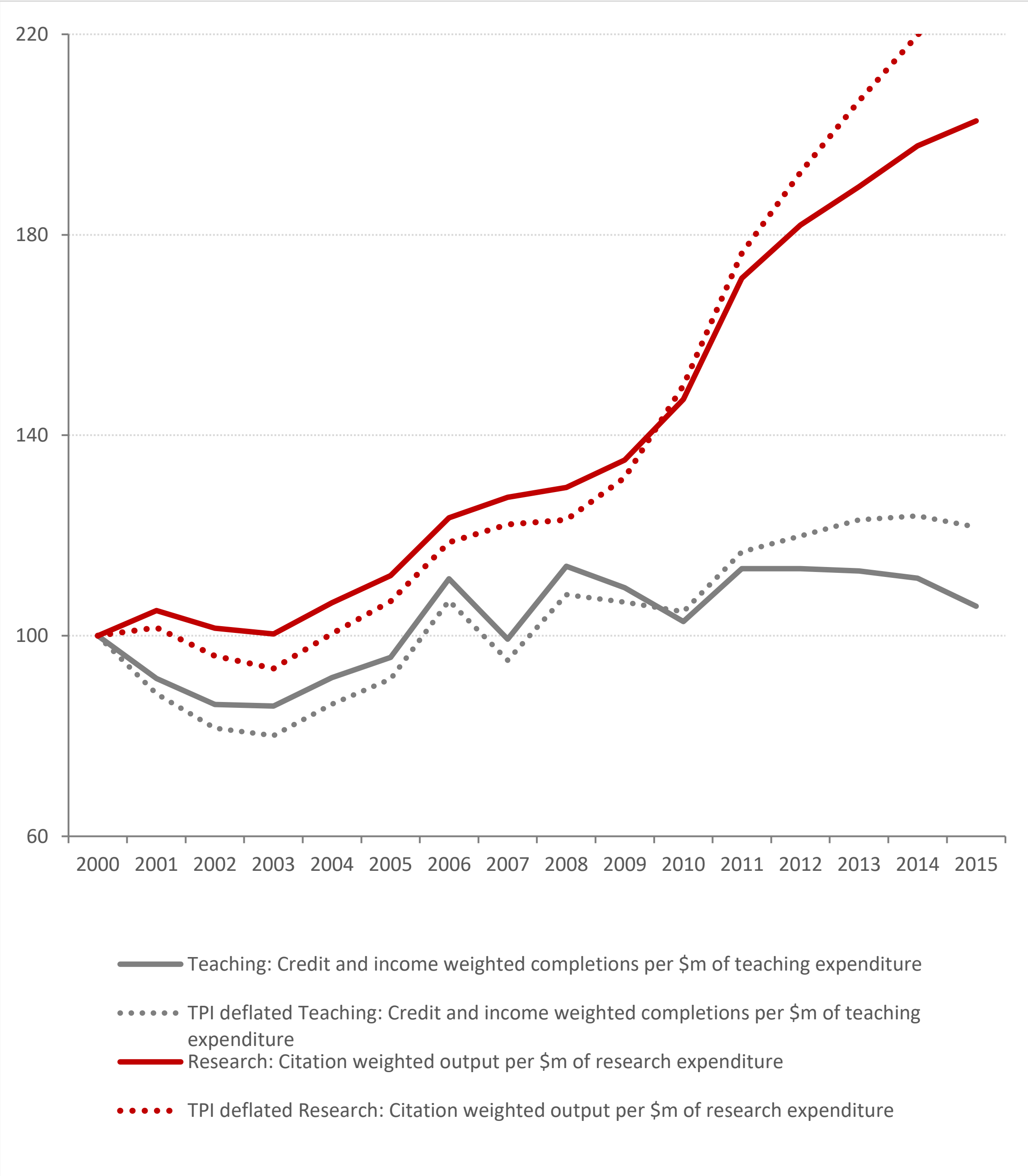


Figure 7.2 Overall university productivity and price deflation: CPI versus TPI



# Appendix A Additional Data for the Tertiary Sector

## Table A1 FTE staff numbers in tertiary sub-sectors

| | Academic | Non-academic | Research | Academic | Non-academic | Research |
|---|---|---|---|---|---|---|
| | Universities | | | Institutes and Polytechnics | | |
| 2000 | 6,440 | 7,940 | 1,100 | 4,035 | 3,135 | |
| 2001 | 6,580 | 8,265 | 1,100 | 4,000 | 2,960 | |
| 2002 | 6,865 | 8,070 | 1,045 | 3,960 | 2,725 | |
| 2003 | 7,065 | 9,100 | 1,245 | 4,210 | 3,365 | |
| 2004 | 7,190 | 9,285 | 1,305 | 4,395 | 3,535 | |
| 2005 | 7,365 | 9,555 | 1,420 | 4,350 | 3,590 | |
| 2006 | 7,245 | 9,550 | 1,435 | 4,380 | 3,630 | |
| 2007 | 7,255 | 9,610 | 1,485 | 4,385 | 3,720 | |
| 2008 | 7,200 | 9,800 | 1,590 | 4,150 | 3,510 | |
| 2009 | 7,220 | 10,030 | 1,730 | 4,085 | 3,635 | |
| 2010 | 7,165 | 10,190 | 1,775 | 4,210 | 3,750 | |
| 2011 | 7,090 | 10,240 | 1,760 | 4,240 | 3,845 | |
| 2012 | 7,060 | 10,640 | 1,675 | 4,440 | 3,960 | |
| 2013 | 7,110 | 10,815 | 1,630 | 4,370 | 3,980 | |
| 2014 | 7,160 | 10,705 | 1,695 | 4,295 | 3,935 | |
| 2015 | 7,170 | 10,720 | 1,790 | 4,455 | 3,890 | |
| | Wānanga | | | Total Tertiary sector | | |
| 2000 | 175 | 150 | | 10,650 | 11,750 | 1,099 |
| 2001 | 235 | 265 | | 10,815 | 11,915 | 1,100 |
| 2002 | 525 | 575 | | 11,350 | 12,395 | 1,047 |
| 2003 | 780 | 965 | | 12,055 | 13,300 | 1,244 |
| 2004 | 985 | 895 | | 12,570 | 13,875 | 1,305 |
| 2005 | 870 | 990 | | 12,585 | 14,005 | 1,422 |
