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Does school type affect cognitive and non-cognitive development in children? Evidence from Australian primary schools☆,☆☆

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HIGHLIGHTS

- Apply various measures to control for selection bias
- Analyze the latest academic tests in Australia
- Focus on primary schools
- Private schooling has little effects on cognitive and non-cognitive outcomes.

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ABSTRACT

This paper investigates the effects of primary school choices on cognitive and non-cognitive development in children using data from the Longitudinal Study of Australian Children (LSAC). We militate against the measurement problems that are associated with individual unobserved heterogeneity by exploiting the richness of LSAC data and applying contemporary econometric approaches. We find that sending children to Catholic or other independent primary schools has no significant effect on their cognitive and non-cognitive outcomes. The literature now has evidence from three different continents that the returns to attending Catholic primary schools are no different than public schools.

1. Introduction

This paper uses the Longitudinal Study of Australian Children (LSAC) data to examine whether or not better cognitive and non-cognitive outcomes are produced by private, than public schools. We make several contributions to the literature, the foremost of which is to show private schooling does not generally give rise to outcomes that are superior to those produced by public schools. Our findings for Australia are similar to those that were shown by Elder & Jepsen (2014) in the US and Gibbons & Silva (2011) in the UK. We thus have evidence now from three continents that the returns to attending private schools are no different to those from attending public schools.

Several other characteristics of the current study distinguish it from the extant literature. First, to the best of our knowledge, this is the first study that investigates the effectiveness of private schooling in Australia. Second, we control for unobserved individual heterogeneity by exploiting the richness of the LSAC data and invoking several relevant contemporary econometric approaches to estimation, including the value-added, propensity score matching, and comparisons of the

☆ This paper uses unit record data from Growing Up in Australia, the Longitudinal Study of Australian Children. The study 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.
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selection on unobservable and observable estimators. Third, we also assess the effects of school choices on non-cognitive measures of child development. Only two US studies by Jepsen (2003) and Elder & Jepsen (2014) examine the impact of Catholic schools on students' non-cognitive outcomes. Unfortunately, due to a complete lack of information on previous non-cognitive skills in their data, they could not effectively deal with unobserved individual heterogeneity. In this paper, we are able to observe previous non-cognitive skills and effectively control for unobserved individual heterogeneity. Finally, instead of comparing the performance of public and Catholic schools exclusively, we are able to examine the effects of other types of private schooling too, and do so.

There is a large literature on the impact of private schooling on academic outcomes. Broadly, six approaches have been used in this literature to isolate the causal effect of school type on educational outcomes. The simplest approach tries to limit the impact of unobservable individual heterogeneity by using a rich set of student, family and school characteristics. The second approach controls for students' prior achievement in a value-added framework (Jepsen, 2003; Reardon et al., 2009). The third approach compares students in private and public schools who have similar estimated propensities to attend private schools in a propensity score matching framework (Elder & Jepsen, 2014; Chudgar & Quin, 2012). The fourth approach takes advantage of panel data and controls for time-invariant individual characteristics using a fixed-effects estimator (Lefebvre et al., 2011). This approach however does not account for the likelihood of reverse causality since it requires that students do not switch schools for reasons that are related to educational outcomes. The fifth approach uses an instrumental variables (IV) method (Cohen-Zada, 2009; Vella, 1999), however, there is considerable evidence that suggests that most of those instruments are unlikely to be strong (Altonji et al., 2005a). The final approach, proposed by Altonji et al. (2005b), measures the ratio of selection on unobservables to selection of observables that would be needed to attribute to the entire impact of private schooling to selection bias alone. Oster (2014) refined this approach to measure the robustness of treatment parameters when the ratio of selection on unobservables to selection on observables varies from a minimum of zero to a maximum of unity.

