2015

Heterogeneous Treatment Effects? An examination of Australian Non-Government Primary Schools

Joan Rodgers
University of Wollongong

Frank Neri
University of Wollongong

Ian Moran
University of Wollongong

Economics Working Paper Series 2015
http://business.uow.edu.au/aef/UOW188178.html

Heterogeneous Treatment Effects? An examination of Australian Non-Government Primary Schools

by
Joan Rodgers, Frank Neri* and Ian Moran

School of Accounting, Economics and Finance,
University of Wollongong,
Wollongong N.S.W.
Australia

* Corresponding author

WP 15-03

December 2015

Heterogeneous Treatment Effects?

An examination of Australian Non-Government Primary Schools

by

Joan Rodgers, Frank Neri* and Ian Moran

School of Accounting, Economics and Finance,

University of Wollongong,

Wollongong N.S.W.,

Australia

December 2015

JEL classification codes: I21, I28, I29

* Corresponding author

Heterogeneous Treatment Effects?
An examination of Australian Non-Government Primary Schools[+]

Abstract

On average, students in Australian non-government schools consistently outperform their counterparts in government schools on standardized tests of literacy and numeracy. However, when differences across school sectors in student characteristics are taken into account there is no evidence that this performance differential is attributable to the nature of the schools. Nevertheless, non-government schools may have heterogeneous effects, that is, they may benefit particular groups of students. This study investigates the extent of non-government school advantage for specific primary school student groups. Test scores from the National Assessment Program Literacy and Numeracy for a nationally representative sample of students from the Longitudinal Study of Australian Children are analysed using inverse-probability-weighted regression adjustment. We find no evidence that attendance at non-government primary schools has a positive effect on academic outcomes of children in general, nor for children categorised by gender or socio-economic status. Although children with an Australian-born primary caregiver perform no better in non-government schools, there is some evidence that children with a non-Australian-born primary caregiver benefit academically from attending non-government schools. Our findings challenge common perceptions of non-government school efficiency and raise some important questions about current policies for funding Australian primary schools.

+ This study uses data from Growing Up in Australia, the Longitudinal Study of Australian Children, which is conducted in partnership between the Department of Social Services (DSS), the Australian Institute of Family Studies (AIFS) and the Australian Bureau of Statistics (ABS). The findings and views reported in this paper are those of the authors and should not be attributed to the DSS, the AIFS or the ABS.

I. Introduction

In 1979 the proportion of students in Australian non-government schools was 21.8 percent. By 2013 this proportion had increased to 34.9 per cent, one of the highest rates of non-government school enrolment among OECD countries (ABS, 2013; ABS, 2001). This trend has coincided with increased government funding for non-government schools and the removal of barriers to their establishment (Buckingham, 2010).

Non-government school students consistently outperform their government school counterparts in standardised tests of literacy and numeracy (Gonski et al., 2011, Figure 11). However, differences in the characteristics of students across school sectors suggest that this outcome could be explained by the attributes of the students rather than the efficiency of the school sectors. For example, while 36 per cent of government school students are located in the bottom quarter of socio-economic advantage, for Catholic and other independent schools the figures are only 21 and 13 per cent, respectively.[1] Similarly whilst only 22 per cent of government school students are located in the top quarter of socio-economic advantage, for Catholic and independent schools the figures are 29 and 47 per cent, respectively (Gonski *et al.*, 2011).

Economic theory suggests that non-government schools should be more efficient than otherwise identical government schools. For example, Friedman (1955) argued that a minimum standard of education for all students could be achieved by an entirely privatised education system, where market forces would combine with parental choice to produce adaptive and productive schools. Chubb and Moe (1990) developed these arguments further, emphasising the importance of school accountability and autonomy, and contending that whereas government schools are excessively bureaucratic and inflexible, non-government schools are accountable to the market and

[1] In this study Australian Catholic schools are those governed by the Catholic Education Commissions and Catholic Education Offices of each state and territory. Other independent schools are a heterogeneous body of private schools, more than 85 percent of which provide religious instruction. They are referred to hereafter as independent schools.

must therefore meet consumer demand to survive. However, the latest empirical evidence does not support this theory, with a number of recent studies finding that once student characteristics are taken into account, non-government schools do not produce significantly better cognitive or non-cognitive outcomes for the average student than government schools.

However, it is possible that particular groups of students benefit from attending non-government schools. This paper investigates whether Australian primary school students, categorised according to gender, socio-economic status, residential location and the primary caregiver's country of birth, benefit academically from attending non-government schools compared with their government school counterparts. We address these questions using inverse-probability-weighted regression adjustment with a control for student ability measured pre-school. To the best of our knowledge, this methodology has not been used previously in this area of research.

The remainder of this paper is organised as follows. In the next section we briefly review the empirical literature on non-government school effects. In section III we present our model and discuss our data. We present descriptive statistics in section IV and estimates of our model in section V. Finally, we discuss our findings and make some concluding comments in section VI.

II. Empirical Literature

Since at least the 1980's a large literature, much of it from the US, has estimated non-government school effects in primary and secondary schools (see Table 1). Early studies generally failed to control for endogenous school choice and so the following discussion concentrates on international studies that have better dealt with this issue. We then briefly review Australian studies of non-government school effects. To the best of our knowledge, no Australian study addresses the possibility that school sector effects differ across demographic groups and so we end this section with a discussion of international studies that have investigated heterogeneous school sector effects.

International studies of non-government school effects[2]

Much of the international literature estimates the effects of non-government schools in the United States, which are mostly Catholic, schools. US non-government schools, unlike those in Australia, do not receive government funding but rather are supported by tuition fees and fund raising (Dronkers and Avram, 2010b; Lubienski and Lubienski, 2006). Consequently, they enjoy more autonomy in their admissions (and other) policies than do non-government schools in Australia. This suggests that non-random selection of students by non-government schools is a larger problem with US data than with Australian data, although selection of schools by students (and/or their parents) is a problem in both cases.[3]

Many early international studies found positive non-government school effects, particularly in reading, using multiple regression, hierarchical linear models or Probit analysis.[4] Some of these studies used instrumental variables (IV) to address endogenous school choice. However, subsequent evaluations of the validity of IV applications to school sector effects conclude that none of the candidate instruments (such as religious affiliation or geographical proximity to non-government schools) in currently available data sets is a useful source of identification.[5] Later studies that more effectively addressed non-random selection – either by controlling for early academic achievement, by using propensity score matching, or by some form of bounds analysis (such as that of Altonji *et al.*, 2005a) – found little evidence of positive non-government school effects. In fact, a negative

[2] A more detailed discussion of the international literature can be found in Nghiem et al. (2015), Elder & Jepsen (2014) and Gibbons & Silva, 2011.

[3] There is also a literature assessing the effects of charter schools in the US and elsewhere (for example, Dronkers and Avram, 2010a). Charter schools are government funded but privately managed.

[4] For example, Coleman *et al.* (1982), Evans & Schwab (1995), Sander & Krautman (1995), Sander (1996), Grogger & Neal (2000), Neal (1997), Peterson & Llaudet (2006), and Braun *et al.* (2006).

[5] For example, see critiques by Gibbons & Silva (2013), Cohen-Zada (2009), Cohen-Zada & Elder (2009) and Altonji *et al.* (2005b).