| 2006 | 680 | 765 | | 12,305 | 13,740 | 1,435 |
| 2007 | 535 | 715 | | 12,175 | 13,660 | 1,485 |
| 2008 | 535 | 600 | | 11,885 | 13,475 | 1,591 |
| 2009 | 610 | 795 | | 11,915 | 13,645 | 1,729 |
| 2010 | 745 | 705 | | 12,120 | 13,895 | 1,774 |
| 2011 | 760 | 735 | | 12,090 | 13,850 | 1,758 |
| 2012 | 750 | 670 | | 12,250 | 13,925 | 1,673 |
| 2013 | 840 | 665 | | 12,320 | 13,950 | 1,631 |
| 2014 | 865 | 625 | | 12,320 | 14,015 | 1,696 |

| | Academic | Non-academic | Research | Academic | Non-academic | Research |
|---|---|---|---|---|---|---|
| | | | | | | |
| 2015 | 870 | 500 | | 12,495 | 14,285 | 1,790 |

*Source:* Ministry of Education.

## Table A2 FTE student numbers in tertiary sub-sectors

| Year | Universities | ITPs | Wānanga | Total Tertiary |
|---|---|---|---|---|
| 2000 | 114,738 | 59,943 | 2,970 | 177,651 |
| 2001 | 118,667 | 65,127 | 8,260 | 192,054 |
| 2002 | 125,202 | 74,035 | 23,990 | 223,227 |
| 2003 | 134,191 | 90,878 | 38,411 | 263,480 |
| 2004 | 136,621 | 95,788 | 34,702 | 267,111 |
| 2005 | 134,241 | 91,282 | 31,405 | 256,928 |
| 2006 | 130,675 | 81,391 | 24,076 | 236,142 |
| 2007 | 130,355 | 80,565 | 22,472 | 233,392 |
| 2008 | 128,446 | 76,361 | 23,113 | 227,920 |
| 2009 | 135,884 | 81,487 | 25,624 | 242,995 |
| 2010 | 138,508 | 84,279 | 26,303 | 249,091 |
| 2011 | 133,039 | 81,966 | 25,172 | 240,177 |
| 2012 | 134,643 | 84,098 | 25,227 | 243,969 |
| 2013 | 132,641 | 81,011 | 25,527 | 239,180 |
| 2014 | 132,115 | 80,790 | 25,054 | 237,898 |
| 2015 | 131,770 | 77,335 | 23,145 | 232,250 |