In contrast to a rich literature on private high schools – see Elder & Jepsen (2014), for example, for a recent survey – only a few studies have examined the impact of private primary schools and almost all of them focus on the US. In particular, these studies show the impact of private primary schooling on student test scores varies by school type (i.e., whether or not the school is Catholic), grade and subject. For example, Jepsen (2003) finds that Catholic schooling has no significant effect on test scores and classroom behavior. By contrast, Carbonaro (2006) finds a negative effect of Catholic schooling (on reading test scores) and private secular schooling (on reading, math and general knowledge test scores) among kindergarten students. Lubienski et al. (2008) also find a negative effect of Catholic schooling but insignificant effect of independent schooling on fifth grade math test scores. Similarly, Reardon et al. (2009) find that Catholic schooling has a negative impact on math test scores and insignificant impact on reading test scores during the period from kindergarten through fifth grade. Elder & Jepsen (2014) find sizable negative effects of Catholic primary school attendance on fifth and eighth grade math test scores. They find no statistically significant effects of school type on reading scores or non-cognitive outcomes. Elder & Jepsen (2014) use the number of days absent, the number of days tardy, whether the student had ever been suspended, whether a student has fallen behind their cohort's grade advancement, and student-reported "locus of control" as indicators of non-cognitive skills. Similarly, Jepsen (2003) uses student compliance, student motivation, and class participation as measures of non-cognitive outcomes.

We also show that sending children to Catholic or other independent primary schools has no significant effect on their cognitive and non-cognitive outcomes. Our findings for Australia are consistent with those of two other rigorous econometric studies of primary school students in the US (Elder & Jepsen, 2014) and the UK (Gibbons & Silva, 2011). The remainder of the paper is structured as follows. Section 2 describes the data and Section 3 presents our econometric specifications. Section 4 presents empirical results and Section 5 concludes the paper.

2. Data

2.1. Data source

This study utilizes data from the first four waves of the nationally representative Longitudinal Study of Australian Children (LSAC) survey. The LSAC contains comprehensive information about children's cognitive and non-cognitive development and other socio-economic and demographic background of children and their parents. The LSAC sampling frame consists of all children born between March 2003 and February 2004 (B-Cohort, infants aged 0–1 years in 2004), and between March 1999 and February 2000 (K-Cohort, children aged 4–5 years in 2004). In this study we focus on children of K-cohort because measures on child cognitive outcomes are more widely available for this cohort in all four waves of the survey. The sample sizes for the K cohort in Waves 1, 2, 3 and 4 are 4983, 4464, 4331 and 4169, respectively.

While most previous studies focus on Catholic schools, we also include independent schools in the analysis as they enroll 13% of the children we observe. The proportions of students enrolled in public and Catholic schools are 67% and 20%, respectively. Further, some of the characteristics of the students who attend these schools and those of their households are significantly different to those observed for other school types: students of independent schools who come from families with higher mean household incomes, are less likely to be of Aboriginal or Torres Strait Islander (ATSI) descent, and their parents are, on average, more highly educated.

2.2. Variable selection

2.2.1. Outcome variables

2.2.1.1. Cognitive outcomes. Four indicators of the latent cognitive development of children are available to us in this study. First, results from the National Assessment Program — Literacy and Numeracy (NAPLAN) test are used. This test program has been implemented nationally for all Australian students in Years 3, 5, 7 and 9 in reading, writing, language conventions (spelling, grammar and punctuation), and numeracy. The test scores range from 0 to 1000 and were designed expressly for the purpose of enabling comparisons of the performance of children to be made from different schools and across time. The test results were collected via data linkage with LSAC data. Although the test is available for students in Years 3, 5, 7, and 9, the linkage data for LSAC were mainly available for children in Years 3 and 5 (Daraganova et al., 2013). We thus focus on Year 3 and Year 5 test results across all subjects as indicators of cognitive skills.

The two additional indicators that are available to us are drawn from the Matrix Reasoning (MR) test and the Peabody Picture Vocabulary Test (PPVT) to measure the cognitive outcomes for children. The MR test is scored using the Wechsler Intelligence Scale for Children, 4th edition (WISC-IV). This test assesses a child's non-verbal intelligence by presenting them with an incomplete set of pictures, which they complete by selecting one picture from 5 different options. The raw MR score is presented as the number of correct answers. This indicator has been widely used in the child development literature (see, for example, Fuchs et al., 2008). The PPVT is an interviewer-administered test to assess a child's listening comprehension ability for spoken words in standard English. The PPVT test requires a child to show the picture that best represents the meaning of a stimulus word spoken by the examiner (Dunn & Dunn, 1997). The sample of words was: sawing, wrapping, cage, exercising, fountain, nest, claw, delivering, frame and envelope. This test was only available in the first three waves of the LSAC. Finally, the Who Am I (WAI) test was also administered to measure the ability of pre-school age children to perform literacy and numeracy tasks, such as reading, copying and writing letters, words, shapes and numbers. The test results were scored by one experienced marker to improve the consistency and reliability of the results (Rothman, 2007). As the WAI test was only administered once, in Wave 1 when the child was 4–5 years old, we exploit it as an indicator of the initial (pre-school) stock of cognitive skills of the child.

