

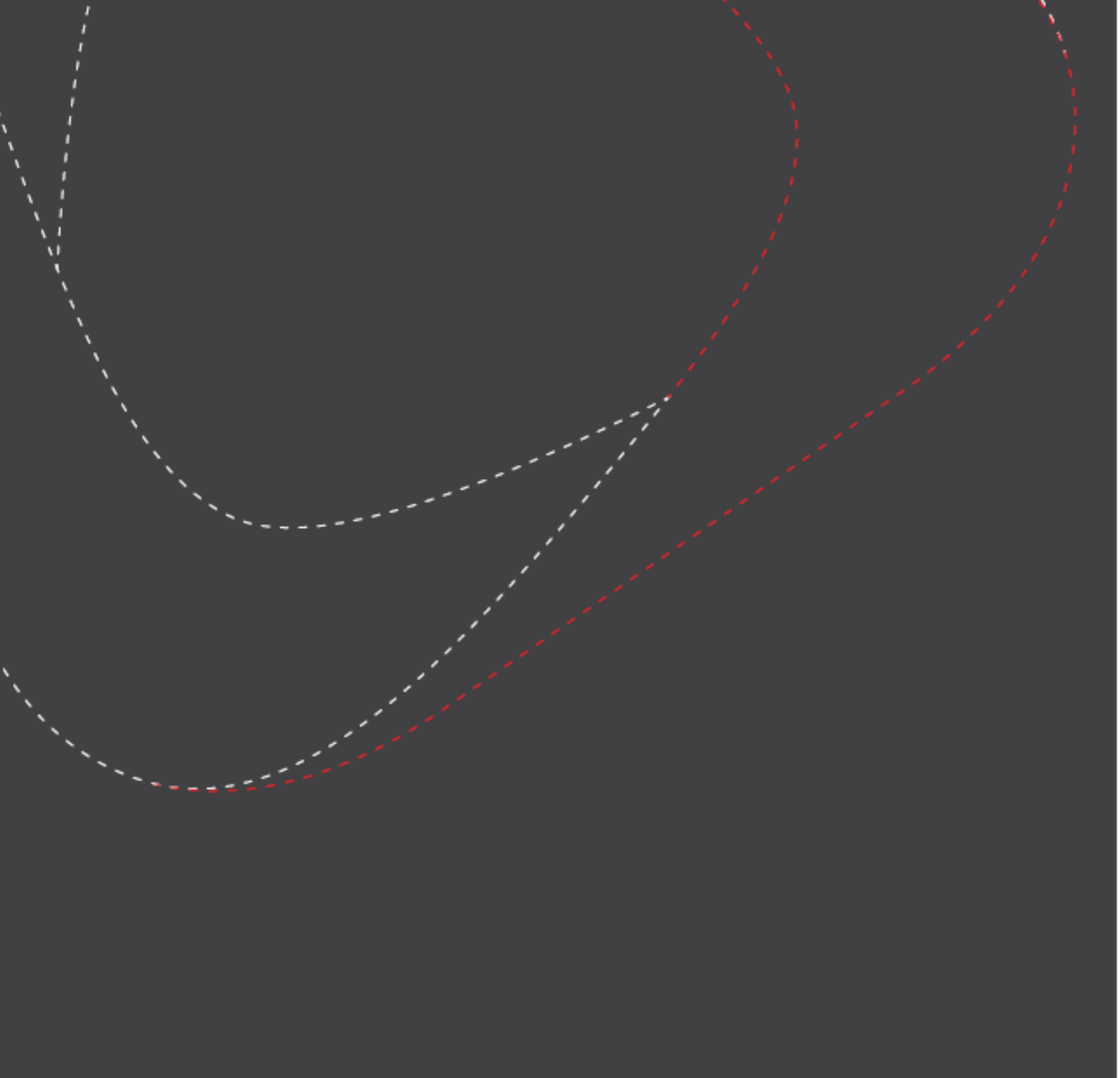


July 2019

STAFF RESEARCH PAPER

# Improving measures of school education output and productivity in Queensland

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## Summary

*This paper defines and measures output in Queensland's school education industry and explores approaches to capturing changes in the quality of education. It concludes with a discussion of how quality-adjusted measures of output matter for productivity analysis.*

### Key points

- In Queensland, governments spend over \$9 billion on school education each year, but, like other non-market sectors, little is known on its measured productivity.
- Productivity analysis measures how effectively inputs are being transformed into outputs. In the context of schools, both outputs (school enrolments) and inputs (numbers of staff and per-student funding) have increased over time.
- It is problematic to calculate productivity for non-market sector industries such as education. This was highlighted in the Commission's *2016–17 Queensland Productivity Update*.
- The key difficulty in measuring output and productivity is to accurately measure output volume in a way that also internalises the quality of education goods and services. Prices cannot be used to calculate output, like in the market sector, as goods and services are not sold through a market but are often allocated through an administrative process.
- This paper proposes that, for schooling, data on the proportion of students achieving above minimum standards on National Assessment Program—Literacy and Numeracy (NAPLAN) testing and the proportion of students receiving a senior secondary certificate can be used to adjust enrolment data for quality.
- Once adjusted for quality, output has grown by 23.24 per cent in Queensland from 2009 to 2016. This compares to raw enrolment growth of 12.02 per cent. Quality-adjusting output therefore has a material impact on the figures produced.
- These adjusted figures have a significant impact on productivity estimates, improving the outlook for Queensland. After adjustment, figures for Queensland's productivity growth average at 0.138 per cent per annum compared to –1.223 per cent without the adjustment. While close to zero, this figure compares favourably with the Australian adjusted average of –0.963 per cent per annum.
- Strong growth in NAPLAN achievement in Queensland has likely driven this result. As these output gains are unlikely to remain consistently high, the key issue is to better understand how productivity is working in terms of inputs.
- The measure for education output developed in this paper can be used to better inform policy making and public discussion on schooling.
- Further, the results of this paper show that adjusting output for quality is important when analysing productivity in non-market sectors. It is hoped that this paper can encourage further discussion on this topic and extend to other non-market industries such as health.

# 1. Introduction

Education is a significant expenditure item for governments, with total yearly expenses of over \$9 billion in Queensland<sup>1</sup>, but little is known about its productivity. While the Australian Bureau of Statistics (ABS) regularly publishes estimates of multifactor productivity (MFP) at the national, state and industry level for the market sector<sup>2</sup>, industries in the non-market sector, such as education, are not included in these calculations. The Commission's *Queensland Productivity Update 2016–17* highlighted the issues related to constructing estimates for productivity in non-market sector industries, particularly in adjusting output for quality.

*Quality* refers to the standard of a good or service, often as compared to similar goods or services. In terms of schooling, the literature often relies on test scores as either a measure of output or a measure of quality (Hanushek 1979). This measure is sometimes controversial, as tests may not accurately measure overall achievement for a student. Test results may also be determined by a student's innate ability rather than any school effects.<sup>3</sup> However, at the aggregated country-wide level, average test scores have been found to be strongly correlated with measures such as national GDP and individual economic wellbeing (Barro 1991; eds Peterson & West 2003).

This paper follows approaches developed in New Zealand and the United Kingdom for using measures of quality, such as test scores, to improve estimates for output in the school education sector. In Australia, scores from the National Assessment Program—Literacy and Numeracy (NAPLAN), which assesses students in Years 3, 5, 7, and 9 on various skills each year, can be used as a measure for quality<sup>4</sup>, alongside data on the number of students leaving school with a senior secondary certificate. NAPLAN testing is related to the achievement of particular learning goals, such as 'being able to add simple numbers'; thus, achieving above minimum standards represents a 'real' learning outcome achievement. Australian test achievement therefore provides a measure of the value of a school year.

Students in Queensland have traditionally lagged behind on NAPLAN performance compared with those in other states of Australia (Miller & Voon 2014). Yet, in 2018, the Grattan Institute highlighted fast growth in Queenslanders' educational achievement (Goss & Sonneman 2018). There is little understanding as to what may be driving this improvement; therefore, further information on the productivity of this sector is useful for Queensland in particular. This paper defines and measures output in Queensland's school education industry and explores approaches to capturing changes in quality. It concludes with a discussion of how quality-adjusted measures of output matter for productivity analysis.

The goal of accurately measuring school education output has broad implications. A credible measure for output helps policy makers to deliver value for taxpayer money and improve sector performance. As the government is not only a service provider of education, but also a regulator and policy maker, it is valuable for the government to develop a better understanding of what is driving efficiency and inefficiency in schools in order to improve student outcomes. Further, the educational attainment of the workforce is a driver of productivity at the economy-wide level.<sup>5</sup>

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<sup>1</sup> Sources: ACARA data, Commission calculations. This figure includes recurrent funding and capital expenditure from both the Australian government and state government in all schools (government and non-government) operating in Queensland in 2016.

<sup>2</sup> The market sector covers industries that buy and sell goods and services, such as retail trade, mining, and manufacturing. The non-market sector encompasses the health care and social services, education and training, and public administration and safety industries (ANZSIC Divisions O, P and Q).

<sup>3</sup> The alternative theoretical approach to schooling is the 'screening' model, where instead of producing human capital, schools are simply screening for the most able individuals and identifying them for the labour market. This theory has received much attention by Caplan in *The Case Against Education* (2018). Studies of productivity analysis of schools therefore rely on accepting the human capital formation theory of educational production.

<sup>4</sup> The Australian Productivity Commission has also emphasised the use of test scores as a preferred outcome measure for schooling (Leigh & Ryan 2008).

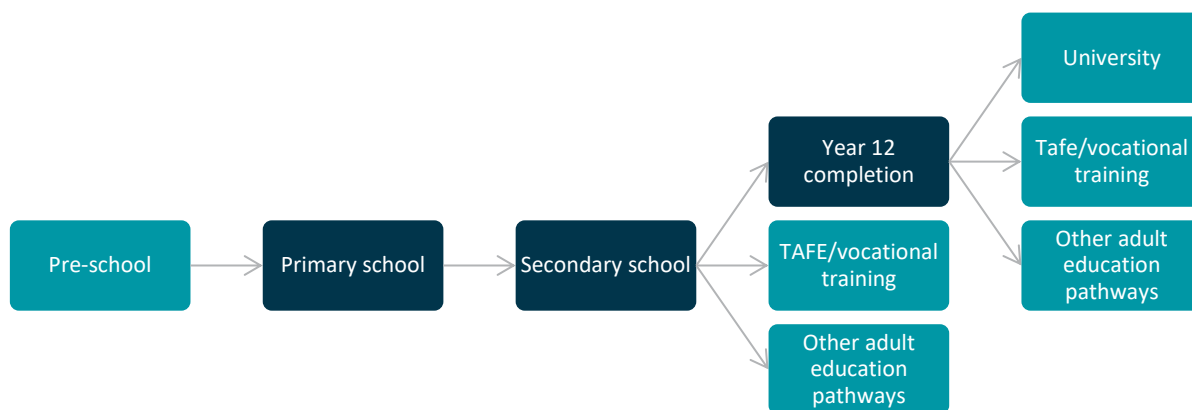
<sup>5</sup> See Barro 1991; Hanushek 2013; Hanushek & Woessman 2008.

The methodological approaches explored in this paper can also be extended to other non-market sectors such as health care.

## 1.1 Scope of research

For the purposes of this paper, the school education industry is considered to cover primary school, secondary school, and Year 12 (Figure 1.1). These levels of schooling are categorised by the Australian and New Zealand Standard Industrial Classification<sup>6</sup> (ANZSIC) in Division P Education and Training through the following codes: 8021 Primary Education, 8022 Secondary Education, and 8023 Combined Primary and Secondary Education. Pre-schooling or further education are not considered in this paper but are valuable areas for further research.<sup>7</sup>

**Figure 1.1 Stages of schooling considered by this paper**



<sup>6</sup> See ABS (2013) for the ANZSIC.

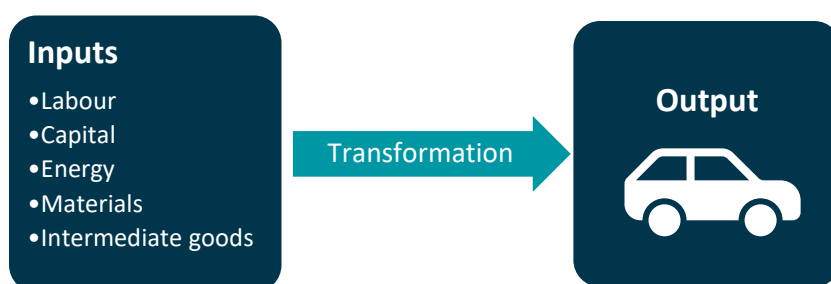
<sup>7</sup> See Moore et al. (2019) for a recent article on productivity in the higher education sector.

## 2. Theory and concepts

### 2.1 The theory of production functions

The production of goods and services can be modelled using a 'production function'—a mathematical abstraction of the process by which inputs are converted into outputs (Box 2.1). This provides a theoretical framework within which to analyse productivity. Consider a typical production process at the level of a firm. For example, a car factory takes a number of inputs—labour (workers), capital (machines), raw materials, energy, and intermediate goods—and through some production process transforms these inputs into its chosen output, 'cars' (Figure 2.1).

**Figure 2.1 A production process**



*Productivity* refers to how efficiently the production process transforms inputs into outputs, expressed in terms of the amount of output produced per unit of input consumed:

$$\text{Multifactor productivity} = \frac{\text{Total output}}{\text{Total input}}$$

*Growth* in productivity means either that more output is produced for the same level of inputs, or similarly that fewer inputs can be used to produce the same level of output.



### Box 2.1 Growth accounting

Detail about the growth accounting framework and its underlying economic theory is useful for linking together the concepts of input, output and productivity.

A production process, such as the car factory producing cars conceptualised in Figure 2.1, gives the following production function:

$$Y_t = f(K_t, L_t),$$

where inputs have been simplified to the quantity of labour,  $L$ , and quantity of capital,  $K$ , and  $Y$  is the quantity of output in time-period  $t$ . Some production process,  $f$ , combines inputs into output. Typically,  $f$  is a Cobb-Douglas production function with constant returns to scale (doubling inputs doubles output):

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha},$$

where  $\alpha$  is the factor share of each input and  $A$  is total factor productivity. The growth equation can be derived by taking the logarithm of both sides and differentiating with respect to time:

$$\dot{Y} = \alpha \dot{K} + (1 - \alpha) \dot{L} + \dot{A},$$

where dots denote growth in the designated variable. Output growth is the sum of the growth in inputs (weighted by their respective factor shares) plus a residual,  $\dot{A}$ , that gives MFP growth. Rearranging:

$$\dot{A} = \dot{Y} - \alpha \dot{K} + (1 - \alpha) \dot{L}$$

As MFP growth is a residual (all other parameters can be measured), estimated MFP growth not only includes technological progress but also any random or systematic errors in measuring inputs. This illustrates the importance of accurately measuring both inputs and outputs to construct productivity measures.

