Norman Gemmell, Patrick Nolan
and Grant Scobie

Quality Adjusting Education Sector Productivity

Abstract

This article examines how quality-adjusted productivity indices for the education sector may be constructed and proposes methods for making such adjustments to basic measures of labour and multifactor productivity growth. Results highlight the need for careful measurement, showing that measures unadjusted for quality are unlikely to provide sufficiently robust signals about changes in productivity performance in the education sector on which policy advice could be built. 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 unadjusted indices.

Keywords productivity, quality adjustment, education

Norman Gemmell holds the Chair in Public Finance, Victoria Business School, Victoria University of Wellington. He is a former Chief Economist at the Treasury and his current research interests focus on behavioural responses to taxation, including tax compliance. Patrick Nolan is a Principal Advisor at the New Zealand Productivity Commission. His research interests include productivity issues and welfare state design. Grant Scobie, an independent researcher, was formerly Professor of Economics at the University of Waikato, and a Principal Advisor at the Treasury and latterly at the Productivity Commission.

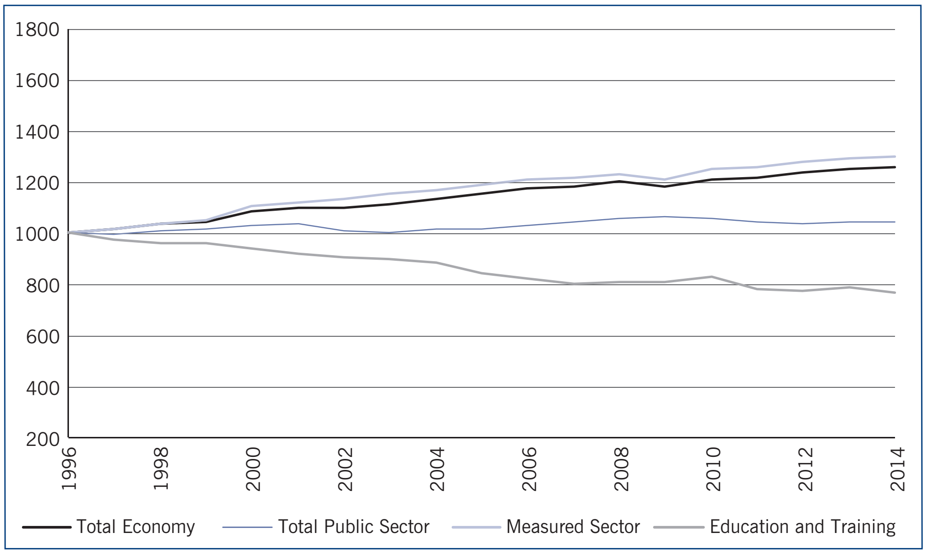
The measurement of productivity in the market sector of the economy is now well established, with estimates by industry group regularly published by Statistics New Zealand. Yet while Statistics New Zealand also publishes some estimates of productivity in the non-measured sector, particularly for areas such as education and health, this is still a developing field.[1]

The limited information we have about the public sector suggests that improvements in productivity have lagged well behind those in the market sector. While the growth of outputs in the public sector has been comparable to that of the market sector, most of that growth is attributable to increased inputs: more people producing more outputs. Consequently, over the last two decades the average growth rate of labour productivity in the public sector, as conventionally measured in national accounts, has been about 0.2% per year, compared with 1.5% in the market sector (Nolan, Fraser and Conway, 2018). Similar results are seen in a number of other countries. Australia, for example, managed only 0.3% per year (Gemmell, Nolan and Scobie, 2017b).

Yet it could be that these existing estimates for the public sector are not giving an accurate picture. It is widely acknowledged that measuring productivity in the public sector faces additional challenges to those encountered in the market sector (Productivity Commission, 2018). For example, one challenge in measuring productivity in public services is that typically there are no market prices for the services or they are offered at highly subsidised prices. As a result, unlike for the market sector, conventional price weights cannot be used to aggregate diverse inputs and outputs or as an indicator of changes in quality.[2] There is a sizeable literature that discusses addressing aggregation issues through the use of producer prices (cost weighting). But guidance is less developed on how changes in quality can be accounted for.