The means of cognitive outcomes in Table 1 shows that students from Catholic and independent schools achieve significantly higher test scores than those from public schools. The magnitude of differences between students from Catholic and public schools is small, at around 1% to 2% while relative figure of students from independent schools is around 5%. This pattern also occurs in the two other tests with repeated measures, i.e., the MR and PPVT.

2.2.1.2. Non-cognitive outcomes. Schooling may facilitate the development of non-cognitive (e.g., social) skills and these are also valued by households. Even if scholastic outcomes across school types are similar, households may not be indifferent between them if they perceive differences in their success in the production of non-cognitive skills. The religious or secular orientation of a school, its governance and resource allocation decisions across the curriculum and extra-curricular activities, thus may matter to households for these or other reasons (e.g., reasons related to religiosity). To the extent that qualitative differences in approaches vary by school type, the LSAC enables us to examine their effect on the development of some such non-cognitive skills in young children. Specifically, the LSAC includes data from the Strengths and Difficulties Questionnaire (SDQ), which contains five SDQ scales: the Emotional Symptoms Scale, Conduct Problems Scale, Hyperactivity Scale, Peer Problem Scale and the Pro-social Scale. Each SDQ scale is scored as the summation of the item scores on each of the five sub-items, and then rescaled to give values from zero to 10. With the exception of the Pro-social Scale, higher scores indicate a greater probability of “caseness”, i.e., of underlying mental health disorders. On the Pro-social Scale, lower scores indicate a higher probability of caseness. Essentially, there are two groups of indicators: one refers to “problems”, so lower scores are preferred, and one refers to “good behaviors” like pro-social behavior, so higher scores are preferred. In practice, the “problems” category is presented a summary score, called the Total Difficulties Score, is derived by summing the scores of sub-scales other than the Pro-social Scale, resulting in a score from zero to 40. Higher values on the Total Difficulties Score indicate a higher probability of “caseness”.

The scores show that children from Catholic and independent schools are assessed to have significantly better behavior on average (i.e., higher scores on pro-social and lower scores on the remaining measures) than students in public schools (see Table 1). Except for the pro-social measure, students from independent schools exhibit better behavior than those in Catholic schools. More interestingly, the mean test for pro-social and conduct problems at Wave 1 (i.e., pre-school age) shows no significant differences between three school types, suggesting similar performance of these school children at “baseline” but differences by school type in subsequent years.

Table 1
Child outcomes by school type.

Variables	Public	Catholic	Independent	Differences (%)	
	(1)	(2)	(3)	(2) vs (1)	(3) vs (1)
Cognitive skills					
WAI score in Wave 1	64.03	64.78	65.92	1.17	2.95
PPVT score in Wave 1	64.13	64.86	65.67	1.14	2.40
Year 3					
Reading	420.94	430.74	443.02	2.33	5.25
Writing	423.50	431.31	440.14	1.84	3.93
Spelling	414.38	419.81	430.89	1.31	3.98
Grammar and punctuation	425.33	434.86	448.06	2.24	5.34
Numeracy	415.91	420.61	438.11	1.13	5.34
Matrix reasoning	10.18	10.26	10.92	0.80	7.28
PPVT	73.15	74.04	74.36	1.22	1.65
Year 5					
Reading	497.40	508.78	526.06	2.29	5.76
Writing	490.60	501.43	509.61	2.21	3.87
Spelling	490.97	494.26	504.40	0.67	2.74
Grammar and punctuation	510.09	516.70	534.63	1.30	4.81
Numeracy	496.86	502.50	521.83	1.14	5.03
Matrix reasoning	10.35	10.50	11.22	1.41	8.39
PPVT	75.72	76.84	76.97	1.48	1.66
Non-cognitive skills					
Pro-social	8.13	8.41	8.31	3.45	2.32
Hyperactivity	3.52	3.21	2.95	−8.87	−16.21
Emotional problems	1.86	1.69	1.60	−8.80	−14.07
Conduct problem	1.73	1.41	1.37	−18.47	−21.15
Peer problem	1.74	1.39	1.31	−20.30	−24.50

Note: F-test statistics for mean differences among schools are all statistically significant at the 1% level.