*Note: Some of these sources formulate their equations in terms of growth rates by dividing through by the level of each variable. The Cobb-Douglas function is widely used to describe the relationship between inputs and output as it has several sensible properties—it has decreasing marginal returns for each factor and it has been shown to be consistent with the production function for the economy as a whole (Cobb & Douglas 1928). The basic function is  $Y = AK^\alpha L^\beta$ , with all parameters defined as above. For constant returns to scale, another restriction is added that  $\alpha + \beta = 1$ , that is,  $\beta = 1 - \alpha$ . This restriction ensures the function has the property that if inputs are doubled, so too is output. Different restrictions on the exponents could be made to enforce either diminishing or increasing returns to scale.*

Sources: ABS 2016; Domar 1961; Gordon et al. 2015; OECD 2001; QPC 2016; Solow 1957.

## 2.2 Educational production functions

Consider schooling as a production process, which produces the output of 'educated citizens'.<sup>8</sup> Inputs—such as teachers, books, and computers—are transformed into the output education. Productivity of the education sector describes how efficiently these inputs are transformed into educated students. For example, given the same inputs, are some schools able to generate a higher level of output than others? This concept of the education production function applies the theory of economic productivity to the education sector.

<sup>8</sup> This theory has its roots in the 1966 'Coleman Report', *Equality of Educational Opportunity*, from the United States, and has been formalised by Hanushek (1979, 2008). Hanushek (1979) emphasises that the conceptual and statistical problems involved in the empirical analysis of production functions is of particular importance to the education sector, where the results are used to prescribe policy, unlike the more esoteric applications in market sectors.

## Defining outputs

The most often employed measure of output is 'attainment', measured at the state-aggregate level by the total number of enrolments. Current ABS estimates (unpublished) for school education output are based on annual full-time equivalent enrolments weighted by the cost of service provision (PC 2017). The total number of enrolments therefore gives the total quantity of education produced in a given period of study.

## Defining inputs

There are many inputs to the education production process, in terms of labour (teachers, teachers' aides, administration staff) and capital (computers, books, buildings). These can be neatly summarised by total expenditure or total expenditure per student. Some studies also include student-teacher ratios, teacher quality (see Box 2.2), and other school or student characteristics, as many of these intangible inputs are strong predictors for educational improvement. For example, each individual student has different cognitive skills, levels of motivation and comes from a different background, which will affect their achievement.<sup>9</sup> However, the difficulties involved with measuring inputs are outside the scope of this paper. Further research into the measurement of intangible inputs would be useful in the education sector.

### Box 2.2 Quality-adjusted labour inputs

The common approach for producing labour productivity statistics is to assume homogeneous labour, which means that one hour of work is equal across all workers and industries. Alternatively, one can quality-adjust labour inputs (the QALI method) by aggregating workers by type and weighting them based on wage share to reflect differences in human capital accumulation. The two improvements to human capital accounted for by the method are education and work experience (Reilly et al. 2005). This reflects the fact that some workers may be able to produce more output per hour than others.

The ABS only uses the QALI method to compile estimates in the market sector. The school education sector would benefit from an improved study of labour inputs. Some claim that the sector suffers from 'Baumol's cost disease'—a term that describes the situation where labour-intensive organisations tend to cost more over time without becoming more productive. Hill and Roza (2010) described school sectors as hiring more teaching and non-teaching staff, while their primary 'production technology' remained the same. Schooling is highly labour-intensive; thus, an improved perspective on labour productivity in the schooling sector would be valuable. That kind of study would also feed into discussions of teacher quality, which are popular both with policy makers and in the economic literature.



## 2.3 Constructing an index for output

### Market sector methods

The ABS framework for calculating output and productivity in market sectors is outlined in a guide to the Australian System of National Accounts (ABS 2016), which aligns with best practice as set out by the OECD (2001). These calculations rely on production function theory (Box 2.1), combined with index number methods. Index numbers measure rates of change in prices and quantities compared to a base period value (often set as 100).<sup>10</sup>

<sup>9</sup> Miller and Voon (2012) found the Index of Community Socio-Educational Advantage (a measure of average student background in a school) to be the main determinant of NAPLAN scores.

<sup>10</sup> See Diewert and Nakamura (2003) for concepts.

Price indexes allow comparisons over time for goods or services but can also allow comparisons between geographical locations (ABS 2011).

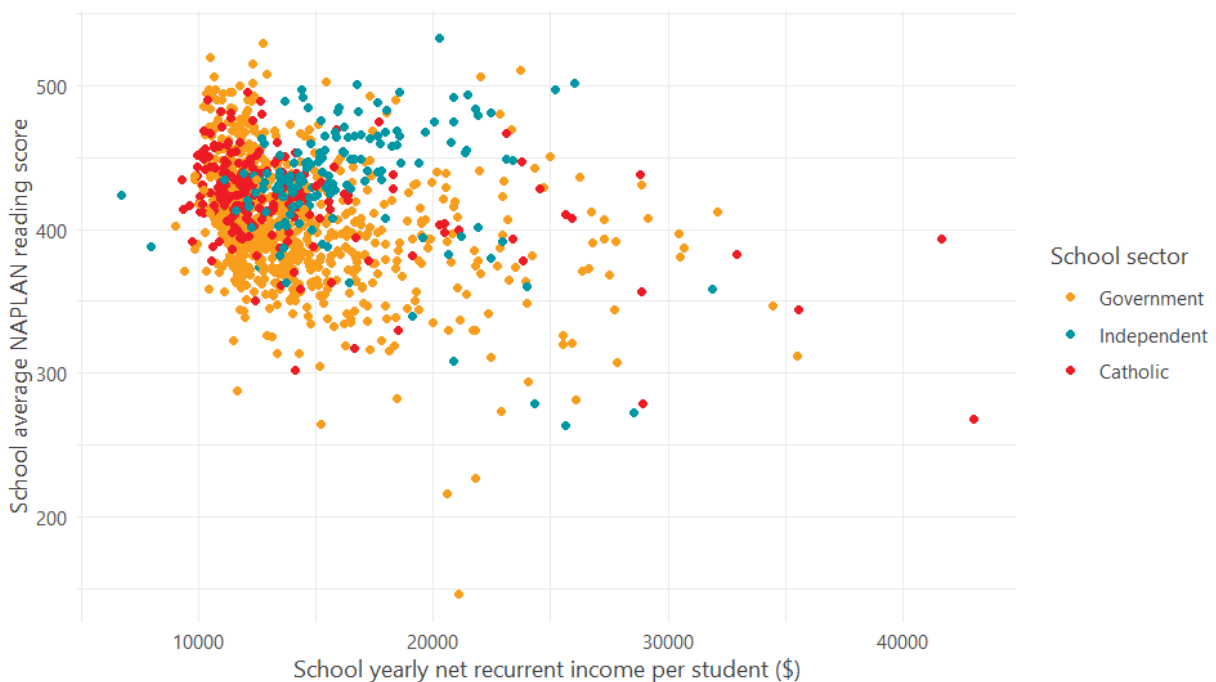
Firms in the market sector typically compete with other firms producing a similar good or service and are intent on maximising their profits. Prices are set by the market and contain information on the value consumers place on these goods and services.<sup>11</sup> This is useful for two reasons. First, it ensures that people value the good or service that is being purchased. Second, it makes different types of goods comparable to each other. The existence of prices means that the value of each good is intrinsically built into measures of output.

For each industry, output volume is measured either in gross or real value-added terms. Gross output refers to the value of all goods and services produced in the period. Value-added output subtracts the value of intermediate inputs such as energy and materials (but not primary inputs such as labour) from the value of output. This is then deflated by a price index (ABS 2016), removing the influence of price changes.

### Current non-market sector industry approaches

Market sector approaches cannot be applied to non-market sector industries as outputs are not sold in a market but are allocated through an administrative process. For example, government schooling is provided to the consumer for free and non-government schooling is provided at subsidised prices. As a result, prices cannot be used to aggregate over different kinds of goods or account for changes in quality, as they are not reflective of economic value. The price paid by a parent for their child to attend school does not equal the value they place on it, or even the quality of the education the child receives. Higher prices do not necessarily seem to be associated with higher quality (Figure 2.2), as measured by NAPLAN scores.

**Figure 2.2 School income per student and NAPLAN performance for Year 3 reading in Queensland**



Note: Similar patterns exist across other year levels and subjects.  
Source: ACARA data.

<sup>11</sup> This theory has limitations even for the market sector, not least in terms of uncertainty regarding which production processes are 'best'.

The key difficulty in measuring output and productivity is to find some other way to accurately measure output volume that internalises the quality of goods and services.<sup>12</sup>

Various approaches have been developed within Australia and internationally to estimate non-market sector output. One approach is to calculate output growth using input costs instead, referred to as an 'input=output' approach. To estimate the value of output, the costs of inputs are summed together. Since MFP is defined as the ratio of inputs to outputs, here set equal, these markets appear to have zero productivity growth.

A more popular approach is the 'direct volume' measure approach, which was recommended by the United Nations' System of National Accounts (1993).<sup>13</sup> This approach is procedurally similar to market methods, aggregating the counted volume of goods using weights given by their relative prices (PC 2017).<sup>14</sup> Following a UK review on measuring government output and productivity known as the Atkinson Review (2005), the government of the United Kingdom recommended measuring output as the number of full-time equivalent students, cost-weighted by their school type (primary or secondary). When the ABS shifted to use this kind of measure for education, output increased modestly from 1.5 per cent per annum to 1.9 per cent per annum (ABS 2001; QPC 2018). However, these ABS estimates for output are not true 'direct volume measures' as they use input data in their calculation to derive cost shares.

## Quality-adjusting output

None of the measures described above incorporate any measure of quality. Enrolments may not accurately measure output, as their quality may change over time or across regions. For example, a year of schooling in Queensland may not be equivalent to a year of schooling in New South Wales. Further, output as defined by enrolments is constrained by compulsory enrolment requirements, so incorporating quality is crucial for understanding meaningful changes to output in this industry.

Evidence from the United Kingdom (ONS 2015, 2017) and New Zealand (Gemmell et al. 2017) suggests that productivity measures in the education sector are significantly biased without adjusting output estimates for changes in quality. The key issues for this paper to address in measuring non-market sector output are outlined in the following box.

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<sup>12</sup> Note that better accounting for quality change is a valid issue to address even for market sector industries. The problems of the 'new good' (for example, the invention of the mobile phone in the telecommunications industry) and 'quality change' (for example, improvements in the fuel efficiency of a car) are noted by Diewert (1992) as creating severe problems for the measurement of productivity even in a simple one good 'ideal scenario' case.

<sup>13</sup> The input=output method is still often used in the public administration and safety industry, where quantity of output is harder to measure than that of the health care and education industries.

<sup>14</sup> In the non-market sector, goods or services are weighted either by the relative expenditure on inputs or by using prices from private sector provision of similar goods or services as a proxy.

## Key issues when measuring non-market sector output

- Defining and measuring output
  - Intangible goods like 'education' are difficult to measure directly but quantity can be proxied by the number of student enrolments.
- Adjusting chosen measures of output for quality
  - Measures of outcome can be used as a quality adjustment—for example, adjusting senior secondary enrolments by the proportion of students who receive a senior secondary certificate, or total enrolments by the proportion of students meeting minimum standards on national testing.
  - Different levels (primary, secondary) and sectors (government, Catholic, independent) of schooling can be treated as different services.
- Understanding how quantity and quality interact for output measures in a specific industry
  - Changes in school output at present appear to be driven purely by population growth due to its construction as 'number of enrolments'.
- Developing an awareness of how accurate measurement of output feeds into accurate estimates of productivity.

## 3. Policy background

### 3.1 Schooling in Queensland

Schools in Queensland provide primary schooling for seven years and secondary schooling for the rest of compulsory schooling to Year 10. At this point, some students may decide to participate in an apprenticeship or traineeship. Secondary schools also teach Years 11 and 12 for those wishing to continue their education in formal schooling. Students who qualify for an overall position (OP) at the end of Year 12 can then apply to attend university to continue their studies.

#### Box 3.1 The schooling system in Queensland

Schools in Queensland are operated by both the government and non-government sectors. Over 1,300 state schools are publicly funded and run by the Department of Education. The cost of schooling is covered by the state, but fees may be charged for specific goods and services. All state schools are co-educational, with the student body usually made up of students living in the local area.

There are two non-governmental school systems in Queensland—the Catholic sector and the independent sector. Catholic schools provide a Catholic-based education and are the largest group of non-government schools. Independent schools provide other kinds of religious education or different curriculums, such as Steiner, and have their own governing boards responsible for their operation. While these schools are not run by the government, they still receive funding from both the Queensland and Australian governments. In addition, these schools may charge fees that vary significantly.

Students in state, Catholic, and independent schools in Queensland face the same National Assessment Program and OP placement systems, so these outcome measures are collected consistently across all schools.

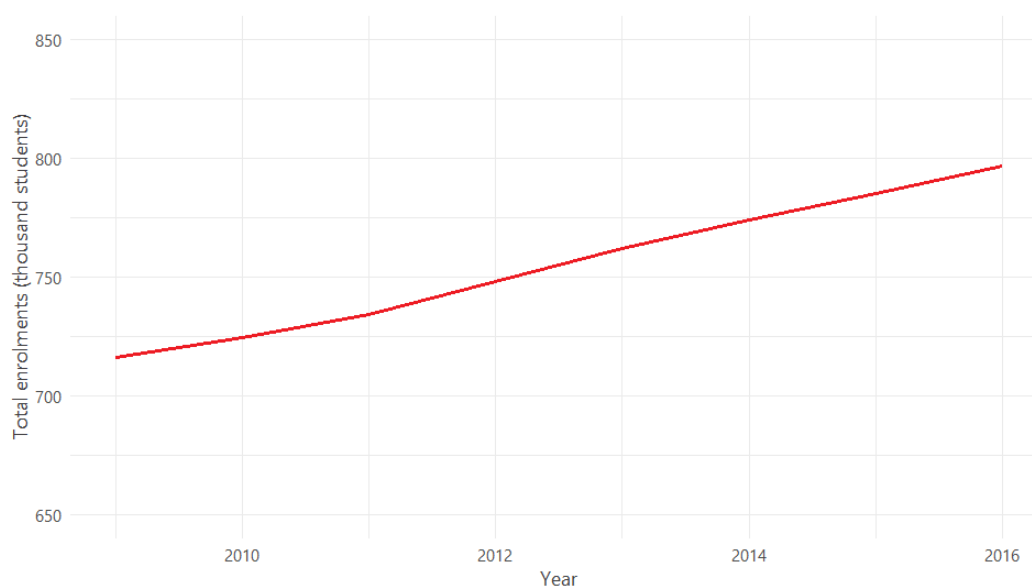
### 3.2 Recent trends in Queensland

To gain insight into recent trends in the Queensland schooling sector, changes over time in input and output measures—such as enrolments, revenue, and teaching staff—have been examined. Changes in these variables can provide a view as to how output and productivity may be changing over time. This descriptive approach to analysing productivity trends was implemented by Triplett and Bosworth in *Productivity in the U.S. Services Sector* (2004) and was also explored by Hanushek and Ettema (2017).