This article reports on two recent studies that quality adjust publicly available data on the productivity of the public education sector in New Zealand (Gemmell, Nolan and Scobie, 2017a, 2017b). The primary objective is to demonstrate that how productivity is measured matters. While we make no attempt to offer a single definitive measure, the range of measures we report provide insights into the importance of the methodology. In short, there are a number of ways to measure educational productivity; the results will depend on the approach chosen to deal with quality adjustments. After summarising existing measures based on national accounts data, we present a range of estimates for productivity in both the school and tertiary sectors, using different methods of quality adjustment.

Figure 1: Trends in labour productivity (1996-2014)



Source: Statistics New Zealand

National accounts measures

Statistics New Zealand regularly publishes estimates for the education sector as part of their annual releases of industry-level productivity measures (Statistics New Zealand, 2013, 2017; Tipper, 2013). The education and healthcare sectors (in addition to central and local government) were given priority as these are areas where most progress has been made in defining output measures. Defining the output of collective services, such as defence, police or fire services, remains relatively difficult.

Output measures are based on a fixed-price value-added, GDP production approach. Value added is defined as output minus intermediate consumption. Once output measures have been defined, their growth rates are computed. The growth rates of the activities are then combined into a single output index for the sub-sector using cost weights for the different components of output which reflect their relative importance.

More specifically, in the case of education and training, overall output is constructed by combining preschool education (contributing 8% of value added to the sector), school education (contributing 50%), tertiary education (contributing 33%) and adult, community and other education (contributing 8%) (Tipper, 2013). The output indicator for each sub-sector is based on cost-weighted numbers of equivalent full-time students (EFTS). Cost weights are derived from financial data on expenditures for each activity. A proportion of the activities is not measured (such as the research outputs of tertiary education). Consistent with Statistics New Zealand (2010, p.18), the growth rates of these later activities are assumed to match those of the measured activities.

In the case of inputs, measures of labour and capital used in the production of the activities are estimated and combined. The labour input is based on hours paid, while the capital input is estimated by applying the user cost of capital concept to the total capital stock used in the industry. The latter is constructed using the perpetual inventory method, which sums, and depreciates, annual investment over a prior period (Tipper, 2013). An exogenously given rate of return of 4% is applied to all industries in the estimation of the user cost of capital.

Figure 1 illustrates the long-run trends in labour productivity based on those measures. These statistics reveal a picture of productivity growth in the public sector lagging well behind that of the so-called measured (mainly market) sector. Furthermore, data on the education and training sub-sector suggests it has experienced a long-run decline in productivity that appears to be ongoing. For over two decades the annual average rate of productivity growth in education and training has been -1.5%.

However, this data is not quality adjusted. Tipper (2013) argued that the decision not to make explicit adjustments for quality in the education and health measures reflected the absence of an internationally agreed set of standards and limitations of the data. There is, however, an implicit quality adjustment contained in the Statistics New Zealand approach. As the measures have been compiled at a disaggregated level, this allows for changes in the composition of output. Yet this method only captures that part of the total potential changes in quality that are associated with compositional shifts (Sharpe, Bradley and Messenger, 2007).

This discussion poses a fundamental question: is the apparent continuous decline in labour productivity in the

Table 1: Annual productivity growth rates of school sector (%)

	2002–08	2008–14	2002–14
Student numbers over staff FTEs	-1.6	-0.4	-1.0
Student numbers over real school revenue	-2.5	-0.9	-1.7
Student numbers over real spending on staff salaries	-4.1	0.2	-2.0
Student numbers adjusted for NCEA level 2 pass rates over staff FTEs	0.8	1.7	1.2
Student numbers adjusted for NCEA level 2 pass rates over real school revenue	-0.5	1.5	0.2
Income-weighted output over staff FTEs	0.6	-0.9	-0.2
Income-weighted output over real school revenue	-0.3	-1.4	-0.9

Source: Authors' calculations

education sector a consequence of the particular methodology and assumptions employed or is it a reflection of a real ongoing decline? This question becomes especially salient when national accounts measures are compared with cross-country studies (largely focusing on schools), many of which have suggested that the New Zealand education system is relatively efficient by international standards (e.g., Afonso and Aubyn, 2005; Sutherland et al., 2007; Schreyer, 2010). More recent work (Dutu and Sicari, 2016) has, however, suggested that the efficiency of New Zealand's school sector has deteriorated.