Catholic school effect, particularly in mathematics, has been a common recent finding although the underlying reason remains speculative.[6]

Australian studies of non-government school effects

Williams and Carpenter (1991) compared test scores, high-school graduation rates and college entry rates for students attending government, Catholic and independent schools. Although there were no school sector effects on test scores in primary school, Catholic and independent school enrolment was associated with higher achievement in high school and beyond. However, the covariates used to control for student heterogeneity across school sectors were limited in number and scope. Furthermore, the data were from 1975 through 1984, at the very early stages of the shift of enrolment from government to non-government schools in Australia, and so the characteristics of students in the different school sectors were likely very different to what they are today.

Vella (1999) examined the effect of attending a Catholic high school on secondary school completion, tertiary education attainment and early labour market outcomes on individuals from the 1985 cohort of the Longitudinal Study of Australian Youth (LSAY). He used a bivariate probit analysis and found positive effects. However, Catholic schools comprised both those operated by Catholic education offices and other private Catholic schools, school sector was recorded immediately prior to leaving school with no account of earlier schooling, the number of covariates was small, and the instrumental variables used to identify school sector effects have since been criticised.

Le and Miller (2003) used linear probability and probit models, with Heckman corrections for selection, to examine the determinants of success in completing Year 12 for students in the Youth in Transition surveys. The coefficients of the inverse Mill's ratios in the equations for Year 12

[6] For example, Elder & Jepsen, 2014; Reardon *et al.*, 2009; Lubienski & Lubienski, 2008.

completion indicate significant negative selection effects for independent schools and (marginally) significant positive selection effects for Catholic schools for students born in 1970. In other words, students who have a higher than predicted probability of attending Catholic (independent) schools have a higher (lower) than predicted probability of completing high school within that system (p.68). The authors then used Blinder decompositions to determine the extent to which differential high-school completion rates were due to differences across school sectors in (a) observable characteristics of students, (b) the selection correction terms, and (c) a pure school effect, measured by differences in the coefficients of observable student characteristics. The authors concluded that the Catholic (independent) school effect for their 1970 cohort was negative (positive). Whilst this is an early study hinting at the possibility of negative Catholic school effects, the validity of the study depends upon the instruments used to identify the high school completion equations and, as already stated, the IVs are weak.

Miller and Voon (2011, 2012) estimated non-government school effects using National Assessment Program - Literacy and Numeracy (NAPLAN) test scores from the My School website.[7] For Year 3, they found positive and significant independent school effects across all learning domains and positive Catholic school effects in grammar, reading, spelling and writing, but not in numeracy. For Year 5, they found positive school sector effects for both sectors across all learning domains. However, their results are not directly comparable with those from other studies because they used school level data and consequently did not control for background characteristics of individual students.

Cardak and Vecci (2013) estimated the effect of Catholic school attendance on high school completion, university commencement and university completion for the 1998 cohort of the LSAY. They used the method of Altonji, Elder, and Taber (2005a) to estimate a range of values for each

[7] We discuss the NAPLAN data in more detail below.

Catholic school effect. Their lower bounds, which assume equality between selection on observables and unobservables, are all negative while their upper bounds, which assume zero selection on unobservables, are all positive. The authors conclude that the Catholic school effect is at best positive but much smaller than previously found by Vella, (1999) and Le and Miller (2003) and that it is possible that the Catholic school effect is zero or even negative for all three outcomes.

Nghiem *et al.* (2015) is the most recent and comprehensive analysis of the extent of non-government primary school effects in Australia. NAPLAN test scores of children from the Longitudinal Study of Australian Children (LSAC) were analysed using regression with extensive covariates, value-added regression and propensity score matching.[8] Oster's (2014) bounds analysis was also used to quantify the extent of selection on unobservables. The authors found that attending an independent primary school was not associated with any significant cognitive advantage as measured by NAPLAN test scores whereas attending a Catholic primary school was associated with negative effects, particularly in mathematics. Additionally the authors tested for non-government school advantages in several non-cognitive domains. They found no statistically significant effects except that Catholic school students had a lower incidence of peer problems than students in government schools.

Consistent with the US literature, the most recent studies suggest that there exists no significant cognitive achievement advantage to students attending a non-government school in Australia. We now briefly review findings from studies that have attempted to estimate heterogeneous treatment effects.

[8] We discuss the LSAC data in more detail below.

Heterogeneous Treatment Effects

Sander (1996) found that students in Catholic schools outperformed their government school counterparts in standardised reading, vocabulary and mathematics tests. After splitting his sample by religious affiliation he attributed his results to non-Catholics attending Catholic schools. Other early studies by Grogger *et al.* (2000), Evans and Schwab (1995) and Neal (1997) found substantial benefits of attending Catholic schools for urban minorities. The suggested reason was that the government schools available to minorities in urban areas are of substantially lower quality than those available to whites. Peterson and Llaudet (2006) found larger non-government school effects for black and Hispanic students. In the same study, heterogeneous treatment effects were also observed for measures of previous performance (with lower performance associated with larger effects) and socio-economic status (with disadvantage associated with larger effects). None of the above studies adequately controlled for selection bias (Jepsen, 2003 for a critique) so their findings provide little unequivocal support for a non-government school advantage.

The following two studies use more convincing methodology. Morgan (2001) used propensity score matching to estimate heterogeneous treatment effects according to the estimated likelihood of attending a US Catholic school. Students who were least likely to attend Catholic schools on the basis of their observed characteristics were found to experience the largest Catholic school advantage. The author offered a number of explanations for this phenomenon: self-selection among disadvantaged students according to the potential benefit from Catholic school attendance; Catholic schooling is particularly beneficial to students who have poor government schools alternatives; disadvantaged students becoming more studious due to the relatively larger financial sacrifice of their families; more equally distributed opportunities for learning in Catholic schools.

Altonji et al. (2005a), under the assumption of equal selection on observables and unobservables, found that Catholic high schools substantially increased the probability of graduating from high school (and more tentatively of attending college) and the effects were generally larger for urban minorities than for urban whites. However, Catholic high schools had no effect on twelfth grade reading test scores and little effect on mathematics scores for either group once family background and eighth grade outcomes were taken into account.

In summary, heterogeneous non-government school effects have received some attention by US researchers but in Australia the topic has been largely ignored. Our study adds to the literature by investigating whether non-government primary schools in Australia produce cognitive advantages for students categorised by gender, by the socio-economic status of their household, by metropolitan versus non-metropolitan residential area, and by whether the student's primary caregiver was born overseas. We address the problem of endogenous school choice by utilising inverse-probability-weighted regression adjustments with a control for student ability measured pre-school, a methodology which we believe has not been used previously in this area of research. In the following section we state our model and provide detailed information on our data.

III. Model and Data

The simplest model of school sector effects on academic achievement is:

$$Achievement_i = \beta_0 + \beta_1 C_i + \beta_2 I_i + \beta_3 X_i + \varepsilon_i \qquad i = 1,2,...n \qquad (1)$$

where C and I are binary variables indicating Catholic and independent school sectors, respectively (the omitted sector being government, G), X is a vector of child, household, environment and peer controls, ε is an unobservable, idiosyncratic error and the subscript refers to student i. Assuming X contains all relevant covariates, the coefficients β_1 and β_2 are the effects on academic achievement of attending Catholic and independent schools, respectively, rather than government schools. The validity of this model depends upon there being no non-random school-choice selection bias. To deal

with this issue, one strategy is to include a control variable that measures achievement prior to, or just after, commencing school.