#### Enrolments

Enrolments in Queensland schools have trended upwards during 2009–2016 at a smooth rate (Figure 3.1), likely driven by population growth, given that schooling is compulsory. The number of total enrolments represents the baseline measure for education output.

**Figure 3.1 Total school enrolments in Queensland, 2009–2016**



Source: ACARA data; aligns with ABS Schools, Australia, 2018 cat. 4221.0, Table 42b, Sum of Full-time Student count.<sup>15</sup>

## School revenues

Yearly school revenue is a simple measure for inputs into education. The value refers to the recurrent income received by a school in a calendar year from the Australian Government, the state government, parent fees, and other sources of private income. It can be thought of as a proxy for the yearly operating expenses of running a school, as it is equivalent to the funding they receive in each year to operate.

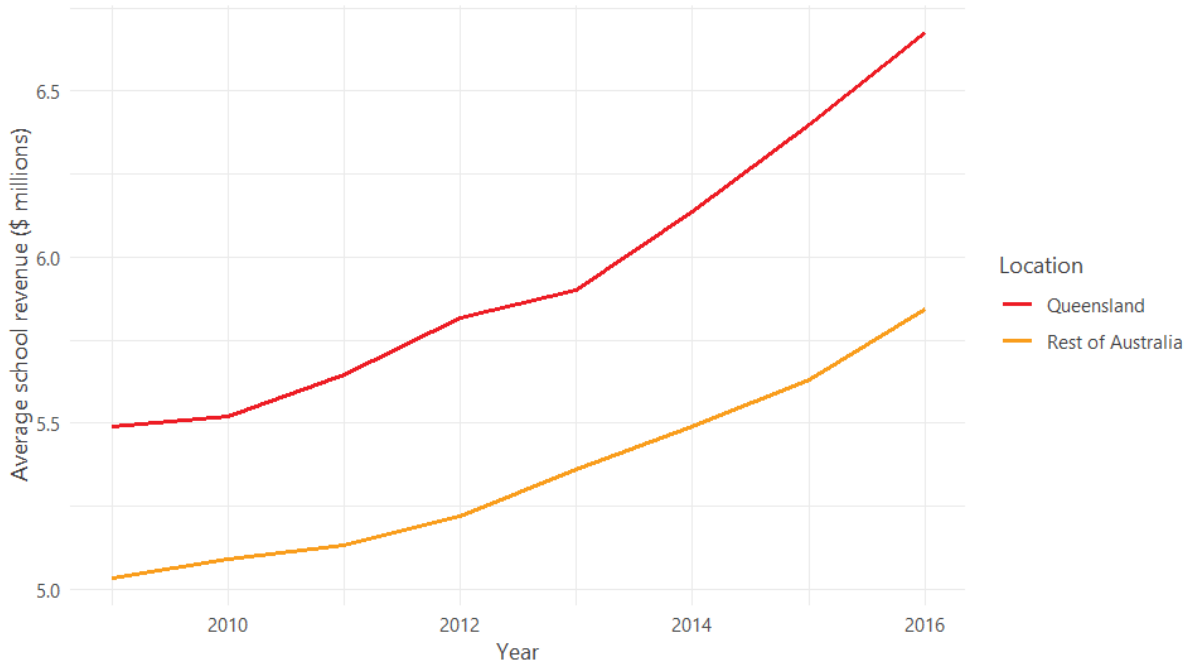
The recurrent income figures do not include income or deductions related to capital expenditure, as the actual expenditure may be tied to another year—for example by being allocated to future projects. Further, capital expenditure is reported separately from funding sourced for recurrent purposes. This data may not be related to actual capital stock, as it is reported as yearly flows. The accounting treatment of depreciation is also unlikely to reflect the actual use of capital in annual production<sup>16</sup>, and thus provides little insight on the use of capital in schools.

Average school revenues have been increasing rapidly over the past decade (Figure 3.2), even once inflation has been taken into account. This would be expected, due to rises in enrolments over time. However, per-student spending has also been increasing (Figure 3.3). This means that growth in school funding is not only due to increased enrolments, but also to higher costs to educate a single student. These increased expenses may be the result of rising costs for educating students and additional funding policies. Keeping these factors in mind, the data implies that school productivity may be decreasing, as per-student funding (funding divided by the number of students) is the inverse of productivity.

<sup>15</sup> It must be noted that there are slight differences between the values reported by the ABS and those reported by ACARA. This is due to matching enrolments to both outcome measures and year level (ungraded enrolments cannot be categorised for the purposes of this paper). Schools with this data missing may be omitted from this study; however, this is only a small proportion of the data and the overall growth rates align with those reported by the ABS.

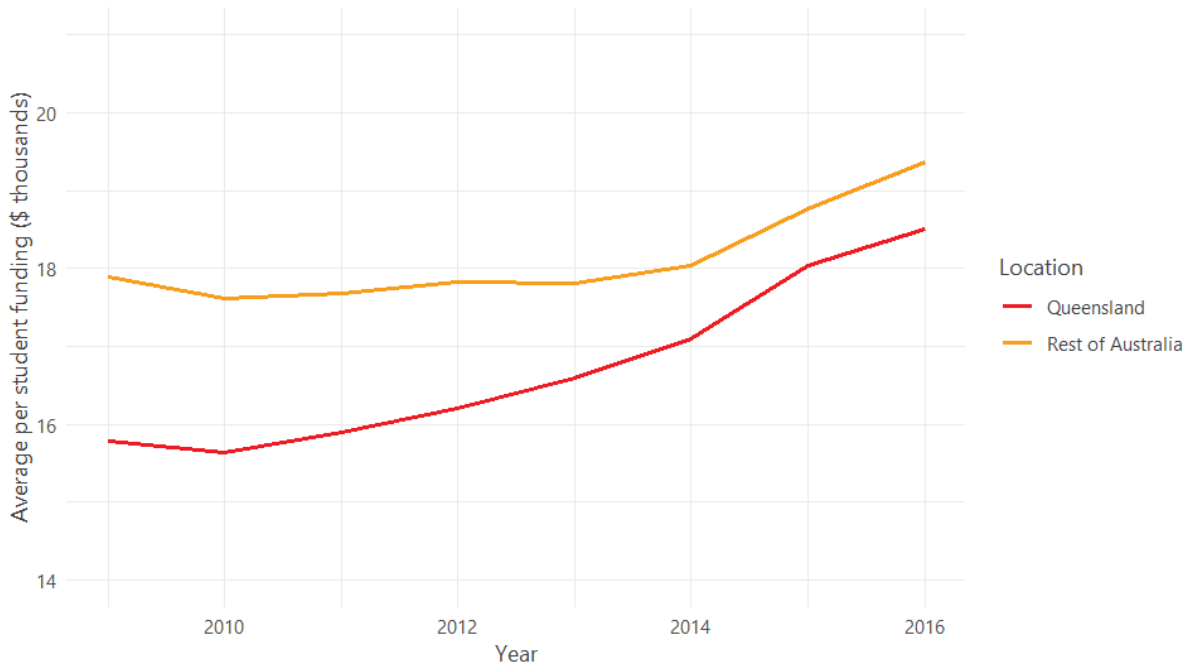
<sup>16</sup> Kim and Moore (1988) found that estimated economic depreciation (a function of the utilisation rate and maintenance) is about half of that used for accounting depreciation.

**Figure 3.2 Average school revenue, Queensland and the rest of Australia**



Source: ACARA data. GGFCE deflator (base period June 2017) from ABS cat. no. 5206.0, table 36.

**Figure 3.3 Average per-student funding, Queensland and the rest of Australia**

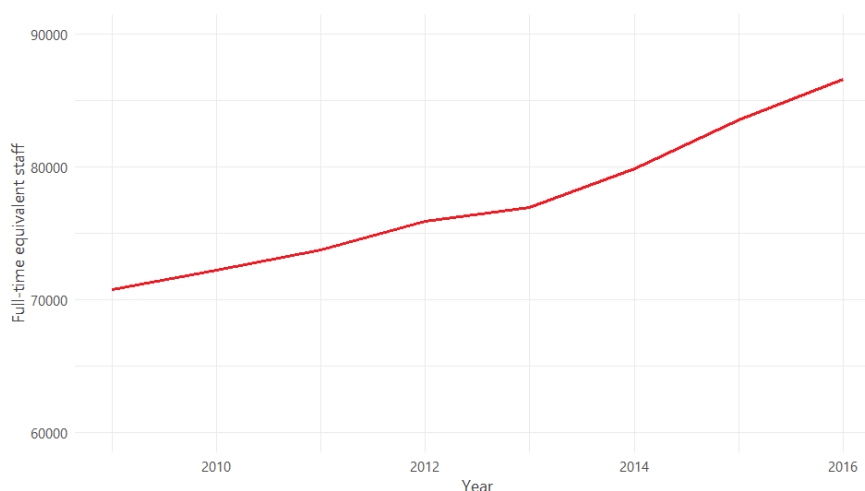


Source: ACARA data; GGFCE deflator (base period June 2017) from ABS cat. no. 5206.0, table 36.



Increases in per-student spending may be explained by increased expenditure on staff. Over 15,000 extra full-time equivalent staff<sup>17</sup> have been hired in Queensland since 2009 (Figure 3.4).

**Figure 3.4 Full-time equivalent school staff in Queensland**



Source: ABS Schools, Australia, 2018 cat. 4221.0, Table 51a.

## National testing

Rises in per-student expenditure indicate that productivity may be decreasing over time. However, this measure does not take quality into account. If NAPLAN test scores are used as a measure of quality, productivity may in fact be stagnant or increasing once quality of education is considered. Students in Queensland have shown rapid improvement in NAPLAN test scores since its introduction (Goss & Sonneman 2018). For example, Year 3 scores for reading and numeracy have risen quickly to just below the Australian average since 2008 (Figure 3.5 and Figure 3.6). Performance in Queensland has improved in all year levels and all subject areas since NAPLAN testing began, although growth is more stable in the later year levels.

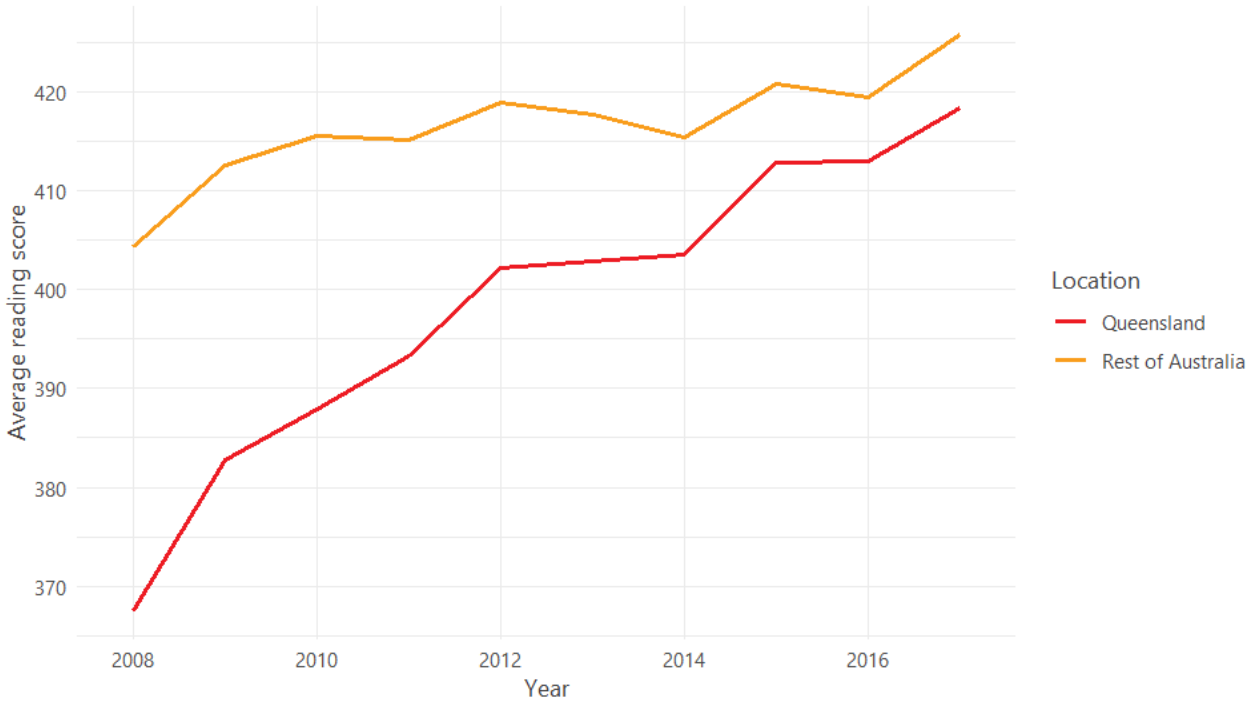
### Box 3.2 The introduction of Prep in Queensland

Prep, which is a year of schooling before Year 1, became compulsory from the 2017 school year. It was originally introduced in 2007, with 98 per cent of children attending by 2015 (ABC News Online 2016). Many believe that it was the introduction of this Prep year that has supported Queensland’s significant improvement in NAPLAN testing.

Note that compulsory Prep did not directly change the age at which children enter Year 1, with most commencing Prep aged 5 and thus still entering Year 1 at age 6. It must be noted, however, that the change also coincided with a six-month shift to the school starting age (from 5 years by 31 December to 5 years by 30 June in the year students enrol). Students in Queensland are now slightly older by Year 3 and have had one extra year of schooling. This may be one of the factors causing NAPLAN scores to increase over the period studied, particularly for students in Year 3 and Year 5 who have benefited from this policy change. In 2008, the average age for a Year 3 student in Queensland was 8 years and 1 month, with 2 years and 4 months of schooling. By 2012, this had increased to an average age of 8 years and 5 months with 3 years and 4 months of schooling. Similar increases are exhibited by Year 5 students.