*Source:* Ministry of Education, Financial performance of tertiary education institutions

## Table A3 Qualification Completions (Total Tertiary)

| Year | Certificates | | | | Diplomas | Bachelor | Grad Cert. & Dip. | Hons. & PG Cert. & Dip. | Masters | Doctorate | Unweighted Total | Weighted Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5-7 | | | | | | | |
| Credit weights | 40 | 40 | 40 | 40 | 120 | 360 | 90 | 90 | 240 | 360 | | |
| 2000 | 440 | 6,070 | 11,625 | 3,700 | 6,375 | 18,880 | 2,455 | 5,400 | 2,985 | 465 | 58,395 | 10,025,950 |
| 2001 | 555 | 5,365 | 12,240 | 4,705 | 6,865 | 18,630 | 2,840 | 5,445 | 2,660 | 455 | 59,760 | 9,993,050 |
| 2002 | 3,570 | 5,660 | 12,560 | 9,005 | 7,775 | 17,980 | 2,900 | 5,470 | 2,905 | 505 | 68,330 | 10,269,900 |
| 2003 | 6,285 | 10,185 | 11,455 | 16,400 | 9,685 | 18,870 | 3,580 | 6,020 | 3,075 | 555 | 86,110 | 11,530,200 |
| 2004 | 547 | 16,725 | 12,195 | 12,830 | 11,085 | 20,435 | 3,535 | 6,650 | 3,535 | 625 | 88,162 | 12,368,730 |
| 2005 | 4,360 | 22,580 | 18,940 | 17,305 | 10,840 | 22,545 | 3,760 | 7,050 | 4,075 | 645 | 112,100 | 14,127,500 |
| 2006 | 2,875 | 19,690 | 11,505 | 14,985 | 10,715 | 25,185 | 4,110 | 8,130 | 4,255 | 645 | 102,095 | 14,669,600 |
| 2007 | 1,780 | 15,375 | 13,175 | 15,070 | 10,430 | 22,765 | 4,205 | 7,545 | 3,250 | 650 | 94,245 | 13,334,500 |
| 2008 | 2,905 | 19,065 | 14,030 | 14,900 | 11,435 | 23,820 | 4,490 | 8,370 | 4,005 | 805 | 103,825 | 14,391,800 |
| 2009 | 3,540 | 19,195 | 17,340 | 18,120 | 11,710 | 23,605 | 5,145 | 9,115 | 3,960 | 885 | 112,615 | 14,783,200 |
| 2010 | 3,100 | 19,160 | 20,860 | 18,320 | 12,815 | 22,790 | 5,200 | 9,740 | 4,185 | 1,015 | 117,185 | 14,914,200 |
| 2011 | 3,210 | 16,975 | 19,855 | 20,385 | 13,670 | 25,430 | 5,825 | 10,145 | 4,585 | 1,115 | 121,195 | 16,151,300 |
| 2012 | 4,400 | 18,285 | 20,345 | 21,255 | 13,940 | 27,465 | 5,225 | 10,280 | 4,645 | 1,070 | 126,910 | 17,027,050 |
| 2013 | 3,230 | 16,445 | 21,475 | 22,000 | 12,640 | 28,180 | 4,750 | 10,255 | 4,715 | 1,310 | 125,000 | 17,141,250 |
| 2014 | 3,805 | 12,880 | 23,025 | 20,250 | 12,470 | 27,835 | 4,805 | 9,550 | 4,895 | 1,440 | 120,955 | 16,900,550 |
| 2015 | 3,375 | 11,700 | 22,545 | 20,575 | 11,265 | 27,520 | 5,215 | 10,040 | 5,505 | 1,345 | 119,085 | 16,765,150 |