In Model (1) the effects of the control variables on achievement, β_3, are the same for government, Catholic and independent schools. To model heterogeneous effects, interactions between C and I and a variable categorising students into groups of interest, such as male and female, could be added to Model (1). However, if β_3 differs across the three school sectors then achievement is better modelled separately for each sector:

$$Achievement_i^S = \beta_0^S + \beta^S X_i + \varepsilon_i^S \qquad i = 1, 2, ..., n_S \tag{2a}$$

where *S* is *G*, *C* or *I*, and choice of school sector is given by:

$$S_i = \gamma Z_i + \upsilon_i \qquad i = 1, 2, ..., n \tag{2b}$$

where *Z* is a vector of variables (possibly the same as *X*), γ is a vector of coefficients and ν is an unobservable, idiosyncratic error.

The effect on Catholic school students of attending a Catholic, rather than a government, school in Model (2) is:

$$E[(\beta^C - \beta^G)X \mid C] \tag{3a}$$

Similarly, the effect on independent school students of attending an independent, rather than a government, school is given by:

$$E[(\beta^I - \beta^G)X \mid I] \tag{3b}$$

Equations (3a) and (3b) are referred to as the average treatment effect on the treated, the treatment being attendance at a Catholic or an independent school, respectively, and the absence of treatment being attendance at a government school. Heterogeneous treatment effects are found by further conditioning on a variable of interest. For example, the Catholic and independent school effects for males and females are given by Equations (4a) and (4b), respectively:

$$E[(\beta^C - \beta^G)X \mid C, male] \quad \text{and} \quad E[(\beta^I - \beta^G)X \mid I, male] \tag{4a}$$

$$E[(\beta^C - \beta^G)X \mid C, female] \quad \text{and} \quad E[(\beta^I - \beta^G)X \mid I, female] \tag{4b}$$

The assumptions needed to identify treatment effects with Model (2) are threefold. The first is mean conditional independence, which states that after conditioning on covariates, government school achievement is independent of selection; no restriction is placed on the relationship between selection and non-government school achievement (Wooldridge, 2010, p.907). Second, each student has a positive probability of being enrolled in any school sector (the overlap assumption). Third, each student's achievement and choice of school sector are unrelated to the achievements and school sector choices of all other students in the population (the independent and identically distributed sampling assumption).[9] We estimated Model (2) using inverse-probability-weighted regression adjustment. This technique is termed 'doubly robust' meaning that it produces consistent estimators of treatment effects, provided either Equation (2a) or Equation (2b) is correctly specified (see Wooldridge, 2010, Section 21.3.4).

The data used for estimation are from the LSAC, the first and most extensive nationally representative survey of Australian children throughout their development. The LSAC follows two cohorts of children, one born between March 2003 and February 2004 (the B cohort) and the other born between March 1999 and February 2000 (the K cohort). Major surveys were conducted in 2004 (Wave 1) and every two years thereafter (Waves 2 through 5), with mail-out questionnaires in the intervening years. No more than one child per family is sampled in the LSAC and information is collected from the study child, his or her parents, childcare workers and teachers. In addition, information is linked at the individual level from the Australian Census, Medicare Australia and,

[9] We argue below that these three assumptions appear to be satisfied for Model 2.

importantly for this study, NAPLAN test scores which provide the measures of academic achievement used in this study.

The NAPLAN was implemented in 2008 and was designed to assess the literacy and numeracy skills of Australian students. In May of each year, standardised testing of students in Years 3 and 5 (primary school) and Years 7 and 9 (secondary school) is conducted. Students' academic capabilities are determined by separate examinations in reading, writing, spelling, grammar and numeracy. Construction of each examination follows the nationally agreed 'Statements of Learning' and focuses on the skills developed throughout the school curriculum (Australian Curriculum and Reporting Authority (ACARA, 2010). All eligible students are expected to take the examinations, with the exception of students with an intellectual disability and those who have recently immigrated and/or have limited English-speaking ability. Students who are absent on the day of examination are required to sit at a later time, preferably within the same week.[10]

Year 5 NAPLAN results for 2010 based on school level data and classified by school sector are presented in Table 2. On average, independent school students performed at a higher level than Catholic school students, and both performed at a higher level than government school students, on all five NAPLAN examinations. Table 2 also shows that, on average, annual progress between Years 3 and 5 ranges from 35.7 points for writing to 48.3 points for grammar. Annual student progress provides a benchmark against which to judge the effect of attending a non-government primary school on academic development, and will be the metric used in discussing the results of this study.[11]

The LSAC sample used in our econometric analysis is restricted to K-cohort children with matched Year 5 NAPLAN scores and observed covariate information. We also require the children

[10] Parents can choose to withdraw their children from NAPLAN testing and there is evidence that some schools persuade poorly performing students to absent themselves from the tests. The latter seems to have become more common over time.

[11] An alternative approach is to report school sector effects in standard deviations. We prefer to report our estimated school-sector effects in months of academic progress.

to be in the same school sector in Years 3 and 5, as switching obscures the effect of school sector in our (cross-sectional) analysis of NAPLAN results in Year 5.[12] Table 3 shows the number of observations in our final sample and the numbers lost in its construction. Our final sample contains 2,799 LSAC children, most of whom sat the Year 5 NAPLAN examinations in 2010.[13] Some children did not complete all five examinations and consequently the sample available for estimation varies across learning domains, from 2,765 for numeracy to 2,780 for reading.

School sector is recorded in the linked LSAC-NAPLAN file as government, Catholic or independent. Government schools are those operated by the state, offering education to students at no fee (though a voluntary contribution from parents is often requested). Catholic schools are those governed by the Catholic Education Commissions and Catholic Education Offices of each state and territory. Finally, the independent school system represents a heterogeneous body of private schools, more than 85 per cent of which provide religious instruction. Religious affiliations range from various Christian denominations to Muslim, Jewish and Hare Krishna. As presented in Table 3, 66 per cent of our 2,799 sample children attended government schools, 22 per cent attended Catholic schools and 12 per cent attended independent schools.

IV. Descriptive Statistics

Table 4 presents Year 5 NAPLAN results calculated using our sample both before, and after, the imposition of the constraints detailed in Table 3. The first point to note is that the loss of observations from 3,659 to 2,799 increased the mean test scores but had little effect on the

[12] We repeated the analysis under the requirement that children be in the same school sector in Years 1, 3 and 5, which excluded another 173 children, but as the results were little changed we prefer results based on the larger sample.

[13] In 2011 the writing examination changed from narrative to persuasive writing. This is problematic for longitudinal analysis of students' or schools' performance over a period spanning 2011. However, it is not a problem for the analysis of the type undertaken in this paper because the proportion of students in our sample who took the Year 5 NAPLAN tests in 2011 is not significantly different across school sectors.

differentials among pairs of school sectors.[14] In both samples, all differentials are statistically significant except those for spelling, grammar and numeracy between children attending Catholic and government schools. The second point to note is that, although the mean scores based on our samples are consistently larger than the mean scores reported in Table 2, the differentials among pairs of sectors are reasonably consistent, given Table 2 is based on school-level data and Table 4 is based on data at the individual level.

Table 5 gives descriptive statistics, which reveal statistically significant differences for most control variables between children attending government and non-government schools. Children in independent schools are a little older at the time of the Year 5 NAPLAN test. Children in government schools are more likely to be Aboriginal or of Torres Straight Island origin, and are more likely to have a mother who smoked during pregnancy.[15] Children in government schools score lower on the "Who Am I?" test, which is taken when the child is 4-5 years old and is a measure of school readiness. Its inclusion is important because it measures the child's innate ability.[16] Children in government schools are more likely to live in a single-parent household, in a household without an employed parent, and are less likely to live in a household with at least one highly educated parent.