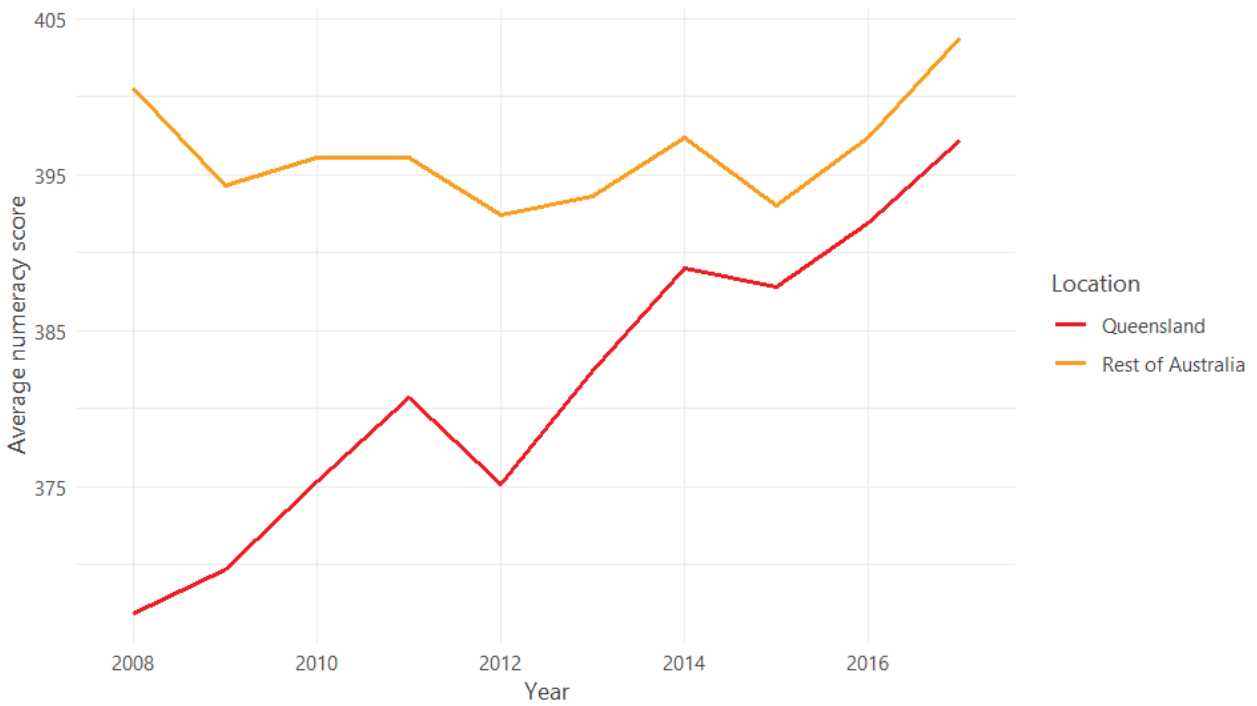
<sup>17</sup> This follows the construction described in Hanushek and Ettema (2017), which includes all staff of a school, not only teaching staff.

Figure 3.5 Average Year 3 reading scores, Queensland and the rest of Australia



Source: ACARA data.

Figure 3.6 Average Year 3 numeracy scores, Queensland and the rest of Australia



Source: ACARA data.

### Box 3.3 NAPLAN testing

The National Assessment Program—Literacy and Numeracy (NAPLAN) was implemented by the Australian Government in 2008. Under the program, students across Australia in Years 3, 5, 7, and 9 are required to sit a suite of tests each year. The four domains tested are reading, writing, language conventions (spelling, grammar and punctuation), and numeracy. The data collected from NAPLAN is used in various ways:

- Comparing an individual student’s performance against national benchmarks, providing information to parents on their child’s progress.
- Helping teachers and schools to set goals by identifying high-achieving students, as well as those that need more support.
- Developing a nationally-comparable data set on literacy and numeracy standards to support school improvement.

The data used in this paper is from the Australian Curriculum, Assessment and Reporting Authority (ACARA), the authority tasked with collecting, analysing, and reporting data on schools and the outcomes of schooling. The data is made available through ACARA’s Data Access Program. The data-sets used in this paper are:

- NAPLAN results data
- school attendance data
- enrolments by year level data
- finance data
- senior secondary outcomes data.

Each item used is outlined in Appendix A.

## Senior secondary graduations

An alternative approach to assessing the quality of schooling is to focus on Year 12 completion, as this is the point at which students 'leave' the system. In Queensland, students complete senior secondary schooling and may receive a senior secondary certificate—the Queensland Certificate of Education (QCE) (Figure 3.7).<sup>18</sup>

The number of students in Queensland choosing to complete Year 12 has increased by approximately 10,000 since 2008, indicating that the output of the education sector has grown in volume. Further, the number of students graduating with a senior secondary certificate has been increasing at a faster rate. In 2008, approximately 9,500 fewer students received a senior secondary certificate than those who completed Year 12, but this gap had closed to only 3,000 in 2016. This may indicate that not only output is increasing, but also the quality of output.

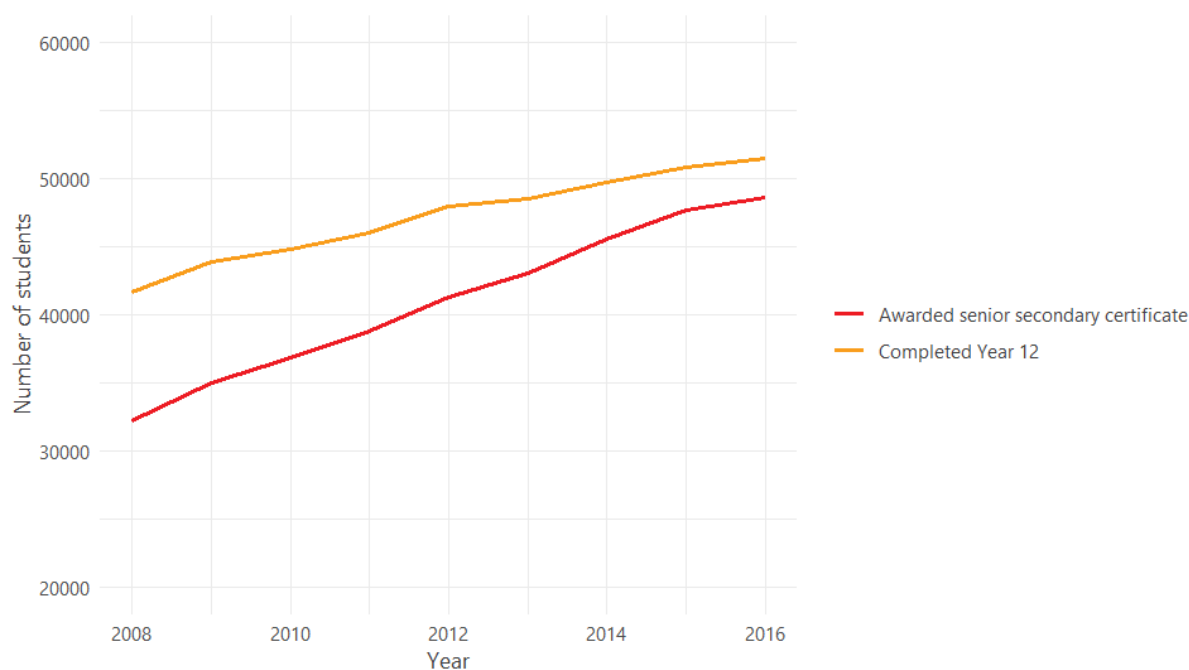
It appears that performance is also improving within the cohort of students graduating each year. Within the cohort of students receiving a senior secondary certificate, a number are ranked for university entrance receiving an OP. OPs are calculated to have 'basic year-to-year comparability' (QCAA 2019), which means that there are variations in the proportion of students that achieve a position in each OP band between years. In 2018, only 7

<sup>18</sup> Note that, in Queensland, students may also receive a Queensland Certificate of Individual Achievement (QCIA). For the purposes of this paper, when referring to senior secondary certification this should be read as meaning receipt of the Queensland Certificate of Education (QCE), as this is the qualification that can be compared with similar qualifications in other jurisdictions.

students received the lowest OP of 24 (QCAA 2019). This compares to 122 students achieving an OP of 24 and 27 students achieving an OP of 25 in 2010 (QCAA 2011).

Over time, fewer students appear to be receiving the lowest OP bands. That said, further research would be required to confirm this finding and analyse the reasons underlying this change. Detailed study of senior secondary results is outside the scope of this paper, but it is important to note that, assuming the difficulty of senior secondary certification has not decreased over time, the improvement in students receiving an OP appears to be not just a change in quantity but also a change in quality.

**Figure 3.7 Senior secondary completion, Queensland**

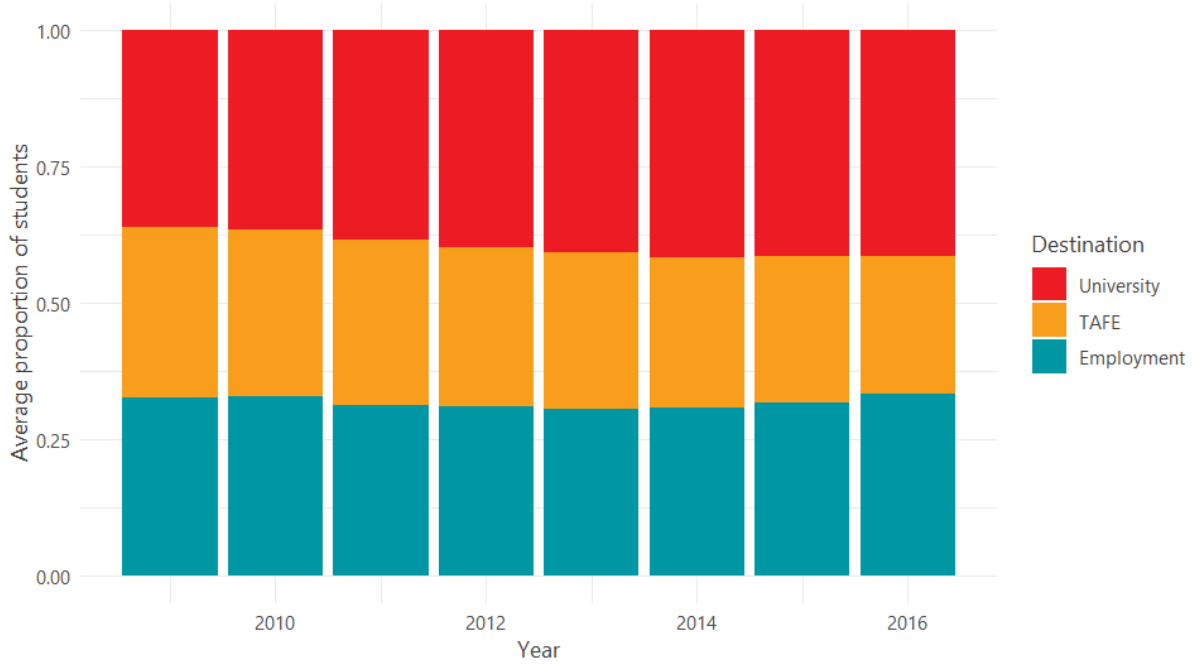


Source: ACARA data.

## Destinations after secondary school

The destinations of students after secondary school have not shown great change in Queensland between 2009 and 2016 (Figure 3.8). While more students are graduating each year, the proportion of students attending university, TAFE or commencing employment has remained relatively stable. A slight shift away from TAFE towards university is apparent, which would be consistent with more students achieving a senior secondary certificate if their scores also meet tertiary admission standards. Using information about labour market outcomes to assess the education system may therefore be difficult, due to the lack of useful variation in this variable. Further, labour market outcomes are often due to many factors other than the impact of schools themselves and therefore do not provide a direct measure of schooling quality.

Figure 3.8 Destinations for students after secondary school, Queensland



Source: ACARA data.

## 4. Quality-adjusting education output

The key challenge for accurately measuring output in the school education sector is to adjust enrolments in such a way that internalises the quality of the service provided. The *2016–17 Queensland Productivity Update* developed exploratory MFP estimates for the education and training, and health care and social assistance industries in Queensland (see Box 4.1 for approaches to quality adjustment in the health care sector).

Commission estimates (2018) for MFP growth in the education and training sector were between –0.2 and 0.0 per cent per annum. As noted in the *Update*, these estimates may be biased as they are not adjusted for quality. Moreover, it is difficult to predict in which direction the quality adjustments will move. The New Zealand Productivity Commission (NZPC) found that as education quantity is largely driven by changes in population, quality adjustment is particularly important for this sector (Gemmell et al. 2017). Both the NZPC and the Office for National Statistics in the United Kingdom (ONS) have proposed methodologies for making this quality adjustment.

### Box 4.1 Quality adjustments in the health care sector

Quality-adjusting output is a challenge that statisticians in the health care sector also face.

#### Quality-adjusted life year

The 'quality-adjusted life year' (QALY) is used to measure the burden of disease by health economists. QALYs combine both quality and quantity into one measure. The measure assigns states of health a utility value on a scale from 1.0 (full health) to 0 (death). The amount of time spent in each state is then multiplied by its utility value to calculate QALYs.

For example, the Department of Health and Ageing (2002) used this measure to assess the return on investment for needle and syringe programs in Australia. After adjusting for quality, the program was found to have greater benefits for those avoiding HIV and Hepatitis C than was calculated when only examining the quantity of life years gained.

The construction of a measure combining quality and quantity of education could be valuable—a 'quality-adjusted school year' (QASY).

#### Disease-based output measures for hospitals

Recent work from the ABS has focused on improving output measures of the health care industry (Luo 2018a, 2018b). Specifically, a focus has been on developing a partial disease-based approach.



This means that output volume is measured based on the treatment of disease by type of provider. The ABS noted that the QALY may be missing some indicators for it to be a valuable measure of output. Another task for forward research is to consult on other methods for quality-adjusting health care outcomes.

### 4.1 International approaches

To measure and quality-adjust output in the school education sector, methodologies proposed in New Zealand and the United Kingdom are adapted to the Australian context. The baseline measure used is a simple measure of quantity—total enrolments in primary and secondary schools (Atkinson 2005; Lee 2008). This aligns with the direct volume measure used by the ABS.

## New Zealand

The NZPC (2017) makes two different adjustments for quality.<sup>19</sup> The first is to adjust output (student enrolments) by student attainment as a measure of quality. That is, one student enrolment at a given school may produce a 'better' output than an enrolment at another school, as that student leaves school with a higher level of achievement (in New Zealand, NCEA level 2 or higher).

The second approach is an income-based or 'human capital' approach, where output is quality-adjusted by earning potential resulting from education. However, the economic literature on the returns to education finds many other factors influence earnings, such as family background. Therefore, measuring quality of education by income may also be capturing other effects (Schreyer 2010). Further, Hill (1975) has emphasised the differences between 'outputs' and 'outcomes', where outcomes are the purpose for which the output is used. The conflation of earnings with education potentially misrepresents education as an outcome instead of an output. This paper therefore does not proceed with this approach.

## United Kingdom

The ONS (2015, 2017) adjusts for quality using General Certificate of Secondary Education (GCSE) performance. This quality adjustment increased the annual average output growth across all years studied (1996–2013). In turn, the quality adjustment to output also led to much stronger productivity growth, more than doubling the measure for 2011 as an example. Adjusting for quality using examination scores has also been attempted in Canada by Gu and Wong (2015), who found that the quality adjustment increased the measure of productivity growth in the sector by 0.2 percentage points per year. The ONS approach also adjusts the number of students (quantity of education) by absences. Adjusting for absences had little effect on the results for Queensland, and as such, those estimates are not reproduced here.

## 4.2 Estimates for education output

The following sections present the results of two simple adjustments for quality, and a final composite index for output (Table 4.1).

**Table 4.1 Quality adjustments considered by this paper**

Measure	Theoretical definition	Data
Baseline	$Q$	Total enrolments (primary and secondary)
Method 1: students achieving above national standard on NAPLAN	$p_1Q$	Total enrolments weighted by the share of students reaching above the minimum national standard on NAPLAN <sup>a</sup>
Method 2: students awarded with a senior secondary certificate	$p_2Q$	Total enrolments weighted by the share of students awarded with a senior secondary certificate
Composite index	$p_1Q_{Prep-Yr10} + p_2Q_{Yr11-12}$	Törnqvist aggregation of total enrolments for various school services, with primary and secondary enrolments weighted by NAPLAN achievement and senior secondary enrolments weighted by senior secondary certification

<sup>a</sup> This proportion is constructed by taking the minimum of the proportion of students meeting minimum standards in the reading and numeracy tests for Year 5 (primary schooling) and Year 9 (secondary schooling).