2.2.2. Control variables

We conceive three groups of covariates: 1) the initial stock of cognitive skills; 2) inputs for cognitive and non-cognitive development; and 3) environmental factors that affect the production of those skills (i.e., taste-shifters for parents and productivity shifters for children). The indicators available for the first group includes the PPVT and WAI score at Wave 1. The second group includes indicators of the availability of market inputs to the household such as the numbers of books at home, whether the child has access to computers and the characteristics of their residential neighborhood (e.g., metropolitan status, availability and quality of infrastructure and the percentage of adults who completed Year 12). Inflation-adjusted household annual income is also used to indicate the household's access to other goods and services including parental inputs for the child's development. The principal non-market input used by households is the time that parents spend on the development of their children. The third group consists of age, gender and ethnic background (i.e., Aboriginal and Torres Strait Islanders status, and whether English is the language spoken at home) as indicators of latent demographic, social and cultural variables that may affect child development. We also control for the current health stock of the child using parent-reported child health status, and the child's initial health stock, as indicated by a dummy variable for low birth-weight children. Some family characteristics may also affect children's development directly via family traits (e.g., genetic inheritance) and indirectly via parents' preferences (as shaped by e.g., family tradition). In this study, we use the level of education of the child's parents and their parents' reported physical and mental health status as factors that may affect child development. In particular, we expect that children of healthy and highly educated parents to have a high level of productivity in the development of cognitive and non-cognitive skills. Finally, we control for the problem of students sitting the NAPLAN test in different years for the same grade by using information both on the age of students at the year they sat the test, plus dummy variables for test year.

Table 2 shows that the characteristics of pupils do vary across the school types. We conducted tests of the hypothesis of no difference between the means and variance of these variables and found that the hypothesis was rejected at the 5% level for most variables. The exceptions were, for the mean test, the gender distribution of pupils, whether or not English was spoken at home, and low birth weight. For the

Table 2
Descriptive statistics for selected covariates by school type.

Variables	Public	Catholic	Independent
Household yearly income ($A, 2004 prices)	72,886	84,818	106,656
Home ownership (1 = owns outright or paying off a mortgage)	0.70	0.83	0.81
Both biological parents are at home (1 = yes)	0.76	0.86	0.86
Household size (people)	4.55	4.64	4.52
Aboriginal and Torres Strait Islanders (ATSI)	0.04	0.02	0.01
English spoken at home (1 = yes)	0.89	0.88	0.87
The household is located in metropolitan area (1 = yes)	0.60	0.63	0.66
Mother's age (years)	37.85	38.95	39.37
Mother completed Year 12 (1 = yes)	0.56	0.66	0.75
Father's age (years)	40.62	41.33	41.88
Father complete Year 12 (1 = yes)	0.49	0.55	0.68
Mother's average hours worked per week	17.65	20.30	19.91
Father's average hours worked per week	42.97	46.12	47.15
Age of the child (in months)	97.72	101.17	98.83
Gender of the child (1 = male)	0.51	0.51	0.48
Low birth weight (1 = birth weight less than 2500 g)	0.08	0.06	0.07
The child was breastfed at 3 months or 6 months old (1 = yes)	0.70	0.74	0.80
The child is in excellent health (1 = yes)	0.51	0.56	0.59
Number of books at home[1]	3.61	3.70	3.78
Home activities index[2]	1.50	1.51	1.58
Out of home activities index[3]	2.50	3.09	3.06
Mother has excellent health	0.18	0.20	0.24
Mother's depression scale[4]	4.40	4.46	4.48
Physical characteristics of the neighborhood[5]	2.00	1.95	1.89
Year 12 completion rate in the neighborhood (%)	44.45	46.45	48.12
Percentage of people employed in the neighborhood (%)	61.91	62.49	62.17
Percentage of households in the neighborhood earning less than $1000 per week (%)	38.57	36.24	36.12
Percentage identifying as ATSI in the neighborhood (%)	2.65	2.71	1.75