[14] The imposition of restrictions on our sample, particularly the requirements of no change of school sector and no missing data on child characteristics, results in a disproportionate loss of observations for children attending independent schools and, to a lesser extent Catholic schools, compared with government schools. Since this had little effect on the school sector differentials in Table 4, we do not pursue this issue further.

[15] The latter is thought to interfere with the developmental process between conception and birth and has been found to correlate with later intellectual capacity (Olds, Henderson and Tatelbaum 1994).

[16] We do not use NAPLAN results in Year 3 as a control because they are missing for a large group of LSAC students. Comprising approximately 23 percent of the sample, these students began school earlier than the majority of the NAPLAN sample due to varying state regulations or parental choice (Daraganova, Edwards & Sipthorp, 2013). Of these students with no Year 3 NAPLAN scores, around 50 percent are from Queensland where school is started 6 months later but begins in year 1. As a result, Queensland students have completed one year less of school at the time of the NAPLAN test. Overall, this censoring produces an LSAC sample of Year 3 NAPLAN students which is, on average, 3 months older than the NAPLAN population.

Their weekly, equivalised, household incomes[17] are also lower on average and they are less likely to have access to a computer at home. Children in independent schools are more likely to have a primary caregiver (PCG) who was born overseas. The neighbourhoods in which government school children live are more disadvantaged and less safe, on average.[18]

The Index of Community Socio-Educational Advantage (ICSEA) is also a control. The ICSEA is a numerical scale applicable to the school that the child attends. It combines the education levels and occupations of the parents of students attending the school, the degree of remoteness of the school, the percentage of students in the school who are indigenous and the percentage of students in the school who have a language background other than English (Gonski et al., 2011, p.81). The ICSEA was developed to identify schools serving similar student populations. We include it as a proxy for peer effects. The notion that student outcomes are dependent on the characteristics of their peers is well established in the literature (e.g. Sacerdote, 2011). Given the heterogeneity of student characteristics across school sectors, there is potential for peer effects to influence estimates of Catholic and independent school effects. Controlling for peer effects should offer a more accurate measure of the effect of organisational characteristics of Catholic and independent schools.

V. Results

Estimates of Catholic and independent school effects are presented in Table 6. Applying the annual progress measures given in the last row of Table 2, the coefficients were converted into months of progress and appear in italics in Table 6. The first section of the table shows results from Model 1. The estimates take account of the complex nature of the sample design and attrition

[17] Weekly household income was converted to 2014 dollars, using the consumer price index, and equivalised by dividing by the square root of the number of people in the household. The square root scale was chosen because it is simple and widely used.

[18] The controls for household and environmental characteristics were averaged over the waves of LSAC prior to when NAPLAN tests were taken.

between waves. With child, household and environmental characteristics and the ICSEA held constant, there is no evidence that children in independent schools perform better or worse academically than children in government schools. However, there is evidence that children in Catholic schools are between 2.3 and 3.2 months less advanced than children in government schools in spelling, grammar and numeracy. These results are very similar to those of Nghiem et al. (2015).

However, an F-test rejected the hypothesis that the effects of the control variables on NAPLAN scores are the same in all three sectors, so the remainder of Table 6 is based on Model 2. The assumptions of Model 2 appear to be satisfied. Consistent with the conditional independence assumption, after weighting, the control variables appear balanced across G, C and I schools, as would occur if students had been randomly assigned to school sector (see Appendix A). Density plots appear consistent with the overlap assumption (see Appendix B). Only one child per household is in the LSAC sample, which is consistent with the independent and identically distributed sampling assumption. Model 2 was estimated using inverse-probability-weighted regression adjustment. Once again, for children as a whole, there is no consistent statistically significant evidence of an independent school differential in NAPLAN performance, whilst children in Catholic schools are approximately three months less advanced than children in government schools in spelling, grammar and numeracy.

For Catholic schools, when separate analyses are conducted for males and females, students from high and low socio-economic status households, students whose primary caregiver is and is not Australian born, and children from metropolitan and non-metropolitan areas, similar results are observed: Catholic school students are between two and nearly five months behind their counterparts in government schools in spelling, grammar and numeracy.

Results obtained for the separate groups of students indicate no advantage from attending an independent, rather than a government school, with two possible exceptions. For children whose primary caregiver is not Australian born, those who attended independent schools did better than

their counterparts in government schools in writing (particularly) and spelling.[19] However, these schools are quite diverse in nature and only 87 children in our data set are in this group so the results should be treated with caution. There is also some evidence that students from independent schools in metropolitan areas are more advanced in reading and grammar than their counterparts in government schools, and that students from independent schools in non-metropolitan areas are more advanced in writing than their counterparts in government schools.

VI. Conclusion

To the best of our knowledge, this study is the first to investigate whether heterogeneous school sector effects exist for a cohort of Year 5 students enrolled in Australian primary schools. The raw data suggest substantial Catholic and independent school sector advantages over government schools. However, consistent with the results in Nghiem *et al.* (2015) and other recent studies, after holding constant a range of student, family and other covariates, we find that government school students perform no worse than independent school students, and somewhat better than their Catholic school counterparts in spelling, grammar and numeracy.

It could be argued that non-government schools are better at catering to the needs of specific categories of students. Whilst there may be some truth to this, we find no heterogeneous treatment effects for students categorised by gender or socio-economic status. There is some evidence that children with a non-Australian born primary caregiver benefit academically from attending independent schools and residential location also seems to have some importance in determining the effectiveness of independent schools. These results are interesting enough to warrant further investigation but that would require a larger set of data than the LSAC.

[19] Recent media coverage has suggested that the supposed private school advantage in Australia and elsewhere is driven in large part by students whose primary caregiver is Asian, and particularly Chinese (see, for example, the article by W. Mansell in The Guardian newspaper, 8 February 2011). We tested the sensitivity of our results to this possibility by excluding all students with primary caregivers from Southeast Asia including China, Japan and Korea, and re-estimating. Doing so made no substantive difference to our conclusions (results available from the authors on request).

Our results raise further questions concerning educational resource allocation. Since the mid-1970s, the Commonwealth and State governments have allocated public funds on a per-capita basis to non-government schools (Campbell, 2009). In 2010, government funding for recurrent and capital expenditures per full-time equivalent student averaged $13,807 for government primary schools, $12,649 for Catholic primary schools, and $12,352 for independent primary schools.[20] At first blush, subsidising non-government schools to this extent may appear to be efficiency enhancing: non-government schools achieved similar learning outcomes (at least in Year 5) to those of government schools for around nine per cent less government funding.

But when we consider expenditures per student from all sources across the sectors the respective figures are $14,304 for government schools, $14,420 for Catholic schools, and $17,607 for independent schools. In other words, non-government schools cost society up to 20 per cent more per student, marginal expenditures which appear to be producing few if any educational benefits at the margin, both for non-government school students as a whole and, as we have shown in this study, for particular categories of non-government school students. Whilst we agree with Petersen and Llaudet (2006) who caution against inferring school sector effects from observations made at a single point in time, there now appears to be a growing tide of empirical results which suggest that the educational productivity of government schools may not be very different to that of non-government schools, despite common perceptions to the contrary.

[20] Calculated using data from file 'lsacmyschool_gr.dta', provided with LSAC_Wave 5_GR_R2_2014.