*Source:* Ministry of Education

## Appendix B Estimating Returns to Qualifications from Census Data

Following the approach of Le et al. (2005) data on qualifications and gender were obtained for each of the seven New Zealand censuses between 1981 and 2013. Of course, gender is not the only factor that influences the income received by a person with given qualifications. To account for these other factors a regression model of the following form was fitted:

$$\ln Y = \beta_0 + \beta_1 G + \beta_2 A + \beta_3 A^2 + \sum_{i=1}^{3} \beta_{4i} Q_i + \sum_{i=1}^{3} \beta_{5i}(Q_i * A) + \sum_{i=1}^{3} \beta_{6i}(Q_i * A^2) + \sum_{j=1}^{6} \beta_{7j} T_j + \sum_{k=1}^{3} \beta_{8k} E_k + \varepsilon \qquad \text{(A1)}$$

where: lnY = the logarithm of earnings; $G$ = a categorical variable for gender; $A$ = age in years; $Q_i$ = a categorical variable for the $i^{th}$ level of qualifications; $T_j$ = is a categorical variable for the census year $j$; $E_k$ = is a categorical variable for the $k^{th}$ ethnicity; and $\varepsilon$ = random disturbance term.

A summary of the variables is given in Table B1. Based on the results of fitting this model, the net present value of the income streams over the lifetime (from age 21 to 64) were computed using three different discount rates. While the absolute values vary predictably with the discount rate, the relative values for the different qualifications are remarkably constant over time.

To explore the possibility that the relative incomes by qualification vary across the age range, the Census data were also used to estimate the incomes predicted at ages 30, 40, 50 and 60 (holding other variables at their average values, and allowing for different premiums by census year 'cohort'). The results are set out in Table B3, with full regression results in Table B4.

**Table B1 Summary of variables from New Zealand census data**

| | 1981 | 1986 | 1991 | 1996 | 2001 | 2006 | 2013 |
|---|---|---|---|---|---|---|---|
| ***Age*** | 39.3 | 39.0 | 39.4 | 39.6 | 40.7 | 41.5 | 42.3 |
| ***Gender*** | | | | | | | |
| Female % | 49.7% | 49.5% | 50.0% | 51.1% | 51.8% | 51.7% | 52.2% |
| Male % | 50.3% | 50.5% | 50.0% | 48.9% | 48.2% | 48.3% | 47.8% |
| ***Employment*** | | | | | | | |
| Employed | 56.2% | 59.9% | 53.9% | 58.3% | 59.7% | 61.7% | 62.1% |
| Employer | 10.2% | 14.1% | 13.9% | 14.8% | 16.0% | 16.0% | 14.3% |
| Not in labour force | 31.5% | 22.3% | 25.8% | 22.0% | 19.6% | 19.2% | 19.0% |
| Unemployed | 2.1% | 3.7% | 6.4% | 4.9% | 4.6% | 3.0% | 4.6% |
| ***Ethnicity*** | | | | | | | |
| European only | 85.9% | 84.8% | 82.1% | 78.3% | 76.1% | 60.2% | 66.3% |
| Mixed European | 2.6% | 2.3% | 2.2% | 5.9% | 5.1% | 6.2% | 6.8% |
| Non-European | 10.8% | 12.4% | 15.4% | 15.1% | 18.1% | 33.1% | 26.5% |
| Not specified | 0.7% | 0.5% | 0.2% | 0.7% | 0.7% | 0.5% | 0.3% |
| ***Qualification*** | | | | | | | |
| Bachelor | 3.8% | 4.4% | 5.4% | 8.0% | 10.0% | 13.9% | 17.2% |
| NCEA 1 or less | 64.2% | 52.5% | 47.5% | 47.5% | 39.9% | 33.8% | 28.4% |
| Other Non-degree | 31.1% | 40.5% | 44.3% | 40.6% | 45.6% | 46.5% | 46.5% |
| Postgraduate | 1.0% | 2.7% | 2.8% | 3.9% | 4.5% | 5.7% | 7.9% |

*Source:* Statistics New Zealand; *Notes*: All figures are based on NZ residents aged between 21 and 64.