Notes:
[1] Categorical variables: 1 = 1–10 books; 2 = 11–20 books; 3 = 21–30 books; 4 = more than 30 books.
[2] Average of 3-point (0 = none, 3 = every day) questions about the frequency of activities that parents and child do together at home (e.g., read books).
[3] Number of "yes" answers to questions about activities that the family do together such as go to cinema and sporting events.
[4] Mean of 5-point scale questions (1 = all the time, 5 = none of the time) on feelings such as nervousness, hopelessness and restlessness.
[5] Average of 4-point Likert scale (1 = strongly agree, 4 = strongly disagree) questions about public transport and other facilities in the neighborhood.

variance test, the only exception was the gender distribution.[1] Several variables are worthy of specific comment. The household incomes of children in public schools are lower than those attending Catholic schools and those, in turn, are lower than the incomes of households for children enrolled in independent schools. Parental education, parental physical health and mental health are the highest for children in independent schools, followed by Catholic schools and public schools. The proportion of students who identify as being from an Aboriginal or Torres Strait Islander (ATSI) background in independent schools is half that of students from Catholic schools which, in turn, is half that of students enrolled in public schools. Children who enrolled in independent schools have higher self-reported health and receive more parental inputs (as indicated by the number of books at home and the indices for activities that the family do together at and outside the home). Finally, children who are enrolled in public schools tend to live in lower socio-economic status (SES) neighborhoods (using indicators for infrastructure, ethnicity, income, employment and educational attainment) than their private school peers. While there appears to be a slightly larger proportion of boys in public and Catholic schools (51%) than independent schools (48%), this difference is not statistically significant.

[1] These tests are not presented here for brevity, but are available from the authors upon request.

3. Methodology

Based on the theory of human capital development (Becker & Tomes, 1986) and the dynamic model of education production (Cunha & Heckman, 2007) we propose a general specification to model the development of a child i at time t as:

$$A_{it} = \beta_0 + \beta_1 A_{i0} + \beta_2 A_{i,t-1} + \alpha S_{it} + \beta_3 X_{it} + \beta_4 Z_{it} + \eta_i + \varepsilon_{it} \tag{1}$$

where A_{it} is a set of the child development outcomes at the current period and A_{i0} is the endowment (or initial outcomes); S_{it} represents the school type (i.e., government, Catholic, and independent) the child attends; X_{it} are the set of capital and labor inputs for child development (e.g., books, computers, schools, teachers); Z_{it} is a set of exogenous factors that may affect knowledge accumulation (e.g., development in information technology); η_i is a family fixed effects, representing time-invariant taste and productivity shifters; ε_{it} is the random error; and α and βs are parameters to be estimated.

One problem with the estimation of Eq. (1) in our study is that only two time points (for Years 3 and 5) are currently available in the data for cognitive outcomes, and hence panel data methods cannot be applied when these outcomes are used as dependent variables. Our strategies to address the endogeneity problem include selecting a comprehensive set of controls for individuals, households, schools and neighborhoods; applying propensity score matching; comparing the effects of selection on observables with selection on unobservables; and using the value-added approach to measure the impact of school choice.[2] These strategies are discussed in more detail below.

3.1. Comprehensive controls

When the data are rich enough, one can argue that the effects of unobservable factors (η_i) can be mitigated, although perhaps not eliminated, by controlling for all of the theoretically-relevant observables. Fortunately, the LSAC contains very rich information about the child, the household, and the neighborhood. We test the effects of exploiting the richness of the dataset by comparing the estimated parameters of interest (α) in the "basic" and "comprehensive" specifications. In the "basic" specification, we only control for the child's age, residential state and the year that the test was conducted. The comprehensive specification also includes these variables, plus the child's initial stock of academic ability as indicated by scores on WAI and PPVT tests (which we discussed above) that are administered prior to school entry, the child's characteristics (i.e., age, gender, ethnicity, health status), household characteristics (i.e., household size, parental education and health, household income), indicators of the latent parental investment in the child's education (e.g., the number of books at home, access to computers, and an index of "quality time" that parents and children spend together), and indicators of neighborhood characteristics (i.e., physical infrastructure, neighborhood social capital).

This estimation is applied to the test scores at Year 3 and Year 5 and hence our empirical specification of this approach is simplified (i.e., via

[2] We considered an IV approach but did not pursue this option when it was clear that there were no good IV candidates in our data set. We also did not attempt a fixed effects (FE) approach because only about 5% of students changed school during the study period: FE results on this small subsample are probably of little, if any, interest.

the removal of the lagged dependent variable and family fixed effects) as follows:

$$A_{it} = \beta_0 + \beta_1 A_{i0} + \alpha S_{it} + \beta_2 X_{it} + \beta_3 Z_{it} + \varepsilon_{it}. \tag{2}$$

We expect the initial stock of development outcome (A_{i0}) to be an important determinant of differences in test scores of students at different school types, as genetic inheritance plays an important role in the cognitive development of children (Plomin & Spinath, 2004), as does nurture in the household environment (Bradley & Corwyn, 2002).