References

ABS (2013). *Schools Australia 2011*. Canberra, ABS. Cat. No. 4221.0

ABS (2001). *2001 Year Book Australia*. Canberra, ABS. Cat. No. 1301.0.

ACARA (2010). *My Schools Fact Sheet*. Sydney, NSW.

Altonji, J., Elder, T. & Taber, C. (2005a). Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools. *Journal of Political Economy*, 113(1), 151-84.

Altonji, J., Elder, T. & Taber, C. (2005b). An Evaluation of Instrumental Variable Strategies for Estimating the Effects of Catholic Schools. *Journal of Human Resources* 40 (4), 791–821.

Braun, H., Grigg, W., Jenkins, F., & Tirre, W. (2006). *Comparing Private Schools and Public Schools Using Hierarchical Linear Modeling*. U.S. Department of Education, NCES 2006-461. Washington.

Buckingham, J. (2010). *The Rise of Religious Schools*. Sydney, NSW.

Campbell, C. (2009). *School choice : How Parents Negotiate the New School Market in Australia*. Crows Nest, NSW: Allen & Unwin.

Cardak, B.A. & Vecci, J. (2013). Catholic School Effectiveness in Australia: A Reassessment using Selection on Observed and Unobserved Variables. *Economics of Education Review*, 37, 34-45.

Chubb E, J. & Moe, T, M. (1990). *Politics, Markets & America's Schools* (1st ed.). Washington, DC: Brookings Institution Press.

Cohen-Zada, D. (2009). An Alternative Instrument for Private School Competition. *Economics of Education Review*, 28, 29–37.

Cohen-Zada, D. & Elder, T. (2009). Historical Religious Concentrations and the Effects of Catholic Schooling. *Journal of Urban Economics*, 66(1), 65-74.

Coleman, J., Hoffer, T. & Kilgore, S. (1982). Cognitive Outcomes in Public and Private Schools. *Sociology of Education*, 55(2), 65-76.

Daraganova, G., Edwards, E. & Sipthorp, M. (2013). *Using National Assessment Program - Literacy and Numeracy (NAPLAN) Data in the Longitudinal Study of Australian Children (LSAC)* (No. 6). Melbourne, VIC.

Davies, S.(2013). Are there Catholic School Effects in Ontario? *European Sociological Review*, 29(4), 871-83.

Dronkers, J. & Avram S. (2010a). A Cross-National Analysis of the Relations of School Choice and Effectiveness Differences between Private-Dependent and Public Schools. *Educational Research and Evaluation*, 16(2), 151-75.

Dronkers, J. & Avram S. (2010b). A Cross-National Analysis of the Relations of School Choice and Effectiveness Differences between Private-Independent and Public Schools. *Sociological Theory and Methods*, 25(2), 183-205.

Elder, T. & Jepsen, C. (2014). Are Catholic Primary Schools More Effective Than Public Primary Schools? *Journal of Urban Economics*, 80 (March), 28-38.

Evans, W.N. & Schwab, R.M. (1995). Finishing High School and Starting College: do Catholic Schools Make a Difference?. *The Quarterly Journal of Economics*, 110 (4), 941-74.

Friedman, M. (1955). The Role of Government in Education. In Robert A. Solo (Ed.), *Economics and the Public Interest* (1st ed., pp. 124-44). New Brunswick, NJ: Rutgers University Press.

Gibbons, S. & Silva, O. (2013). Faith Primary Schools : Better Schools or Better Pupils? *Journal of Labor Economics*, 29(3), 589-635.

Gonski, D., Boston, K., Greiner, K., Lawrence, C., Scales, B. & Tannock, P. (2011). *Review of Funding for Schooling*. Canberra, ACT.

Grogger, J. & Neal, D. (2000). Further Evidence on the Effects of Catholic Secondary Schooling . *Brookings-Wharton Papers on Urban Affairs*, 151–93.

Hoffer, T., A. Green & J. Coleman (1985). Achievement Growth in Public and Catholic Schools. *Sociology of Education*, 58(2), 74-97.

Jepsen, C. (2003). The Effectiveness of Catholic Primary Schooling. *Journal of Human Resources*, 38(4), 928-41.

Le, A. T. & Miller, W. (2003). Choice of School in Australia: Determinants and Consequences. *The Australian Economic Review*, 36, 55-78.

Lefebvre, P., Merrigan, P. & Verstraete, M. (2011). Public Subsidies to Private Schools Do Make a Difference for Achievement in Mathematics: Longitudinal Evidence from Canada. *Economics of Education Review*, 30(1), 79-98.

Lubienski, S.T. & Lubienski, C. (2006). School Sector and Academic Achievement: A Multilevel Analysis of NAEP Mathematics Data. *American Educational Research Journal* 43(4), 651-98.

Lubienski, C., Crane, C. & Lubienski, S.T. (2008). What Do We Know about School Effectiveness? Academic Gains in Public and Private Schools. *Phi Delta Kappan* 89(9), 689–95.

Miller, P. W. & Voon, D. (2011). Lessons from My School. *Australian Economic Review*, 44(4), 366-86.

Miller, P. W. & Voon, D. (2012). Government versus Non-Government Schools: A Nation-Wide Assessment Using Australian NAPLAN Data. *Australian Economic Papers*, 51(3), 147-66.

Morgan, S.L. (2001). Counterfactuals, Causal Effect Heterogeneity, and the Catholic School Effect on Learning. *Sociology of Education*, 74 (4), 341–74.

Neal, D. (1997). The Effects of Catholic Secondary Schooling on Educational Achievement. *Journal of Labour Economics*, 15(1), 98-123.

Nghiem. H.S., Nguyen, H.T., Khanam R. & Connelly, L.B. (2015). Does School Type Affect Cognitive and Non-Cognitive Development in Children? Evidence from Australian Primary Schools. *Labour Economics*, 33, 55–65.

Noell, J. (1982). Public and Catholic Schools : A Reanalysis of Public and Private Schools. *Sociology of Education*, 55(2), 123-32.

Olds, D. L., Henderson, C. R. & Tatelbaum, R. (1994). Intellectual Impairment in Children of Women who Smoke Cigarettes During Pregnancy. *Pediatrics*, 93(2), 221-7.

Oster, E. (2014). Unobservable Selection and Coefficient Stability: Theory and Evidence. NBER Working Paper No. 19054.

Peterson, P. E. & Llaudet, E. (2006). On the Public-Private School Achievement Debate. Program on Education Policy and Governance, Research Paper 06-02, John F. Kennedy School of Government, Harvard University, Cambridge, MA.

Reardon, S. F., Cheadle, J. E. & Robinson, J. P. (2009). The Effect of Catholic Schooling on Math and Reading Development in Kindergarten Through Fifth Grade. *Journal of Research on Educational Effectiveness*, 2(1), 45-87.

Sacerdote, B. (2011). Peer Effects in Education: How Might They Work, How Big Are They and How Much Do We Know Thus Far? In E. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the Economics of Education,* 1st Ed., vol. 3, pp. 175-33). North Holland.

Sander, W. (1996). Catholic Grade Schools and Academic Achievement. *Journal of Human Resources*, 31(3), 540-8.

Sander, W. & Krautman, A. (1995). Catholic Schools, Dropout Rates and Educational Attainment. *Economic Inquiry*, 33(2): 217-33.

Vella, F. (1999). Do Catholic Schools Make a Difference? *Journal of Human Resources*, 34(1), 208-24.