**Table B2 Net present value of life time income by qualification**

| Discount rates | NCEA 1or less | Other qualification | Bachelors degree | Postgraduate |
|---|---|---|---|---|
| 3% | 712,223 | 934,051 | 1,229,375 | 1,419,866 |
| 5% | 520,489 | 674,883 | 869,587 | 991,819 |
| 7% | 400,933 | 513,738 | 647,227 | 730,839 |

*Notes:* Derived from Census data for 1981 to 2013 and expressed in 1981 constant dollars.

**Table B3 Relative incomes by qualification at decade intervals of age**

| Age | 30 | 40 | 50 | 60 | Average |
|---|---|---|---|---|---|
| NCEA 1 or Less | 0.64 | 0.53 | 0.51 | 0.59 | 0.57 |
| Other Qualification | 0.79 | 0.70 | 0.68 | 0.75 | 0.75 |
| Bachelors Degree | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Postgraduate | 1.06 | 1.09 | 1.17 | 1.31 | 1.17 |

*Notes:* Derived from Census data for 1981 to 2013 using a 5% discount rate. 'Average' is average earning premium over ages 25-65 based on estimates at 5-yearly intervals.

**Table B4 Regression results for earnings regressions with census cohorts**

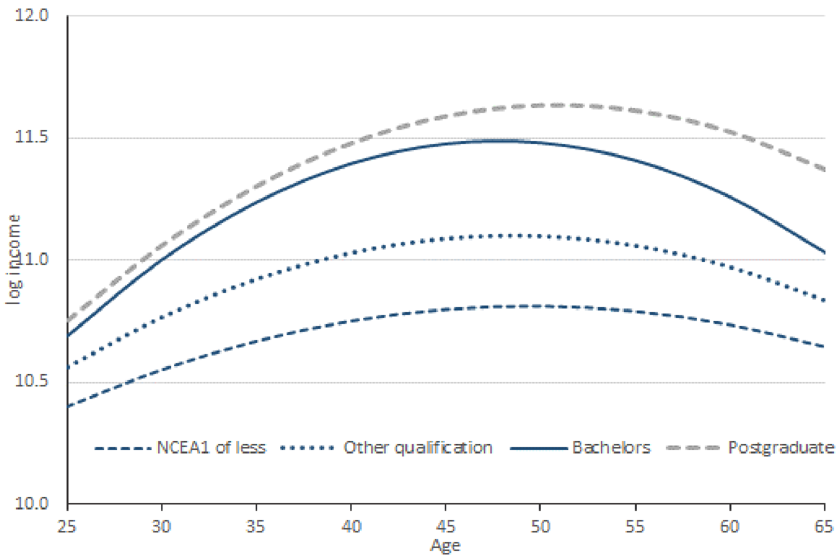
| Variables | Parameter | St. error | *t*-ratio | 95% interval | |
|---|---|---|---|---|---|
| Age | 0.098462 | 0.008572 | 11.49 | 0.08166 | 0.11526 |
| $Age^2$ | -0.00104 | 0.000102 | -10.21 | -0.00124 | -0.00084 |
| Qualification: | | | | | |
| NCEA1 of less | 1.140166 | 0.144803 | 7.87 | 0.856353 | 1.423979 |
| Other qualification | 0.838240 | 0.149931 | 5.59 | 0.544376 | 1.132105 |
| Postgraduate | 0.254493 | 0.16786 | 1.52 | -0.07451 | 0.583498 |
| Qualification * Age | | | | | |
| NCEA1 of less | -0.07840 | 0.007252 | -10.81 | -0.09262 | -0.06419 |
| Other qualification | -0.05265 | 0.007503 | -7.02 | -0.06736 | -0.03795 |
| Postgraduate | -0.01309 | 0.008307 | -1.58 | -0.02937 | 0.003191 |
| Qualification * $Age^2$: | | | | | |
| NCEA1 of less | 0.000845 | 8.59E-05 | 9.84 | 0.000677 | 0.001013 |
| Other qualification | 0.000566 | 8.88E-05 | 6.37 | 0.000392 | 0.00074 |
| Postgraduate | 0.000222 | 9.78E-05 | 2.27 | 3.03E-05 | 0.000414 |
| Census Year: | | | | | |
| 1986 | 0.108298 | 0.207209 | 0.52 | -0.29783 | 0.514427 |
| 1991 | 0.06696 | 0.170536 | 0.39 | -0.26729 | 0.40121 |
| 1996 | -0.53894 | 0.193085 | -2.79 | -0.91739 | -0.1605 |
| 2001 | -0.64620 | 0.182301 | -3.54 | -1.00351 | -0.28889 |
| 2006 | -0.70154 | 0.164969 | -4.25 | -1.02488 | -0.3782 |
| 2013 | -0.94357 | 0.164824 | -5.72 | -1.26663 | -0.62052 |
| Year * Age: | | | | | |
| 1986 | -0.01339 | 0.010686 | -1.25 | -0.03433 | 0.007555 |
| 1991 | 0.00020 | 0.008727 | 0.02 | -0.0169 | 0.017305 |
| 1996 | 0.02899 | 0.009843 | 2.95 | 0.009696 | 0.04828 |
| 2001 | 0.03581 | 0.009192 | 3.90 | 0.017795 | 0.053828 |
| 2006 | 0.04014 | 0.008230 | 4.88 | 0.024004 | 0.056265 |
| 2013 | 0.04906 | 0.008156 | 6.02 | 0.033077 | 0.06505 |