Quality-adjusted measures of school productivity

The presence or otherwise of quality adjustments can make a substantial difference to measured productivity and plays an important role in the interpretation of productivity data (Maimaiti and O'Mahony, 2011). For example, in the United Kingdom, where the Office for National Statistics quality adjusts education productivity data, between 1997 and 2011 measured output in this sector grew at an annual average rate of 2.7%. Of this, the estimated quality adjustment accounted for 90%, or an annual rate of growth of 2.5% (Caul, 2014, p.8).

However, while important, adjusting basic estimates of public sector productivity for quality is complex. As Schreyer and Lequiller (2007) noted, information beyond that contained in the national accounts will generally be needed to adjust for quality and, as quality is multidimensional, a single approach is unlikely to be adequate. To illustrate a broader suite of approaches to quality adjustment, Gemmell, Nolan and Scobie (2017b) first computed unadjusted or basic measures for labour productivity and multifactor productivity (MFP). A sample of their results for the 2002–14 period is reproduced in Table 1. These are the measures that are widely reported internationally. Both measures use total student places as the proxy for output of the school system; inputs for labour productivity are based on Ministry of Education data on the numbers of full-time equivalent (FTE) teaching staff (including principals, management, classroom teachers, resource teachers, guidance counsellors and therapists), and for MFP they are total school revenue (including both core Crown expenditure and non-government revenue).

Various adjustments to these basic productivity measures were then introduced. First, on the input side, clearly not all staff FTEs are the same: differences in age, qualifications, type of position and experience may be important. However, at the aggregate level no suitable data was available to make these adjustments. A simpler (less data-intensive) approach was thus taken: real (inflation-adjusted) expenditure on staff salaries was used as a proxy for quality. This was based on the supposition that variations in the hours of paid work and the composition of the labour force were reflected in salaries paid. However, as the Productivity Commission (2018) noted, this approach requires careful consideration as it can be sensitive to the ways in which wage rates are set in different sectors. On output measures, two adjustments were made based on student attainments: (1) drawing on PISA scores, and (2) drawing on the share of students leaving with NCEA level 2 (or equivalent).

A further adjustment was made to capture educational outcomes as distinct from outputs of the school system. Following international studies, such as Murray (2007) and O'Mahony and Stevens (2009), this was based on expected earnings by educational attainment level. This involved a two-step process: first, output was adjusted for the domestic attainment of students; the average real expected income for students based on this attainment was then estimated and multiplied by the number of students in each category. The expected real income was based on average weekly incomes from the New Zealand Income Survey at three NCEA attainment levels (1, 2 and 3 or their equivalent) and adjusted for unemployment rates for each group.

This work illustrated both the importance and the difficulty of quality adjusting sector-level productivity data. Policy decisions (e.g., regarding smaller class sizes) were reflected in the basic labour productivity measures. Further, when the measure of labour input was adjusted in an effort to capture quality changes (e.g., through using data on real salaries), this labour productivity performance also worsened. But there are caveats. These include questions over the use of salaries as a proxy for quality of inputs – particularly given the nature of public service labour markets (e.g., whether a change in salaries reflects quality/compositional changes or changes in government policy) – and the importance of missing inputs such as the previous performance of students (needed for measures of value added).

Nonetheless, a similar story emerged from measures that adjust outputs based on attainment in international assessments (such as New Zealand students' PISA scores), where performance has worsened. This reflects a decline in aggregate PISA points (an average annual decline of 0.1%), which itself reflected a larger fall in the average PISA score (an average annual decline of 0.3%). However, there were differences in measured attainment according to international and domestic assessments, with an increasing proportion of students leaving school with at least NCEA level 2 or equivalent. Consequently, (labour) productivity based on a measure that adjusted for domestic attainment (e.g., the proportion of students achieving NCEA level 2) increased between 2002 and 2014. This difference between international and domestic assessment points to the need to better understand what measures of attainment reflect the performance of New Zealand schools. Similar questions have been raised recently in the United Kingdom, where the Office for National Statistics had to revise its approach to quality adjusting education quantity when practices regarding students sitting exams changed.

Finally, measures adjusted for final outcomes (in this case the performance of school leavers in the labour market) also suggested falling productivity, but they can be subject to attribution problems. Indeed, given the improved domestic attainment noted above, the decline in these measures reflected changes in unemployment and real wage growth following the global financial crisis. With the use of sector-level data it would not be valid to conclude that changes in these measures were directly attributable to the performance of schools; they may, for example, also reflect differences in the economic context facing different cohorts of school leavers. To estimate the incremental value of school education on earnings, it would be necessary to use linked unit record data.