Williams, T. & Carpenter, P. (1991). Private Schooling and Public Achievement in Australia. *International Journal of Educational Research*, 15(5), 411-31.

Wooldridge, J.M. (2010). *Econometric Analysis of Cross Section and Panel Data*. 2nd ed. Cambridge, MA: MIT Press.

Table 1. Academic Effects of Non-Government Schools

Study	Sector	Country	Method	Domain	Level	Effect
Secondary School Effects						
Altonji *et al.*, 2005a	C	USA	ATE	Reading, maths	Year 12	n.s.
				High school completion, college attendance	Year 12	Positive
Braun *et al.*, 2006	Pr	USA	HLM	Reading	Year 8	Positive
				Maths	Year 8	n.s.
Cardak & Vecci, 2013	C	Australia	ATE	High school completion	Age 20-25	n.s.
				University attendance, university completion	Age 23-25	n.s.
Coleman *et al.*, 1982	C	USA	OLS	Vocabulary, maths	Years 10,12	Positive
				Reading	Years 10,12	n.s.
Cohen-Zada & Elder, 2009	C	USA	OLS, IV	Reading, maths	Year 12	n.s.
Dronkers & Avram, 2010a	Pr-dep	26 nations	PSM	Reading	Age 15	10+,2-,14 n.s.
Dronkers & Avram, 2010b	Pr-ind	26 nations	PSM	Reading	Age 15	7+,4-,15 n.s.
Elder & Jepsen, 2014	C	USA	OLS-LDV, PSM, AET	Reading	Year 8	n.s.
				Maths	Year 8	Negative
Evans & Schwab, 1995	C	USA	Probit, IV	High school completion, college attendance	Year 12	Positive
Grogger & Neal, 2000	C	USA	Probit	High school completion	Years 8-12	Positive
Hoffer *et al.*, 1985	C	USA	VA	Vocabulary and maths	Years 10-12	Positive
Le & Miller, 2003	C	Australia	LPM, Probit (IV)	High school completion	Year 12	Positive
Lefebvre *et al.*, 2011	Private	Canada	FE	Maths	Years 7 & 8	Positive
Miller & Voon, 2011, 2012	C & I	Australia	OLS	Reading, writing, spelling, grammar, maths	Years 7, 9	Positive
Morgan, 2001	C	USA	PSM	Maths & reading	Years 10,12	Positive

Table 1 continued. Academic Effects of Non-Government Schools

Study	Sector	Country	Method	Domain	Level	Effect
Neal, 1997	C	USA	Probit (IV)	High school & college completion, wages	Age 14-21 & not in school	Positive
Noell, 1982	C	USA	OLS, IV	Maths & reading	Years 10, 12	n.s.
Peterson & Llaudet, 2006	C & I	USA	HLM	Reading & maths	Year 8	Positive
Sander, 1996	C	USA	OLS, 2SLS	Reading, vocab, maths, science	Year 10	Positive
Sander & Krautman, 1995	C	USA	Bivariate probit (IV)	High school completion Educational attainment	Year 10 Year 12	Positive n.s.
Vella, 1999	C	Australia	Probit (IV)	High-school completion, higher educational attainment, labour-market outcomes	Age 16-24 & not in school	Positive
Williams & Carpenter, 1991	C & I	Australia	OLS Logit	Reading/maths/ vocab High-school completion, university entry	Age 14 Age 19	Positive Positive
Primary School Effects						
Braun et al., 2006	Pr	USA	HLM	Reading Maths	Year 4 Year 4	n.s. Negative
Davies, 2012	C	Canada	PSM	Reading, writing, maths	Year 3	Small
Elder & Jepsen, 2014	C	USA	OLS-LDV, PSM, AET	Reading Maths	Year 5 Year 5	n.s. Negative
Elder & Jepsen, 2014	C	USA	PSM	Maths and reading	Grades 5 & 8	Negative
Gibbons & Silva, 2011	C/CoE	England	VA, SS-FE & AET	English/ maths	Year 5	n.s.
Jepsen, 2003	C	USA	VA	Maths and reading	Year 4	n.s.
Lubiesnki et al., 2008	C & I	USA	HLM, VA	Maths	Year 5	Negative
Miller & Voon, 2011, 2012	C & I	Australia	OLS	Reading, writing, spelling, grammar, maths	Years 3, 5	Positive

Table 1 continued. Academic Effects of Non-Government Schools

Study	Sector	Country	Method	Domain	Level	Effect
			PSM	Reading, writing	Year 5	n.s.
Nghiem *et al.*, 2015	C	Australia	PSM	Spelling, grammar, maths	Year 5	Negative
			VA, Oster	Reading, writing, spelling, grammar, maths	Year 5	Negative
			PSM	Reading	Year 5	Positive
Nghiem et al., 2015	I	Australia	PSM	Writing, spelling, grammar, maths	Year 5	n.s.
			VA, Oster	Reading, writing, spelling, grammar, maths	Year 5	n.s.
Peterson & Llaudet, 2006	C & I	USA	HLM	Reading & maths	Year 4	Positive
Reardon *et al.*, 2009	C	USA	PSM	Reading	Years 3, 5	n.s.
			PSM	Maths	Years 3, 5	Negative
Williams & Carpenter, 1991	C & I	Australia	OLS	Reading/math/ vocabulary	Age 10	n.s.

Notes: C = Catholic; I = Other Independent; CoE = Church of England; Pr-dep = private and government funded; Pr-ind = private and not government funded; n.s. = no statistically significant effect; AET = Altonji, Elder & Taber's bounds analysis; HLM = hierarchical linear models (students within schools); LDV = lagged dependent variable; LPM = linear probability model; MB-FE = market-based fixed effects; OLS = ordinary least squares; Oster = Oster's bounds analysis; PSM = propensity score matching; SS-FE = secondary school fixed effects; VA = value added.

Table 2. School Level NAPLAN Performance, by School Sector

		NAPLAN Score, Year 5, 2010 (3,699 schools)				
A. School Sector		Reading	Writing	Spelling	Grammar	Numeracy
Government	mean	483.1	482.3	484.2	495.5	487.3
	st dev	35.1	29.4	30.2	37.9	35.3
	n	2215	2214	2214	2214	2212
Catholic	mean	497.3	496.6	492.7	509.7	493.2
	st dev	24.5	21.0	21.5	26.3	23.6
	n	704	704	704	704	704
Independent	mean	520.9	509.5	506.4	530.7	517.7
	st dev	29.1	24.0	23.6	30.2	30.0
	n	473	471	473	473	472
Differences in Performance						
Catholic - government	mean	14.2	14.3	8.5	14.2	5.9
	signif	***	***	***	***	***
Independent - government	mean	37.8	27.2	22.1	35.2	30.5
	signif	***	***	***	***	***
Independent - Catholic	mean	23.6	12.9	13.7	21.0	24.6
	signif	***	***	***	***	***
B. All Sectors						
Year 5, 2010	mean	494.4	491.2	490.9	506.3	495.4
Year 3, 2008	mean	407.5	419.8	404.9	409.6	402.8
Progress per year	mean	43.5	35.7	43.0	48.3	46.3

Source: File 'lsacmyschool_gr.dta', provided with LSAC_Wave 5_GR_R2_2014.
Notes:
1. Averages were weighted by total school enrolments.
2. ***, **, * indicate significant differences at the 0.1, 1 and 5 per cent levels, respectively.