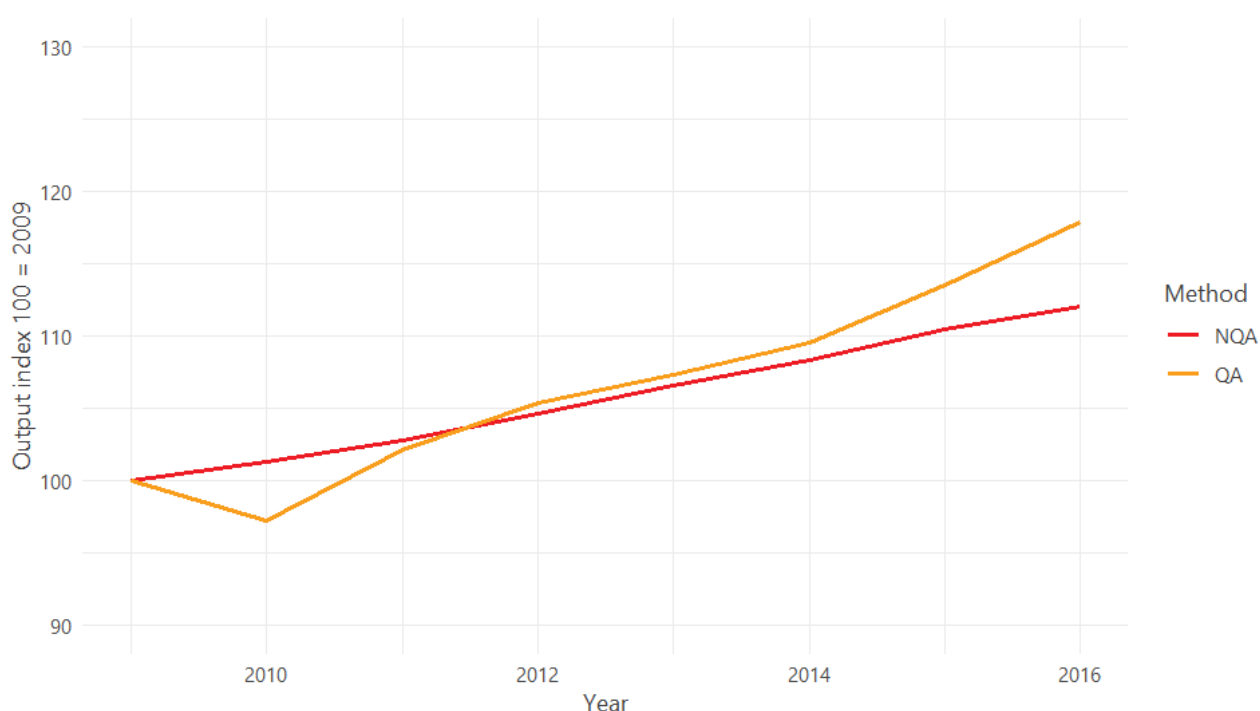
<sup>19</sup> The NZPC also construct measures for labour productivity, which are not covered here.

## Quality-adjusting by NAPLAN score

Output growth for schools in Queensland is slightly higher after adjusting for quality by NAPLAN performance, after a drop in the first period (Figure 4.1).<sup>20</sup> Note that this quality adjustment depends on the number of students that switch from not meeting minimum standards to achieving above minimum standards across time. This means that growth is driven from the lower end of the distribution, and not from improvements in score at the medium-to-top end of the distribution.

These results indicate that the rate at which schools in Queensland are enabling students to improve sufficiently to achieve above minimum standards is faster than the rate of enrolment growth. However, this growth rate may not be sustainable in the future, as more and more students are already achieving above minimum standards—that is, there is an upper bound to this growth.

**Figure 4.1 Quality-adjusting by NAPLAN score, Queensland**



Note: NQA refers to non-quality-adjusted output and QA refers to quality-adjusted output.  
Sources: ACARA data; Commission calculations.

## Quality-adjusting by senior secondary certificate

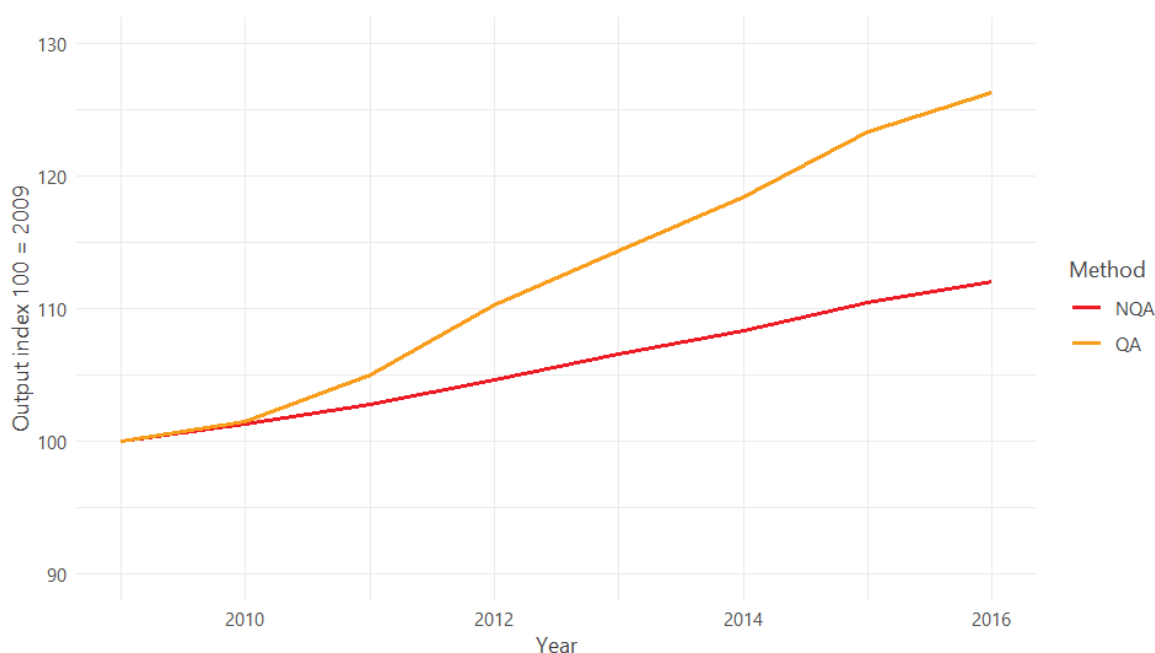
Compared with the quality adjustment based on NAPLAN scores, senior secondary certification has a significant impact on the estimate for output growth. Output has grown rapidly between 2009 and 2016 (Figure 4.2). This result must be viewed with caution, as it implies a very significant increase in output over a short time period.

<sup>20</sup> This drop is due to an increase in the proportion of students not meeting minimum standards in the period 2009–2010. This effect is mirrored across many other states (see Appendix C) and the Australian average. While average scores increased in this period (see Figure 3.5 and Figure 3.6), this improvement appears not to be driven by the tail end of the data. However, this period is at the start of the series and there is only one period of contraction. Focus should be placed on the overall trend over time, not necessarily period-to-period growth. ACARA notes that there may be fluctuations in test results between periods due to statistical error, and that statements about improvement or decline in standards should only be made confidently when a trend persists over time or is particularly large (ACARA 2010, p. iv).



Further, school completion is not completely tied to school quality or productivity. For example, in Australia, labour market conditions for youth are an important factor influencing students' decisions to stay in school or leave to seek employment (Leigh & Ryan 2008; Ryan & Watson 2004). It would therefore not be appropriate to adjust all enrolments by Year 12 certification. Instead, it should only be used to quality-adjust the population of students that have already opted to stay in senior secondary schooling (those in Years 11 and 12).

**Figure 4.2 Quality-adjusting by senior secondary certificate, Queensland**



Note: NQA refers to non-quality-adjusted output and QA refers to quality-adjusted output.  
Sources: ACARA data; Commission calculations.

### Final index for quality-adjusted output

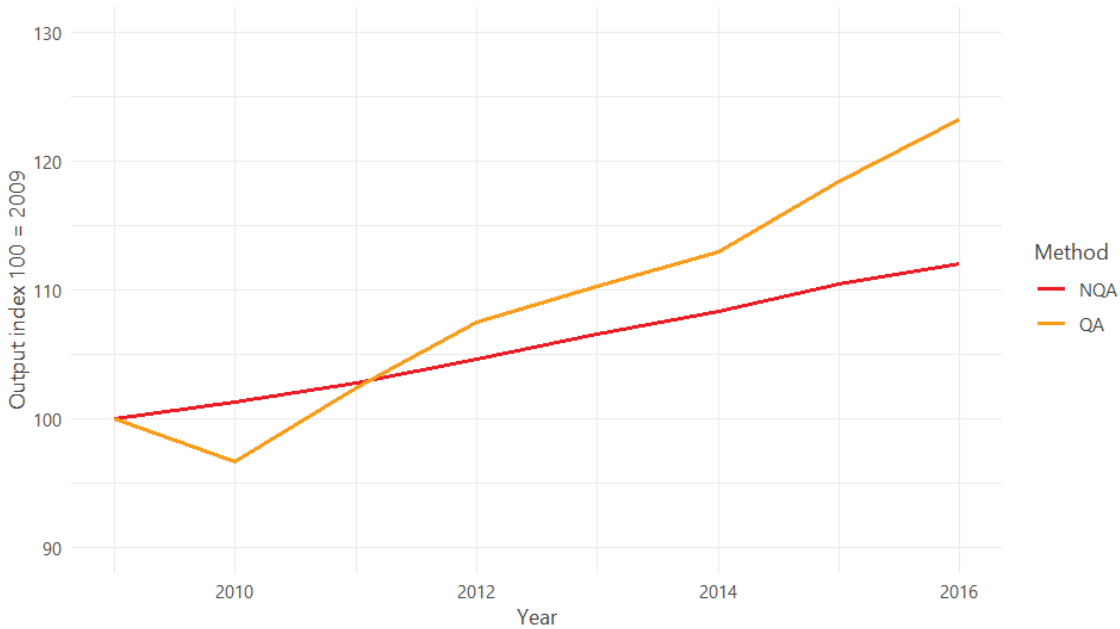
To construct a final measure for output, only enrolments in Years 11 and 12 are adjusted by senior secondary certification. The remainder are adjusted using NAPLAN scores. An aggregate is then created by weighting each service by enrolment share. This provides an index for output that better accounts for each different type of service provided and only quality-adjusts senior secondary enrolments by senior secondary completion. See Appendix B for derivations.

The resulting index for Queensland<sup>21</sup> shows that output growth became slower when adjusted for quality in the first few periods studied (Figure 4.3). However, significant improvements in NAPLAN scores achieved since the first years of testing, paired with increases in the number of Year 12 students graduating with a senior secondary certificate, has caused output growth to increase. By 2016, quality-adjusted output growth is 11 index points higher than growth in enrolments alone. This translates to output growth of 23.24 per cent from 2009 to 2016, compared to 12.02 per cent in enrolment growth. Approximately 11 per cent of growth can therefore be attributed to improvements in education quality. Over the period studied, output growth ranges between -3.29 and 5.91 per cent per annum, averaging at 3.07 per cent.

<sup>21</sup> Graphs for the other states of Australia are given in Appendix C.

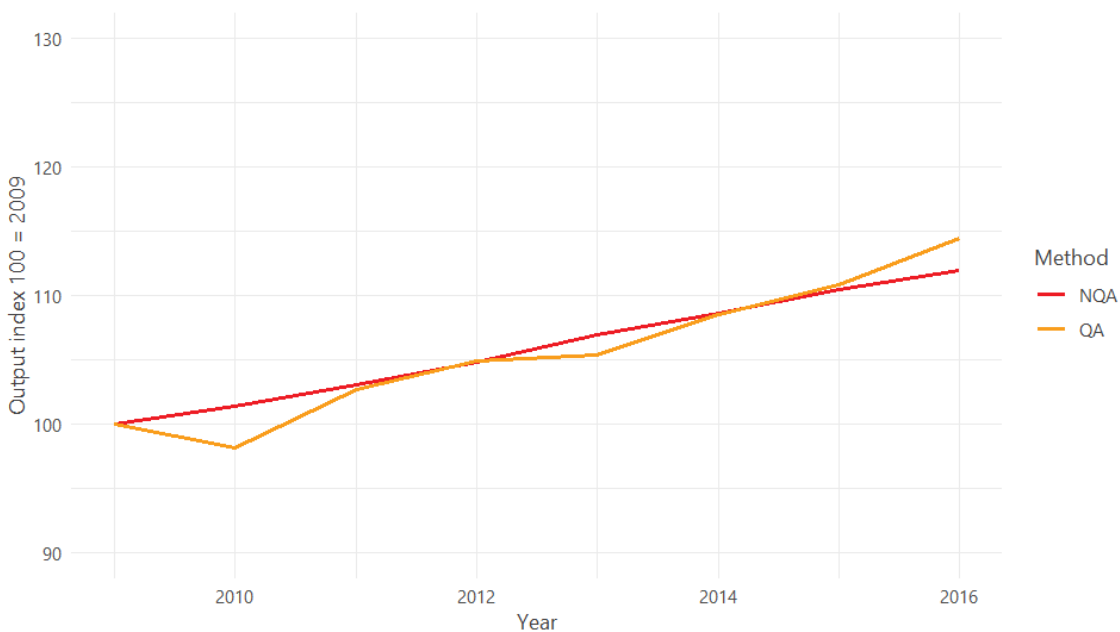
Output growth figures for Australia show that output has been growing at a faster rate in Queensland than the Australian average (Figure 4.4). Moreover, the effect of the quality adjustment is more pronounced in Queensland as a result of the significant NAPLAN gains the state has made over the period studied.

**Figure 4.3 Quality-adjusted output for the school education sector, Queensland**



Note: NQA refers to non-quality-adjusted output and QA refers to quality-adjusted output.  
Sources: ACARA data; Commission calculations.