| Variables | Parameter | St. error | *t*-ratio | 95% interval | |
|---|---|---|---|---|---|
| Year * Age$^2$: | | | | | |
| 1986 | 0.000153 | 0.000128 | 1.19 | -9.8E-05 | 0.000404 |
| 1991 | -1.9E-05 | 0.000105 | -0.19 | -0.00022 | 0.000186 |
| 1996 | -0.00033 | 0.000118 | -2.80 | -0.00056 | -9.8E-05 |
| 2001 | -0.00041 | 0.000109 | -3.77 | -0.00063 | -0.0002 |
| 2006 | -0.00044 | 9.68E-05 | -4.56 | -0.00063 | -0.00025 |
| 2013 | -0.00050 | 9.53E-05 | -5.26 | -0.00069 | -0.00031 |
| Ethnicity: | | | | | |
| Mix-Euro | -0.01934 | 0.008315 | -2.33 | -0.03564 | -0.00304 |
| Non-Euro | -0.19165 | 0.007888 | -24.29 | -0.20711 | -0.17619 |
| Other | -0.08432 | 0.010268 | -8.21 | -0.10444 | -0.0642 |
| Gender: Female | -0.49744 | 0.008017 | -62.05 | -0.51315 | -0.48173 |
| Constant: | 8.90887 | 0.169582 | 52.53 | 8.576487 | 9.241246 |
| | | | | | |
| Number of obs = 71,430 | R-squared = 0.241 | | | | |
| F( 17, 71,412) = 773.69 | Root MSE = 0.65857 | | | | |
| Prob > F = 0.0000 | | | | | |

*Note:* The default categories are: qualification = bachelors degree; census year = 1981; ethnicity = NZ European; gender = male.

Based on our census data regressions, Figure B1 shows profiles of predicted incomes (for log income in 2013) for individuals with different qualifications, from age 25 to 65. It can be seen that, except for postgraduate qualifications, the premium associated with higher level qualifications tends to first increase, then decrease, with age, and peaking around age 40-50.

**Figure B1 Lifetime income profiles by age and qualification (2013)**



## About the Authors

Norman Gemmell is Professor of Public Finance at Victoria University of Wellington, New Zealand.
Email: norman.gemmell@vuw.ac.nz

Patrick Nolan is Principal Advisor, Economics and Research, at the New Zealand Productivity Commission.
Email: Patrick.nolan@productivity.govt.nz

Grant Scobie is an independent researcher and former Advisor at The Treasury and the New Zealand Productivity Commission.