Table 3. Number of Children in the Sample

	Government	Catholic	Independent	All Sectors
Wave 1 (2004)				4983
Wave 4 (2010)				4169
With NAPLAN Year 5 Results (2009-11)	2,366	789	504	3,659
Same School Sector	2,289	724	411	3,424
Child Characteristics	1,936	630	336	2,902
Household Characteristics	1,880	617	323	2,820
Local Environment	1,860	616	323	2,799
Year 5 NAPLAN in 2009	465	138	56	659
Year 5 NAPLAN in 2010	1,297	458	247	2,002
Year 5 NAPLAN in 2011	98	20	20	138
Gender				
Male	966	306	162	1,434
Female	894	310	161	1,365
Socio-Economic Status				
High	854	306	197	1,357
Low	1,006	310	126	1,442
Primary Caregiver				
Australian Born	1,474	509	236	2,219
Not Australian Born	386	107	87	580
Location				
Metropolitan	1,099	371	210	1,680
Not Metropolitan	761	245	110	1,119
Reading	1,848	613	319	2,780
Writing	1,835	614	322	2,771
Spelling	1,841	614	322	2,777
Grammar	1,841	614	322	2,777
Numeracy	1,835	611	319	2,765

Source: LSAC_Wave 5_GR_R2_2014.
Note: One LSAC child who completed Year 5 NAPLAN in 2008 was excluded from our sample.

Table 4. Estimates of NAPLAN Performance, by School Sector

		NAPLAN Score, Year 5, 2010 (Sample of 3,659 Children)				
A. School Sector		Reading	Writing	Spelling	Grammar	Numeracy
Government	mean	492.2	482.8	487.9	502.9	492.5
	s.e.	2.6	2.0	2.2	2.7	2.3
	n	2,350	2,336	2,342	2,342	2,332
Catholic	mean	504.1	498.2	492.5	511.1	494.5
	s.e.	3.5	2.9	2.8	3.5	2.8
	n	785	785	785	785	782
Independent	mean	525.2	510.2	503.6	533.1	514.7
	s.e.	4.4	3.4	3.2	4.4	4.2
	n	499	502	502	502	499
Differences in Performance						
Catholic - government	mean	11.9	15.4	4.6	8.2	1.9
	signif	**	***			
Independent - government	mean	33.0	27.4	15.7	30.2	22.2
	signif	***	***	***	***	***
Independent - Catholic	mean	21.1	12.0	11.1	22.0	20.2
	signif	***	**	*	***	***

		NAPLAN Score, Year 5, 2010 (Sample of 2,799 Children)				
B. School Sector		Reading	Writing	Spelling	Grammar	Numeracy
Government	mean	497.4	485.7	490.6	509.3	495.8
	s.e.	2.8	2.3	2.3	2.8	2.4
	n	1,848	1,835	1,841	1,841	1,835
Catholic	mean	507.9	501.4	492.9	515.9	497.8
	s.e.	3.7	3.0	3.0	3.4	2.8
	n	613	614	614	614	611
Independent	mean	532.9	513.9	505.9	539.5	520.0
	s.e.	4.7	4.2	3.7	5.1	4.5
	n	319	322	322	322	319
Differences in Performance						
Catholic - government	mean	10.5	15.6	2.3	6.6	2.0
	signif	*	***			
Independent - government	mean	35.5	28.2	15.3	30.2	24.2
	signif	***	***	***	***	***
Independent - Catholic	mean	25.0	12.6	13.1	23.6	22.2
	signif	***	*	**	***	***

Source: LSAC_Wave 5_GR_R2_2014.
Notes:
1. Means and standard errors were calculated using svy commands to account for complex random sampling and attrition between waves.
2. ***, **, * indicate significantly different from zero at the 0.1, 1 and 5 per cent levels, respectively.

Table 5: Descriptive Statistics by School Sector

Variable	Government	Catholic	Independent	C-G	I-G	I-C
Child Characteristics						
Mean age in months at Naplan test	125.53	125.58	126.71		***	**
% female	47.81	50.98	50.23			
% indigenous	3.74	0.66	0.47	***	***	
Mean WAI test score at age 4-5 years	63.77	65.03	65.41	**	**	
% mother smoked during pregnancy	23.65	13.49	6.72	***	***	**
Birth weight (grams)	3381.18	3429.06	3450.68			
Household Characteristics						
Highest parental level of employment:						
% unemployed	2.81	0.89	1.06	***	**	
% not in labour force	8.59	2.09	3.45	***	***	
Highest parental level of education:						
% less than Year 11	7.93	5.72	2.95		***	
% Year 11 or 12	11.18	8.02	5.68	*	***	
% bachelor degree	46.38	43.08	31.84		***	**
% higher degree	12.69	19.68	25.24	***	***	
% other	17.59	20.13	31.32		***	***
Mean, equivalised, weekly h'hold income ($00)	8.72	10.00	13.29	***	***	***
% with access to a computer at home	85.16	90.38	90.99	***	***	
% with >30 books in the home	82.64	84.63	88.88		**	
% single-parent family	16.33	8.24	9.99	***	**	
Mean number of siblings	1.56	1.61	1.45			*
% PCG not born in Australia	22.61	19.76	29.49		*	**
Neighbourhood Characteristics						
Neighbourhood SEIFA index	1002.73	1012.00	1024.13	*	***	*
% living in safe neighbourhood	91.77	94.61	93.98	**		
% living in remote area	3.94	4.14	1.91		*	
ICSEA Index	1012.20	1058.67	1097.64	***	***	***

Source: LSAC_Wave 5_GR_R2_2014.

Notes: 1. Means and standard errors were calculated using svy commands in Stata to account for complex random sampling and attrition between waves.

2. *, ** and *** indicate significantly different from zero at the 5%, 1% and 0.1% levels, respectively.

Table 6: Estimates of School Sector Effects

Model 1		Reading		Writing		Spelling		Grammar		Numeracy	
All	Catholic	-5.56		1.39		-8.25	*	-9.78	**	-12.45	***
		-1.53		*0.47*		*-2.30*		*-2.43*		*-3.23*	
	Independent	2.71		0.89		-7.12		-0.94		-4.27	
		0.75		*0.30*		*-1.99*		*-0.23*		*-1.11*	
Model 2											
All	Catholic	-5.82		-0.03		-9.84	**	-10.88	**	-11.80	***
		-1.61		*-0.01*		*-2.74*		*-2.70*		*-3.06*	
	Independent	5.97		-0.22		-1.99		1.98		2.20	
		1.65		*-0.08*		*-0.56*		*0.49*		*0.57*	
Males	Catholic	-1.59		3.96		-11.55	*	-8.10		-13.85	**
		-0.44		*1.33*		*-3.22*		*-2.01*		*-3.59*	
	Independent	7.55		11.39		1.46		8.87		1.59	
		2.08		*3.83*		*0.41*		*2.20*		*0.41*	
Females	Catholic	-9.50		-3.67		-9.27	*	-15.57	**	-10.05	*
		-2.62		*-1.23*		*-2.59*		*-3.87*		*-2.60*	
	Independent	0.97		0.16		-3.94		-3.35		3.05	
		0.27		*0.05*		*-1.10*		*-3.87*		*0.79*	
High SES	Catholic	-4.92		4.26		-10.06	*	-10.16	*	-16.15	***
		-1.36		*1.43*		*-2.81*		*-2.52*		*-4.19*	
	Independent	6.42		4.61		-6.64		2.82		0.23	
		1.77		*1.55*		*-1.85*		*0.70*		*0.06*	
Low SES	Catholic	-10.99		-4.33		-11.50	*	-19.22	**	-7.92	
		-3.03		*-1.46*		*-3.21*		*-4.78*		*-2.05*	
	Independent	0.59		0.39		4.48		-6.51		9.96	
		0.16		*0.13*		*1.25*		*-1.62*		*2.58*	
PCG-Aust	Catholic	-5.03		-0.39		-8.23	*	-9.86	*	-9.50	*
		-1.39		*-0.13*		*-2.30*		*-2.45*		*-2.36*	
	Independent	2.19		-6.88		-2.03		-3.16		6.52	
		0.60		*-2.31*		*-0.57*		*-0.78*		*1.62*	
PCG-notAust	Catholic	-10.02		3.48		-13.75		-18.48	*	-16.93	**
		-2.77		*1.17*		*-3.84*		*-4.59*		*-4.21*	
	Independent	18.83		38.77	***	18.49	*	21.95		9.57	
		5.20		*13.03*		*5.16*		*5.45*		*2.38*	
Metro	Catholic	-5.06		4.16		-9.72	*	-9.03		-11.54	**
		-1.40		*1.40*		*-2.71*		*-2.24*		*-2.99*	
	Independent	17.39	**	7.46		7.54		20.82	*	11.90	
		4.80		*2.51*		*2.11*		*5.17*		*3.08*	
Non_Metro	Catholic	-11.17		-4.37		-11.75		-17.99	**	-13.35	*
		-3.08		*-1.47*		*-3.28*		*-4.47*		*-3.46*	
	Independent	-0.64		15.14	*	2.88		4.14		5.32	
		-0.18		*5.09*		*0.80*		*1.03*		*1.38*	