**Figure 4.4 Quality-adjusted output for the school education sector, Australian average**



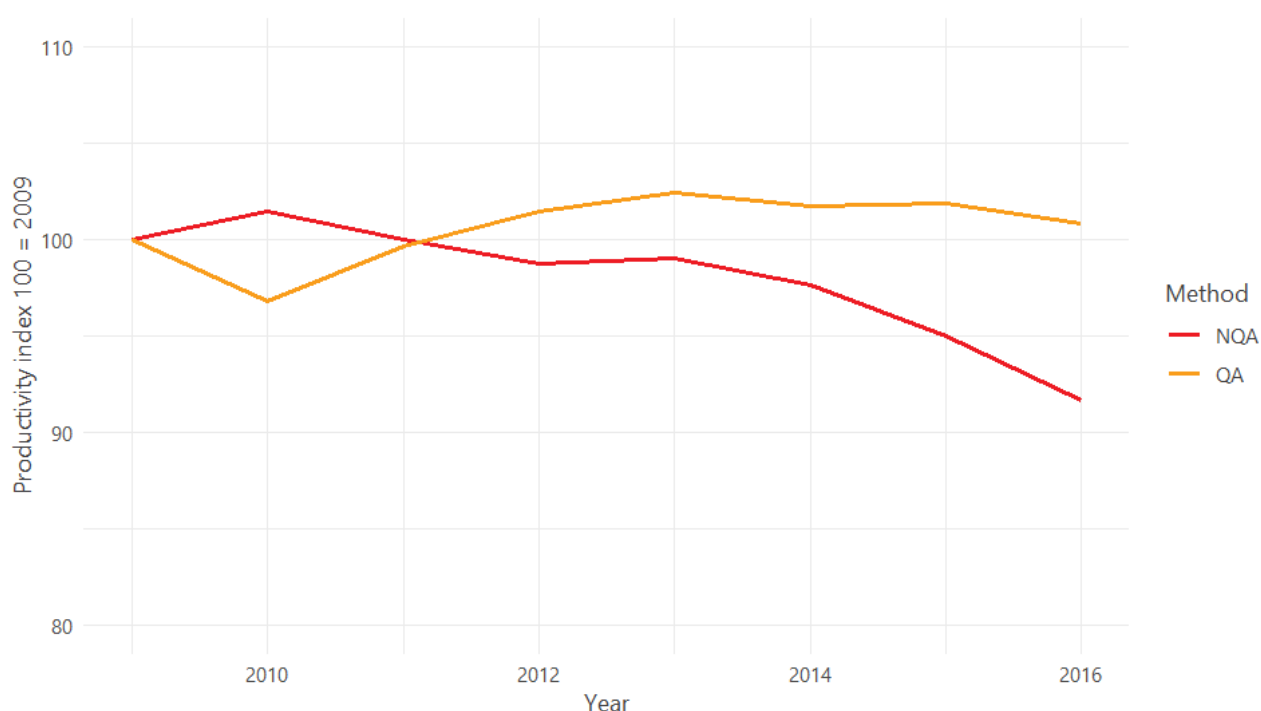
Note: NQA refers to non-quality-adjusted output and QA refers to quality-adjusted output.  
Sources: ACARA data; Commission calculations.

## 5. Exploratory productivity estimates

Productivity estimates are underpinned by accurate measures of output. Using the quality-adjusted measure for output, exploratory estimates for productivity show a different outlook than when non-quality-adjusted measures are used.

To produce the productivity index, the estimates for output are divided by total revenue in the school sector, which encompasses all recurrent spending in a school each year (see Table B.5 in Appendix B). A similar measure (productivity as output per dollar) was estimated by Leigh and Ryan (2008), who found that productivity decreased in Australian schools between 1964 and 2003. The results of this paper (Figure 5.1) provide evidence for the later period 2009–2016.

**Figure 5.1 Productivity in the school education sector, Queensland**



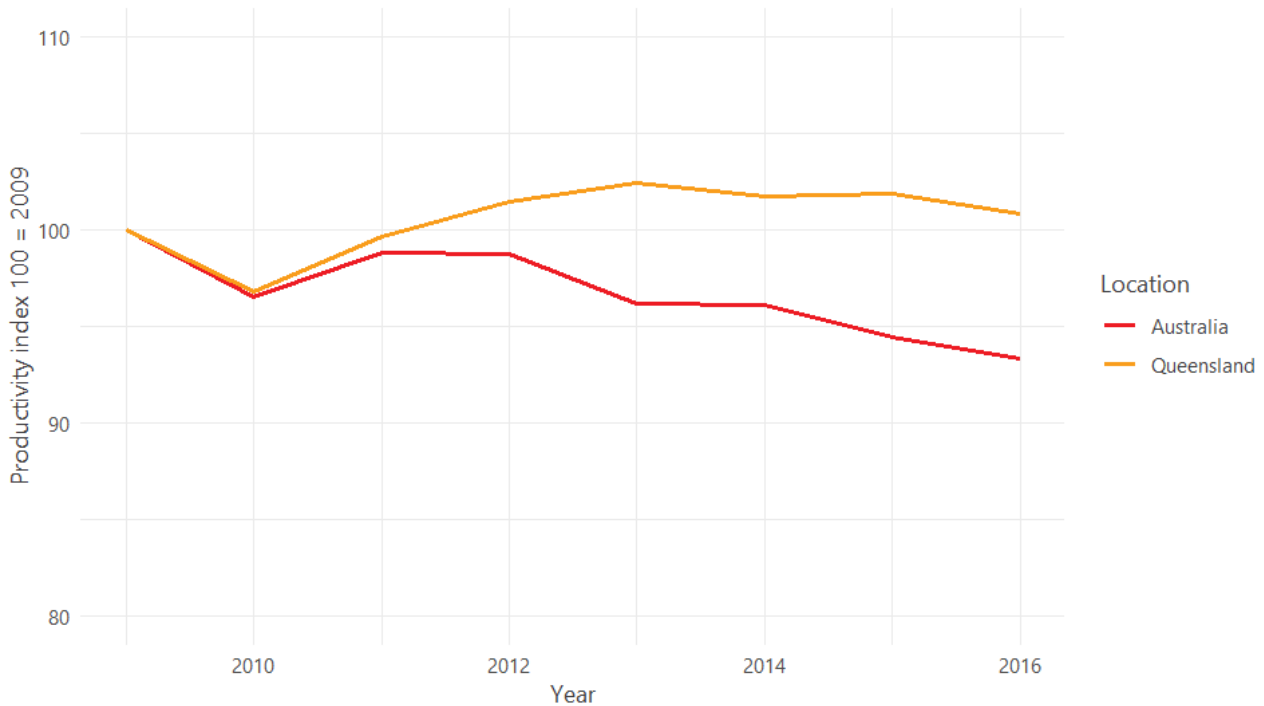
Note: NQA refers to non-quality-adjusted output and QA refers to quality-adjusted output.  
Sources: ACARA data; Commission calculations.

The non-quality-adjusted measure supports the conclusion that productivity has been declining in the school education sector in Queensland over the past decade, except in 2011 and 2013 when productivity grew slightly. Once adjusted for quality, however, estimates for productivity are more favourable. This finding is in line with findings in New Zealand, where productivity was estimated to be declining by 1.7 per cent per year on average between 2002 and 2014. However, once adjusted for quality, productivity was estimated to decrease only by 0.5 per cent on average each year over the same period. These results show that incorporating quality into measures for output has a material impact on the figures for productivity. Developing measures of output that incorporate quality are therefore crucial for understanding how non-market sectors are performing.

Notably, Queensland's productivity performance is better than the Australian average (Figure 5.2). In Queensland, productivity growth per annum is estimated to range between  $-3.173$  and  $2.940$  per cent and averages at  $0.138$  per cent per annum. This average growth rate aligns with the findings of the *Queensland Productivity Update 2016–17*, which found productivity to range between  $-0.2$  and  $0.0$  per cent per annum.

This compares with a decline in productivity at an average rate of 0.963 per cent per annum for Australia. Queensland’s performance is likely due to strong growth in NAPLAN scores compared to the Australian average. Nevertheless, more needs to be done to assess how inputs can become more productive in the sector. Gains in NAPLAN achievement and Year 12 certifications are unlikely to be consistently sustained. Negative growth between 2015 and 2016 may indicate that this slowdown is already starting to be felt. This will put more pressure on the input side of the equation to make productivity gains.

**Figure 5.2 Productivity in the school education sector, Queensland and the Australian average**



*Note: These graphs were generated using the quality-adjusted measures for output.  
Sources: ACARA data; Commission calculations.*

Note that the estimates produced here are purely exploratory due to the data limitation restricting the time-period studied to 2009–2016. The ABS recommends studying productivity growth only in the long-run, and Quiggin (2001) has recommended considering productivity growth over business cycles instead of in isolation. Nevertheless, this section illustrates the potential usefulness of the measure for output developed in this paper for improving productivity analysis in the future.

## 6. Discussion

This paper shows that adjusting for quality affects education output growth. Further, the choice of measure used for the quality adjustment matters.

The quality adjustments used were:

- the proportion of students achieving above minimum standards on NAPLAN testing
- the proportion of students achieving senior secondary certificates at the end of their schooling.

Each of these quality adjustments provided a different picture of how quickly output in the education sector is growing. The simple NAPLAN adjustment estimated that output growth averaged at 2.41 per cent per year, whereas adjusting all enrolments by senior secondary certification estimated average output growth at 3.40 per cent per year—almost 1.5 times the NAPLAN adjustment. The difference between these two estimates indicates high variability depending on the choice of adjustment. Caution must be used when implementing these kinds of approaches. For these reasons, an estimate that adjusted only the relevant year levels by the relevant adjustment was preferred. This approach led to an average growth estimate of 3.07 per cent per year.

Measuring output and productivity in non-market sectors is difficult, and no measure will perfectly capture quality. Depending on the policy problem under consideration, it may be preferable to employ different combinations of the quality adjustments explored here.

The use of test scores may also 'explain away' the issue of how socio-economic factors are impacting achievement in schools. Test scores may measure the socio-economic background of a school, rather than the effect of a school itself (Voon & Miller 2012). As this paper focuses on the **growth** of output, not the levels of achievement, these factors should be making little impact on the final result, unless the socio-economic composition of schools has also changed significantly over the same time period.

### 6.1 Falling productivity in Australian schools

The conclusion that productivity is falling in the Australian education sector is not controversial—average per student funding has risen significantly over the last 50 years in Australia (see Figure 3.3 and Leigh & Ryan (2008) for evidence in the period preceding this paper). The inefficiency of schools in other Australian jurisdictions has been documented in the economic literature (Blackburn et al. 2014a; Chakraborty & Blackburn 2013; Dancer & Blackburn 2017), and productivity growth is typically lower for service sectors when compared with other sectors in the Australian economy (Harper et al. 2015, p. 19). However, there is evidence that schools may be operating efficiently once socio-economic factors are accounted for (Chakraborty & Harper 2017).

It must also be noted that increased funding to schools may be going towards programs to support important non-academic outcomes such as co-curricular activities and student wellbeing. Improvements in these areas will not be reflected well in the productivity estimates here.

It is hoped that the findings of this paper will encourage further discussion and analysis on the drivers of productivity in the school education sector, and the role government policy may play in this space.

### 6.2 Limitations of productivity analysis

Productivity measurements come with some caveats. For example, the ONS (2015) has pointed out that 'they do not measure value for money or the wider performance of public education services'. In terms of policy, these statistics say nothing about the other determinants driving output in this sector. Further, they are not granular enough to provide much indication of the reasons behind the changes in output or productivity. Particularly, they

say nothing about the drivers of productivity.<sup>22</sup> For example, the numbers tell us little about if changes are being driven by technological change embodied in new capital (consider better quality computers) or if change is driven by what is called 'disembodied' technological change (consider a restructuring that allows a school to become more productive without investing in new capital). This limits the use of this information in a policy context. The Atkinson (2005) report described aggregated measures of output and productivity for each non-market sector as an important starting point, but also emphasised that measuring output in a more detailed way is pivotal for understanding policy changes. The OECD handbook also makes it clear that there is a methodological difference between measuring productivity for the national accounts versus measuring it to improve service delivery (Schreyer 2010).

The Australian Productivity Commission has argued that macro and micro-level studies of productivity need not be mutually exclusive (PC 2017). Industry-wide estimates, such as those generated in this paper, are important for informing an understanding of the direction the sector is moving in and for the formation of policy goals. This study can be followed with more detailed micro-level studies of productivity to discover the drivers for the results, and to uncover possible policy solutions.

### 6.3 Recommendations for future study

This paper finds that productivity in the school education sector has decreased nationally over the past ten years, but that Queensland has fared more favourably. Future studies could employ techniques such as data envelopment analysis (Blackburn et al. 2014a, 2014b; Bradley et al. 2004; Nghiem et al. 2016), stochastic frontier analysis (Battese & Coelli 1995; Chakraborty & Blackburn 2013; Chakraborty & Harper 2017), technical inefficiency effects models (Dancer & Blackburn 2017) or generation of Malmquist productivity indexes (Caves et al. 1982) to create a comparative study among schools to uncover best practice regarding efficiency in the sector. The schools can then be studied to isolate good practice. For example, the Centre for Education Statistics and Evaluation (CESE) in New South Wales has undertaken a case study of effective practices in schools with a high value-add (Johnston-Anderson 2017). More detailed efficiency studies could be undertaken within socio-economic bands (measured by the Index of Community Socio-educational Advantage in the NAPLAN data), to ensure that best practice schools are identified from all backgrounds.<sup>23</sup>

Further questions for consideration that this paper highlights are:

- What kind of environment allows funding to be spent most efficiently in schools?
- What is the regulatory burden placed on schools? Are the costs of constraints outweighing the benefits?
- How do we consider issues of equity while also improving productivity?
- How can we better support innovation in schooling in both the government and non-government sectors?
- How efficient are schools in other countries? What can we learn from them?

A study along the lines of the inquiry in 2013 by the Victorian Competition and Efficiency Commission (VCEC) into school devolution and accountability may provide valuable insight into both improving educational outcomes and cost efficiency in Queensland's schools. The final report of that inquiry emphasised the importance of considering cost efficiency alongside drivers to improve performance (VCEC 2013, p. XXVII).

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<sup>22</sup> See Gordon et al. (2015) for more on intra-industry dynamics regarding productivity.

<sup>23</sup> The Centre for Independent Studies (CIS) has recently published a study on Australia's top-performing disadvantaged schools (Joseph 2019). This research only considered schools in Victoria, and one in South Australia, although three government schools in Queensland were identified for possible study. These schools were uncovered solely by high NAPLAN performance, but other factors such as productivity could be considered in future studies.

## 7. Conclusion

This paper defines and measures output in the non-market sector of school education and estimates an output index for the sector in Queensland using enrolment data. It explores two quality adjustments to this output measure:

- the proportion of students achieving above minimum standards on NAPLAN testing
- the proportion of students achieving a senior secondary certificate.

It generates a chain-linked Törnqvist index for output, which both adjusts for quality and treats each discrete type of schooling service separately. The paper finds that output growth in the Queensland schooling sector may be faster than previously believed. Further, output growth in Queensland has been faster than the Australian average.

Exploratory estimates for productivity in the paper are based on school revenue data as an input measure. Using non-quality-adjusted output, productivity is shown to be not only sluggish in Queensland schools, as concluded by the *Queensland Productivity Update 2016–17*, but decreasing. This is consistent with rises in average per-student funding in schools across Australia. However, once adjusted for quality, Queensland has been making productivity gains in some periods due to strong growth in NAPLAN achievement and senior secondary certifications. This marginal improvement contrasts with the falling rate of productivity for Australia as a whole.

As these output gains are unlikely to remain at a consistent pace in future, the key issue for Queensland is to better understand how productivity is working in terms of inputs. Further research should consider what is driving productive or unproductive uses of inputs in the sector to avoid productivity declines in future.