Table 2: Annual average productivity growth rates of tertiary sector teaching (2000-15)

	Basic	With wage-adjusted input	With completion-adjusted output	With earnings-adjusted output
Labour Productivity Growth Rates (%)				
Universities	-0.5	-1.4	0.9	1.1
ITPs	0.7	0.0	3.9	4.0
Wānanga	4.2	1.0	5.0	4.0
Total sector	0.2	-0.6	1.9	1.8
Multifactor Productivity Growth Rates (%)				
Universities	-0.3	n.a.	0.8	1.3
ITPs	0.7	n.a.	4.4	4.0
Wānanga	3.1	n.a.	7.2	2.9
Total sector	0.3	n.a.	3.3	1.0

Source: Authors' calculations

Quality-adjusted measures of tertiary productivity

Gemmell, Nolan and Scobie (2017a) also considered approaches to quality adjusting the productivity of tertiary providers. The approach taken was similar to that taken to school productivity, but, as some tertiary providers (particularly the university sector) can be seen as 'multi-product firms' – producing both teaching and research outputs – they also considered approaches to cost weighting different outputs into a single output index.

Tertiary teaching productivity

The teaching productivity growth rates in the tertiary sector were calculated for three sub-sectors: universities, institutes and polytechnics (ITPs), and wānanga. In 2015 the shares of student numbers in the three sub-sectors were 57%, 33% and 10% respectively. For ITPs and wānanga it was assumed that all staff FTEs and real expenditure could be allocated to teaching activities. For universities, academic staff were assumed to spend 60% of their time teaching (and the remainder researching), research staff were fully allocated to research outputs, and all other staff were allocated to the production of teaching outputs. Further, for universities the shares of total expenditure and salaries attributed to teaching were based on the share of total university expenditure which went to teaching (defined as total expenditure minus research expenditure).

As with the analysis of productivity growth in schools, some basic measures were first developed and a series of adjustments for quality were then considered. The results are presented in Table 2. The first column lists the estimates of basic productivity growth based on student numbers and teaching staff FTEs for labour productivity and on teaching expenditures for MFP. The overall growth of productivity was positive although very modest, dominated by negative teaching productivity rates for the university sector, which, as noted above, accounted for around 57% of the student numbers in the sector. High growth rates for wānanga (around 10% of the sector) are in part because they started from a low base of student numbers soon after inception.

The basic rates were then adjusted by proxies for quality and the adjusted estimates are in the next three columns in the table. As in the case of schools, and following York (2010), staff FTEs were weighted by inflation-adjusted salaries as a proxy for changes in the composition of teaching staff over time. Further, rather than raw student numbers, completion rates were used to provide a better measure of output. These completion rates were adjusted by NZQA credit weights for different types of qualifications to help account for possible changes in quality over time (e.g., students being directed to easier courses). Finally, outputs were adjusted in line with a human capital framework, in which education is viewed as an investment, with the pay-off taking the form of higher expected future earnings.

As the results in the table illustrate, productivity growth rates were lower for the adjustment based on salaries. This reflected the effect of a growth in salaries greater than growth in FTEs, which effectively raised the level of inputs relative to the basic case and consequently led to lower labour productivity growth rates. In contrast, both labour productivity and MFP were substantially higher in all sub-sectors once quality-adjusted measures based on completions and expected earnings were incorporated.[3]

The use of measures based on expected earnings merits further discussion. 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). Yet, of course, as Hanushek (2015) acknowledges, there are limitations to using expected earnings as a measure of the value of education. First, it can be influenced by selection bias, where students

Table 3: Annual average productivity growth rates in the university sector

	Teaching	Research	Overall
	Labour Productivity Growth Rates (%)		
	Credit and income weighted completions per teaching staff FTE	Citation weighted research output per PBRF adjusted research staff FTE	
2000-06	3.4	0.7	1.8
2006-15	0.4	6.0	4.0
2000-15	1.6	3.8	3.1
	Multifactor Productivity Growth Rates (%)		
	Credit and income weighted completions per $ teaching expenditure	Citation weighted research output per $ research expenditure	
2000-06	1.8	3.6	2.9
2006-15	-0.6	5.7	4.0
2000-15	0.4	4.8	3.6

Source: Authors' calculations

enrolling in additional education are self-selecting. Second, 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. Third, while any earnings premium is often attributed to education, some portion may well reflect innate ability, family background, health status, subsequent employer-based training, the performance of the economy, and so on.