Source: LSAC_Wave 5_GR_R2_2014.
Notes: 1. *, ** and *** indicate significantly different from zero at the 5%, 1% and 0.1% levels, respectively.
2. Coefficients expressed in months of progress are in italics.
3. Model 1 was estimated using 'svy' commands in Stata 14.
4. Model 2 was estimated using 'teffects' commands in Stata 14.

Appendix A: The Conditional Mean Independence

Consistent with the mean conditional independence assumption, weighting the covariates achieves balance in most cases. For government versus Catholic schools, weighted standardised differences are closer to zero than raw standardised differences in 25 out of 27 cases and weighted variance ratios are closer to unity than are variance ratios in 25 out of 27 cases. For government versus independent schools, weighted standardised differences are closer to zero than raw standardised differences in 24 out of 27 cases and weighted variance ratios are closer to unity than are variance ratios in 24 out of 27 cases.

Government Vs Catholic Schools	Standardised Differences		Variance Ratio	
	Raw	Weighted	Raw	Weighted
Child Characteristics				
Mean age in months at Naplan test	0.009	-0.002	0.881	0.947
% female	0.047	-0.025	1.003	1.001
% indigenous	-0.160	0.014	0.248	1.190
Mean WAI test score at age 4-5 years	0.120	-0.017	0.887	0.888
% mother smoked during pregnancy	-0.229	0.002	0.643	1.004
Birth weight (grams)	0.059	-0.040	0.841	0.892
Household Characteristics				
Highest parental level of employment:				
% unemployed	-0.182	0.021	0.335	1.121
% not in labour force	-0.269	0.018	0.345	1.529
Highest parental level of education:				
% less than Year 11	-0.095	-0.013	0.690	0.938
% Year 11 or 12	-0.099	-0.001	0.753	0.958
% bachelor degree	0.181	0.002	1.326	0.998
% higher degree	0.038	-0.011	1.050	0.987
% other	-0.030	0.014	0.882	1.047
Mean, equivd, weekly hh income ($00)	0.180	0.008	0.932	0.844
% with access to a computer at home	0.163	0.006	0.615	0.848
% with >30 books in the home	0.081	0.037	0.869	0.977
% single-parent family	-0.229	0.009	0.578	1.067
Mean number of siblings	0.055	-0.031	0.942	0.994
% Parent 1 not born in Australia	-0.086	-0.018	0.875	0.971
Neighbourhood Characteristics				
SEIFA index – quartile 2	-0.038	-0.031	0.961	0.967
SEIFA index – quartile 3	0.041	0.000	1.055	1.000
SEIFA index – quartile 4	0.041	-0.048	1.050	0.950
% living in safe neighbourhood	0.129	0.014	0.668	1.000
% living in remote area	-0.001	0.016	1.046	1.098
ICSEA Index – quartile 2	-0.038	-0.002	0.961	0.997
ICSEA Index – quartile 3	0.566	0.025	1.666	1.008
ICSEA Index – quartile 4	0.102	-0.009	1.145	0.989

Appendix A: The Conditional Mean Independence (continued)

Government Vs Independent Schools	Standardised Differences		Variance Ratio	
	Raw	Weighted	Raw	Weighted
Child Characteristics				
Mean age in months at Naplan test	0.207	0.004	0.859	0.942
% female	0.045	-0.076	1.004	0.999
% indigenous	-0.197	-0.024	0.119	0.705
Mean WAI test score at age 4-5 years	0.197	-0.042	0.964	1.001
% mother smoked during pregnancy	-0.408	0.006	0.373	1.015
Birth weight (grams)	0.119	0.023	0.956	1.129
Household Characteristics				
Highest parental level of employment:				
% unemployed	-0.193	0.070	0.344	1.408
% not in labour force	-0.200	-0.044	0.448	0.682
Highest parental level of education:				
% less than Year 11	-0.174	-0.002	0.431	1.010
% Year 11 or 12	-0.239	-0.069	0.460	0.772
% bachelor degree	0.340	0.059	1.613	1.106
% higher degree	0.338	0.071	1.402	1.093
% other	-0.114	-0.106	0.550	0.537
Mean, equivd, weekly hh income ($00)	0.575	-0.027	3.462	1.024
% with access to a computer at home	0.225	0.053	0.577	0.823
% with >30 books in the home	0.174	-0.094	0.662	1.329
% single-parent family	-0.202	-0.007	0.647	1.091
Mean number of siblings	-0.070	0.052	0.869	1.073
% Parent 1 not born in Australia	0.140	0.024	1.193	1.040
Neighbourhood Characteristics				
SEIFA index – quartile 2	-0.045	-0.096	0.955	0.894
SEIFA index – quartile 3	0.143	0.105	1.178	1.119
SEIFA index – quartile 4	0.181	0.004	1.202	1.004
% living in safe neighbourhood	0.047	-0.053	0.904	1.008
% living in remote area	-0.140	0.034	0.458	1.117
ICSEA Index – quartile 2	-0.330	0.002	0.607	1.003
ICSEA Index – quartile 3	0.378	-0.004	1.534	0.999
ICSEA Index – quartile 4	0.638	0.031	1.544	1.035

	Observations	
	Raw	Weighted
Government schools	1844	900.1
Catholic schools	609	937.9
Independent schools	318	932.9
Total	2771	2771.0

Note: Stata 14's 'tebalance summarize' routine was used to calculate summary statistics

Appendix B: The Overlap Assumption – Density Plots

Stata 14's 'teffects overlap' routine was used to produce density plots. They show the probability of government school students attending government schools (G), Catholic school students attending government schools (C) and independent school students attending government schools (I).

Consistent with the overlap assumption, the estimated density plots have considerable mass in the regions where they overlap, little mass around 0, and with the exception of government school students in government schools, little mass around 1.