It is hoped that the approaches for quantifying output and productivity explored in this paper will encourage a shift in policy discussion from emphasising school funding and resourcing, to understanding the most efficient uses of resources in the schooling sector. Another positive outcome would be if a dialogue can be opened on how productivity in schools can be lifted to get the most value out of spending in this sector.

## Appendix A ACARA data

**Table A.1 Data items used by this study**

Field code	ACARA description	Data set to request	Use
AGE ID	Australian Government Department of Education ID	Needed in all to link data sets	Merging each ACARA data set
School name	The official name of the school	Any	Merging each ACARA data set
Calendar year	The year to which the data relates	Needed in all to link data sets	Constructing time dimension
State	The state in which the school is located	Any	Constructing Queensland and 'Rest of Australia' estimates
School sector	The sector that the school belongs to (Government, Catholic or Independent)	Any	Differentiating by sector to weight by revenue share)
School type	The type of school (primary, secondary, etc.)	Any	Differentiating by school type to weight by revenue share
Attendance rate	The student attendance rate in percent	School attendance	Quantity-adjusting for attendance
Testing domain	One of the five domains tested in NAPLAN (reading, writing, numeracy, spelling, grammar and punctuation)	NAPLAN results	Quality-adjusting for test scores
Year level	The school year being tested (Year 3, Year 5, Year 7, Year 9)	NAPLAN results	Quality-adjusting for test scores
Average NAPLAN score	The selected school's average NAPLAN score by domain and year level	NAPLAN results	Quality-adjusting for test scores
Band 'X' percentage	The percentage of students who were in the achievement band 'X'	NAPLAN results	Quality-adjusting for test scores (proportion achieving above minimum standards)
Total gross income	The amount of recurrent income received by a school from all sources	Finance	Measuring input
Enrolments (primary and secondary non-graded)	The total number of students enrolled at the	Enrolments by year level	Constructing output (number of students)



Field code	ACARA description	Data set to request	Use
Completed senior secondary school	school (separated into primary and secondary)  The number of students at the school who left at the end of the calendar year having completed the equivalent of two or more years post Year 10 studies (not necessarily full-time nor consecutive) who are eligible for a statement of results, or a record of achievements.	Senior secondary outcomes	Constructing output (number of graduating students)
Senior secondary certificates awarded	The number of students at the school who left at the end of the calendar year having fulfilled the requirements for a senior secondary certificate issued by a Board of Studies in the relevant state or territory	Senior secondary outcomes	Quality adjusting for receiving a senior secondary certificate

Source: ACARA Data Dictionaries.

## Appendix B Methodology

### Estimates for quality-adjusted output

The estimates for each approach to quality adjusting output are reproduced in Table B.1. Each method weights total enrolments by a proportion of students meeting certain standards, which will necessarily be smaller than total enrolments.

**Table B.1 Raw estimates for quality-adjusted enrolments, Queensland schools**

Method	Estimated enrolments							
	2009	2010	2011	2012	2013	2014	2015	2016
$Q_t$ (Baseline)	714,738	724,158	734,650	748,097	762,078	774,344	789,492	800,682
$p_{1t}Q_t$	581,970	565,811	594,230	613,450	624,533	637,317	660,736	686,246
$p_{2t}Q_t$	573,266	581,965	602,084	632,027	655,489	678,996	707,286	723,987

Sources: ACARA data; Commission calculations.

$Q_t$  refers to the total number of enrolments (primary and secondary) in a given year,  $t$ .  $p_{1t}$  gives the proportion of students achieving above minimum standards on NAPLAN, and  $p_{2t}$  the number of students achieving a senior secondary certificate.

Next, the raw estimates are converted into a quantity relative (Table B.2), setting 2009 as the base year. The formula is

$$\frac{Q_t}{Q_0} \times 100$$

where  $Q_0$  refers to the estimate in the base year, and  $Q_t$  the estimate in the current year,  $t = 0, \dots, 8$ . For this purpose, we are calculating with a fixed base period. Indexes are given to two decimal places.

**Table B.2 Estimates for growth in quality-adjusted output, Queensland schools**

Method	Estimated growth in output quantity							
	2009	2010	2011	2012	2013	2014	2015	2016
$Q_t$	100.00	101.32	102.79	104.67	106.62	108.34	110.46	112.02
$p_{1t}Q_t$	100.00	97.22	102.11	105.41	107.31	109.51	113.53	117.92
$p_{2t}Q_t$	100.00	101.52	105.03	110.25	114.34	118.44	123.38	126.29

Sources: ACARA data; Commission calculations.

These numbers can be interpreted as the change in education output between the given year and the base year. For example, 104.67 in 2012 means that there has been a rise in education output of 4.67 index points from 2009 to 2012. To calculate the percentage change, divide this difference by the index for the earlier period and multiply it by 100.

Next, we amalgamate the test score and Year 12 certification approaches to quality adjustment to produce our final estimate for output. Given the level of disaggregation in the ACARA data it is possible to differentiate school services by type. We have data for nine types of student cohort (Table B.3). The enrolment shares are given below as an average over time for illustrative purposes.

**Table B.3 Education services provided in Queensland, differentiated by type**

Service	Enrolment share	Quality adjustment
<i>State-provided</i>		
Primary	0.441	Year 5 NAPLAN
Secondary (to Year 10)	0.190	Year 9 NAPLAN
Years 11 and 12	0.040	Awarded QCE
<i>Catholic-provided</i>		
Primary	0.110	Year 5 NAPLAN
Secondary (to Year 10)	0.059	Year 9 NAPLAN
Years 11 and 12	0.014	Awarded QCE
<i>Independently-provided</i>		
Primary	0.077	Year 5 NAPLAN
Secondary (to Year 10)	0.057	Year 9 NAPLAN
Years 11 and 12	0.014	Awarded QCE

Note: The column for enrolment shares sums to greater than one due to rounding. The Year 5 and Year 9 NAPLAN quality adjustments are given by the minimum proportion of students in that schooling service meeting minimum standards in each time period based on achievement in the reading and numeracy tests.

Sources: ACARA data; Commission calculations.

The estimates for quality-adjusted enrolments (disaggregated by service type) can then be used to produce a chain-linked quantity index for output. The ABS uses a Törnqvist index, which is a weighted geometric mean of the quantity relatives<sup>24</sup> (ABS 2016):

$$\prod_i \left( \frac{q_{it}}{q_{it-1}} \right)^{s_i}$$

where  $i = 1, \dots, 9$  are the nine different education services provided in Australia.

$$s_i = \frac{1}{2} \left( \frac{e_{it-1}}{\sum e_{it-1}} + \frac{e_{it}}{\sum e_{it}} \right)$$

is the average of the enrolment shares for the  $i^{\text{th}}$  item in the two periods (ABS 2011, p. 47). This means that the index gives equal weight to both periods, unlike the simpler Laspeyres or Paasche formulas, which only use one of the periods for the weightings.<sup>25</sup> Importantly, it is a 'superlative' formula, which means it can approximate any smooth production (or cost) function (Diewert 1976). This is likely important for the school education sector as it is 'non-market', so avoiding making restrictions on functional form of the production function (such as Cobb-Douglas in Box 2.1) is an advantage as the true functional form is unknown. It is most easily calculated by taking logarithms of the formula. Then the final step is to take the exponent to reverse the taking of logarithms and multiply it by 100.

<sup>24</sup> Note that this formula has been adapted to be a quantity index, rather than a price index.

<sup>25</sup> The Laspeyres formula is often useful as the index can be continually extended as new data becomes available, because the weights are fixed at the base period (ABS 2011, p. 4). See Johnson (1996) for a survey on each kind of index.

For a chained index, the changes between each period are calculated using the method above and then chained together (ABS 2011):

- Calculate the change from period 1 to period 2 to calculate a Törnqvist 'link'.
- Calculate the change from period 2 to period 3 to calculate the next link.
- Calculate the movement from period 1 to period 3 by multiplying these two changes together.
- Continue for each period.

This process differs from the fixed base method employed in Table B.2. The calculated Törnqvist links and the resulting indexes (both quality-adjusted and non-quality-adjusted) are presented in Table B.4.

**Table B.4 Calculated Törnqvist links and indexes for output**

Year	QA Törnqvist link	QA chain-linked index	NQA Törnqvist link	NQA chain-linked index
2009	1.00	100.00	1.00	100.00
2010	0.97	96.71	1.01	101.32
2011	1.06	102.42	1.01	102.79
2012	1.05	107.54	1.02	104.67
2013	1.03	110.29	1.02	106.62
2014	1.02	112.94	1.02	108.34
2015	1.05	118.47	1.02	110.46
2016	1.04	123.24	1.01	112.02

Sources: ACARA data; Commission calculations.

## Exploratory estimates for productivity

To estimate productivity, first construct an index for inputs using total revenue by sector (Table B.5).

**Table B.5 Total revenue by sector (\$ million)**

Year	Government	Independent	Catholic	Total
2009	6,172.15	1,503.92	1,467.15	9,143.22
2010	6,124.71	1,534.36	1,576.58	9,235.65
2011	6,287.10	1,595.81	1,622.68	9,505.60
2012	6,427.42	1,707.05	1,716.87	9,851.34
2013	6,528.73	1,732.65	1,778.07	10,039.46
2014	6,688.67	1,815.64	1,945.58	10,449.89
2015	6,985.96	1,927.47	2,064.60	10,978.03
2016	7,375.63	1,985.59	2,154.22	11,515.43

Sources: ACARA data; GGFCE deflator (base period June 2017) from ABS cat. no. 5206.0, table 36; Commission calculations.

The resulting index for input is then used to generate the quality-adjusted and non-quality-adjusted productivity indexes displayed in Table B.6 (divide output by input).

**Table B.6 Input, output and productivity indexes, Queensland**

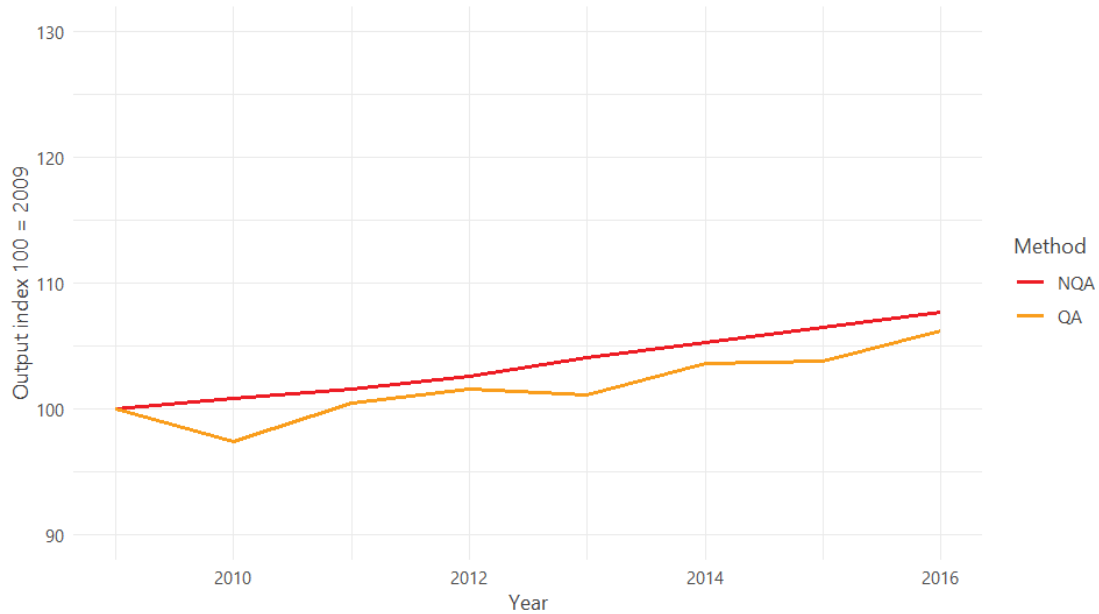
Year	Input index	Productivity index	NQA productivity index
2009	100.00	100.00	100.00
2010	99.88	96.83	101.44
2011	102.76	99.67	100.02
2012	105.96	101.49	98.78
2013	107.68	102.43	99.02
2014	110.97	101.78	97.63
2015	116.29	101.87	94.98
2016	122.20	100.85	91.67

Sources: ACARA data; Commission calculations.

## Appendix C Indexes for quality-adjusted output

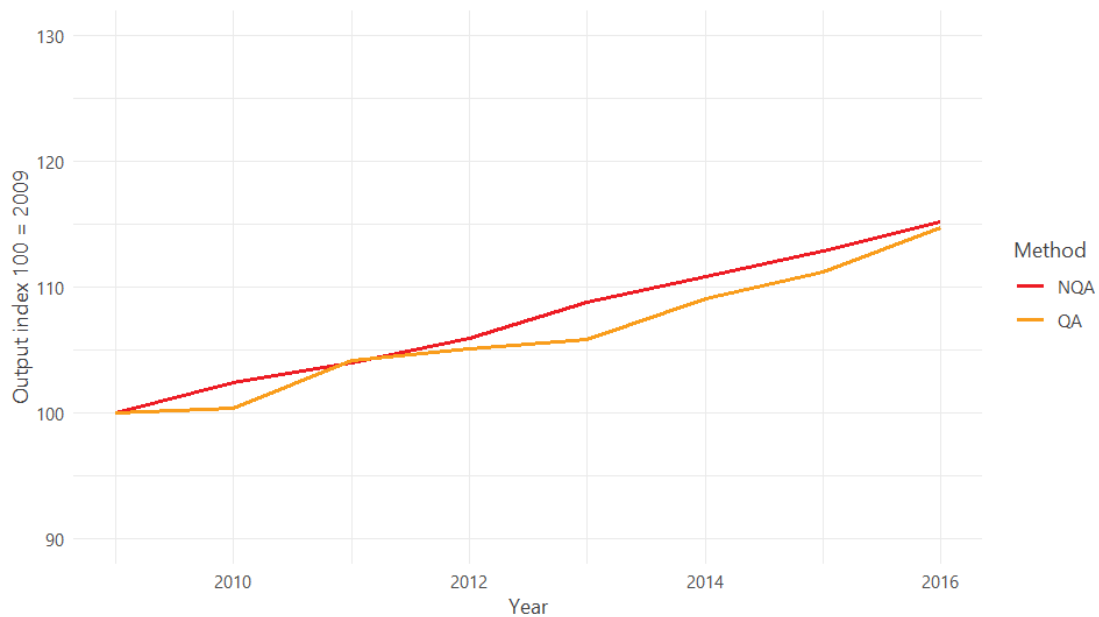
The final index for output constructed by this paper uses NAPLAN scores to adjust output for primary and secondary schooling, and senior secondary certification to adjust output for Years 11 and 12. An aggregate is created by weighting each service by enrolment share. The derivations are shown in the preceding Appendix B. The following figures present the resulting index for each of the other states in Australia, for interest.