University research productivity

An important output of the university sector is research, for which a basic measure is simply the count of research outputs (books, journal articles, conference papers, etc). To derive a quality-adjusted measure, Gemmell, Nolan and Scobie (2017a) weighted the number of publications by the average number of citations, on the grounds that more extensively cited works were likely to be of higher 'quality'. This is one of a number of possible approaches to weighting research output (see Gemmell, Nolan and Scobie, 2017a, p.19 for a fuller discussion). The citation data was drawn from the Web of Science and SCOPUS.

In relation to research inputs, the authors estimated the number of university research staff FTEs. Further, as there was no simple indicator of changes in quality of research staff, a quality adjustment of the labour input was based on the results of three Performance-Based Research Fund (PBRF) reviews (2003, 2006 and 2012). Key results are presented in Table 3. Labour productivity is calculated as the quality-adjusted research output over the quality-adjusted labour input, and MFP is based on the quality-adjusted research output over university expenditure on research. Since expenditure specifically on research is not available across universities, this has been estimated on a pro rata basis from universities' teaching- and research-related income. Estimates for research productivity and for teaching productivity were combined using cost weights. These weights reflected the cost shares of these outputs based on the share of total university expenditure accounted for by each activity.

A number of significant findings emerge from the results in Table 3. First, the rates of research productivity growth are generally substantially above national productivity growth rates in the market sector of the economy. This applies to both the labour and multifactor productivity indices. Second, there is an acceleration in both sets of growth rates after 2006. These research productivity results are therefore 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. Similar findings were reported by Smart (2009, 2009a, 2013), Margaritis and Smart (2011), Smart and Engler (2013) and Buckle and Creedy (2018).

Conclusions

This article has examined how quality-adjusted productivity indices for the 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. While we recognise that none of these fully captures relevant quality dimensions for educational inputs or outputs, we would argue that they provide additional useful information beyond the 'basic' productivity measures more commonly used.

In should be stressed that the results in this article identify *changes* in productivity; they do not address the issue of the absolute *levels* of educational 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. In addition, our results relate to only one dimension of the overall performance of the education sector. Performance has many dimensions, including contributions to the wider society, with productivity representing but one element – albeit an essential and often-neglected one.

The estimates here reinforce the finding of Statistics New Zealand (2017) and the OECD (Dutu and Sicari, 2016) that there has been a fall in school productivity in New Zealand since 2002. Interestingly, there was only one exception to this trend: productivity improved when the proportion of students leaving school with the equivalent of NCEA level 2 or higher was accounted for. The difference between this series and others points to the need to better understand what measures of attainment reflect the performance of New Zealand schools.

Further, when looking at tertiary sector productivity, a striking result is that most quality adjustments lead to estimates of substantially faster productivity growth in New Zealand tertiary education than the simple unadjusted measures reveal. These results are consistent with a marked improvement in the productivity of research within universities following the introduction of the PBRF (Buckle and Creedy, 2018) and an expansion in student numbers among some providers over the early part of this century.

More generally, the results in this article highlight both the importance and the difficulty of quality adjusting state sector productivity data. Results can be sensitive to the methodology and approaches employed and be influenced by factors largely outside managers' control, such as policy decisions to lower class sizes or increase teachers' pay. But these are not reasons for giving up on measuring the productivity of the New Zealand education sector. Indeed, as this article also shows, it is possible to develop reasonable measures of dimensions like quality with publicly available sector-level data. With more detailed data, better measures could be developed. The key is to ensure that any measures developed are treated as one (albeit essential) element of a broader framework for the assessment of the sector

1 For a discussion of issues regarding measuring health sector productivity, see a companion article by Patrick Nolan in this issue of *Policy Quarterly.*
2 For a discussion of measurement challenges in the measured sector, see Pells (2018) in this issue of *Policy Quarterly.*
3 It is possible that some of the growth in productivity may have arisen from so-called grade inflation over time. Gemmell, Nolan and Scobie (2017a) explore this issue and, based on overseas evidence, conclude that up to 0.5% might be attributable to grade inflation..

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