**Figure C.1 Quality-adjusted output, New South Wales**



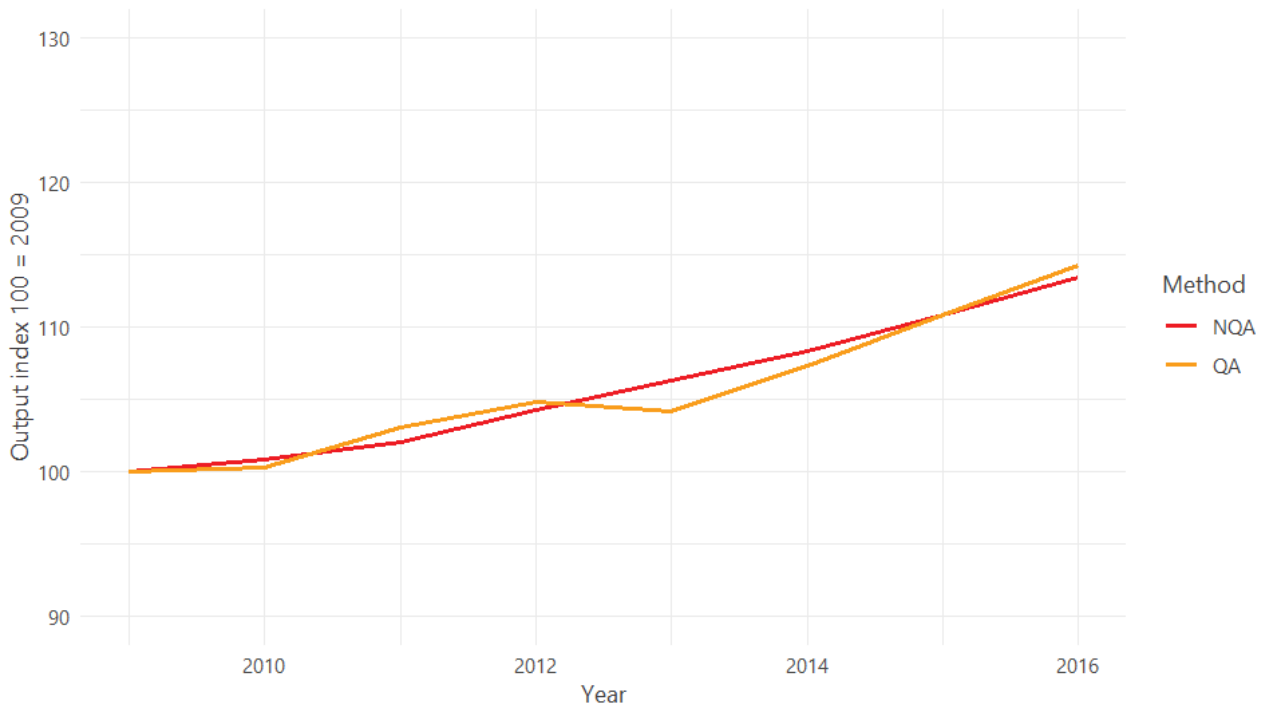
Sources: ACARA data; Commission calculations.

**Figure C.2 Quality-adjusted output, Victoria**



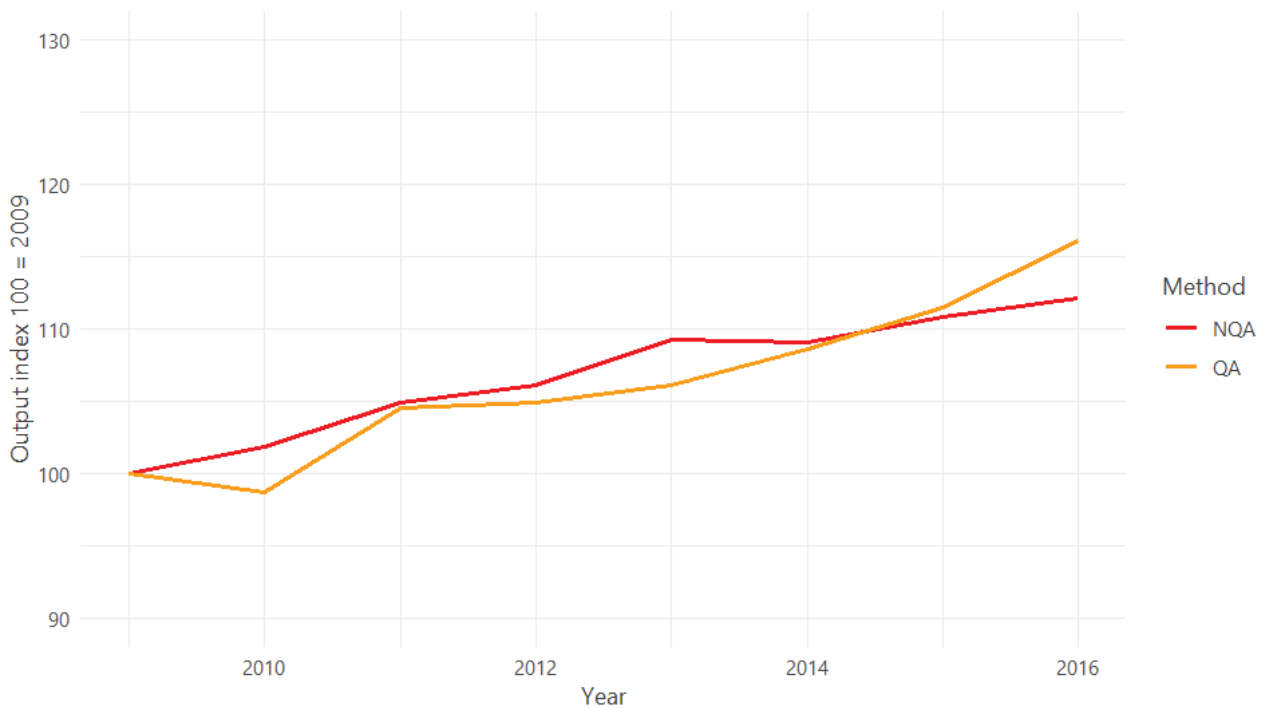
Sources: ACARA data; Commission calculations.

**Figure C.3 Quality-adjusted output, Australian Capital Territory**



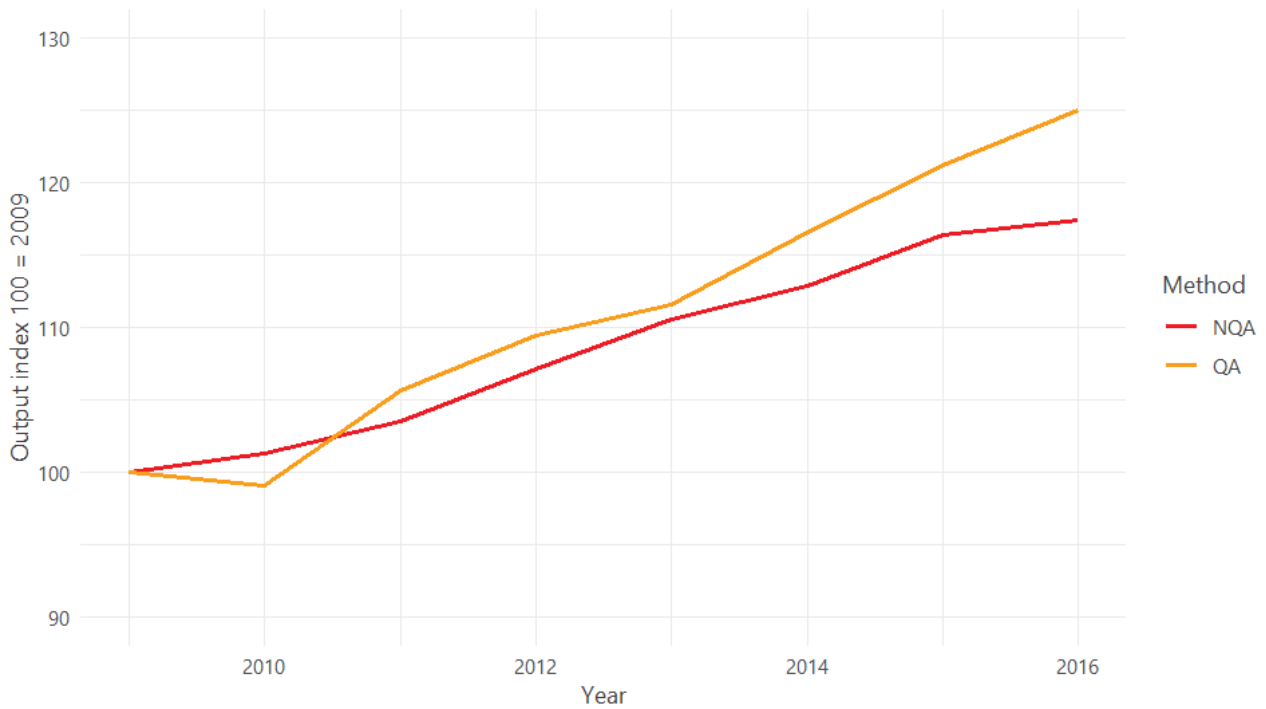
Sources: ACARA data; Commission calculations.

**Figure C.4 Quality-adjusted output, South Australia**



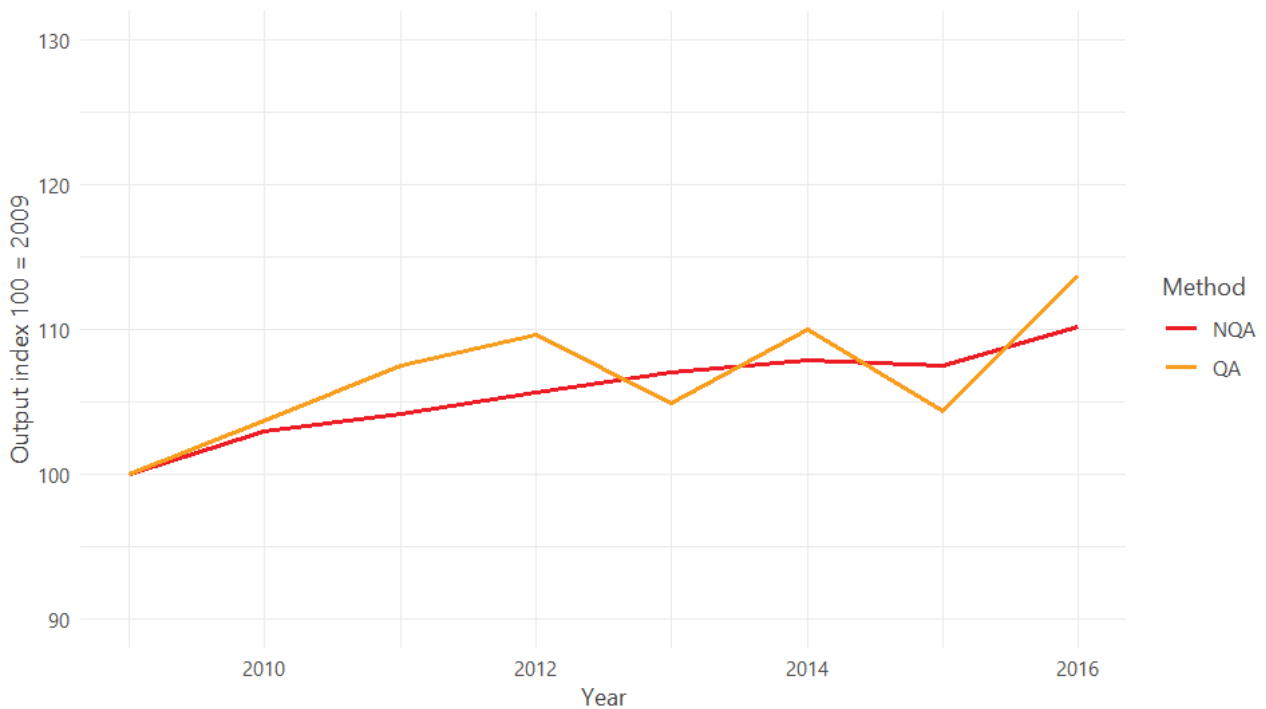
Sources: ACARA data; Commission calculations.

Figure C.5 Quality-adjusted output, Western Australia



Sources: ACARA data; Commission calculations.

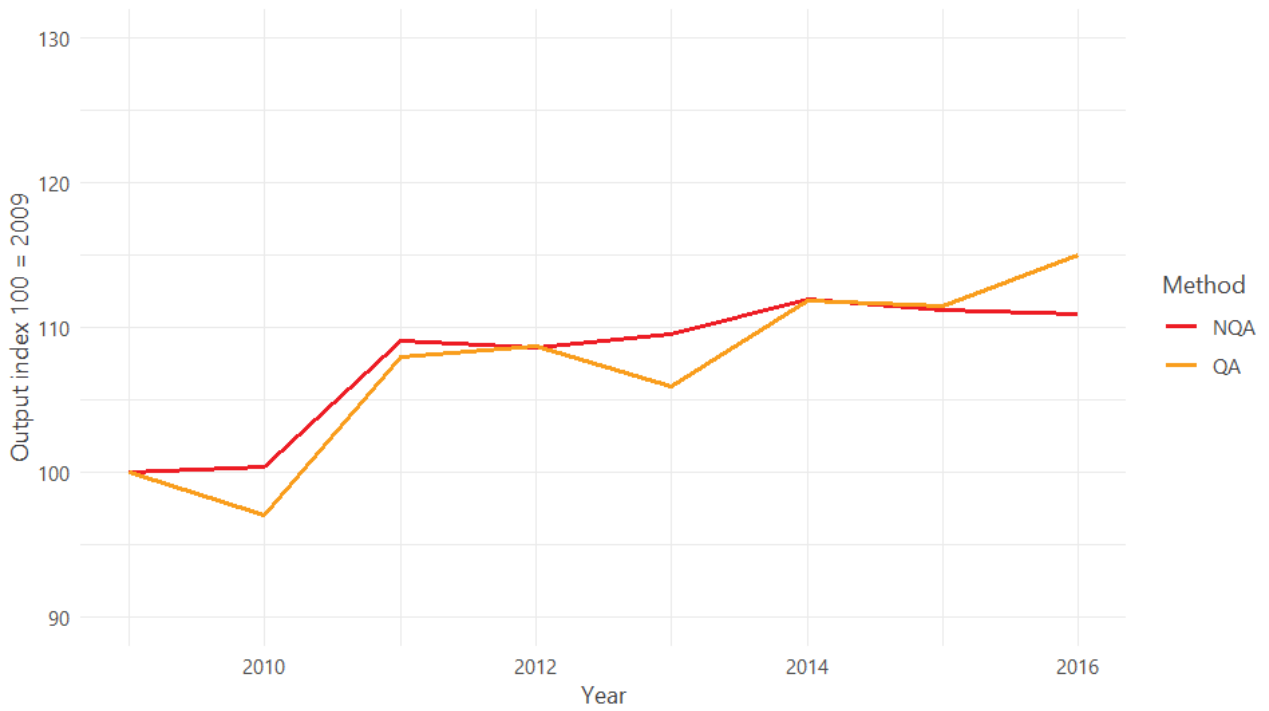
Figure C.6 Quality-adjusted output, Northern Territory



Sources: ACARA data; Commission calculations.



Figure C.7 Quality-adjusted output, Tasmania



Sources: ACARA data; Commission calculations.

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