3.2. Propensity score matching

This approach is based on the assumption that, conditional on observed characteristics, there is no systematic difference among students in different school types according to unobservable characteristics. This is a strong assumption and we use this strategy mainly to test how sensitive our results are to unobserved heterogeneity. Essentially, this approach is used to compare the test scores of students in Catholic or independent schools with those in public schools who have a similar propensity to attend non-government schools. The propensity scores are estimated as:

$$S_{it} = 1\left(f(X_{it}, Z_{it}) + \eta_i > 0\right) \tag{3}$$

where 1(.) is a function that takes the value of one if its arguments are true and zero otherwise and other notations are as previously defined. In order to compare our results with previous studies by Elder & Jepsen (2014), we estimated Eq. (3) using the probit estimator.[3]

3.3. Selection on observables and unobservables

This approach, developed by Altonji et al. (2005b), uses the degree of selection on observables as a guide to determine the amount of selection on unobservables that may be present. In particular, the ratio of selection on unobservables to selection on observables can be interpreted as the magnitude by which significant effects of school choices on academic outcomes are due to selection bias.

Defining the effects of observables as $O_i = \beta_1 A_{i0} + \beta_2 A_{i,t-1} + \beta_3 X_{it} + \beta_4 Z_{it}$, Eq. (1) can be expressed as:

$$A_{it} = \beta_0 + O_i + \alpha S_{it} + \eta_i + \varepsilon_{it}. \tag{4}$$

Defining δ as the proportion of selection on unobservables and observables:

$$\delta = \frac{\text{Cov}(\eta, S)}{\text{var}(\eta)} \Big/ \frac{\text{Cov}(O, S)}{\text{var}(O)}. \tag{5}$$

Defining the parameter of school choice in a naive regression of A_{it} on S_{it} only as α° with the corresponding R-squared of R°; defining the parameter and corresponding R-squared of a regression that ignores unobservable factors in Eq. (2) as $\widetilde{\alpha}$ and $\widetilde{R}$; and defining the R-squared for a hypothetical regression where unobservables are identified in Eq. (1) as R_{max}, Oster (2014) showed that:

$$\delta \approx \frac{(\widetilde{\alpha} - \hat{\alpha})\left(\widetilde{R} - R^\circ\right)}{(\alpha^\circ - \widetilde{\alpha})\left(R_{max} - \widetilde{R}\right)} \tag{6}$$

where $\hat{\alpha}$ is a targeted parameter (e.g., zero). Altonji et al. (2005b) argued that selection on unobservables should not be greater than selection on observables but that the two sources of selection are positively correlated. Thus, the lower bound for δ is zero and the upper bound is one. Altonji et al. (2005b) assumed that R_{max} is one and choosing a target parameter ($\hat{\alpha}$) of zero they calculated the "implied ratio" δ using a formula similar to Eq. (6). A δ that is greater than one suggests that the estimated parameter for school choice is robust since selection on unobservables must be greater than that on observables to explain away the effects of school choice.

Oster (2014) argued that the parameter of school choice effects should range from $\widetilde{\alpha}$, which assumes $\delta = 0$, to β^*, which is estimated using R_{max} and the assumption that $\delta = 1$. If this bound does not contain zero, the parameters of school choice are robust. The main difference between the robustness test by Oster (2014) and Altonji et al. (2005b) is that the former relaxes the assumption that $R_{max} = 1$ (i.e., there are no measurement errors in the data). Instead, Oster (2014) tested the robustness of treatment parameters from randomized control studies published in reputable economic journals (e.g., *American Economic Review*, *Journal of Political Economy*, and *Econometrica*) between 2008 and 2013 by using $R_{max} = \Pi\widetilde{R}$ with various values of Π. The author found that only 20% of results were robust when $R_{max} = 1$ while using $R_{max} = 1.3\widetilde{R}$ (i.e., $\Pi = 1.3$) reproduced 90% of randomized results. Therefore, we choose to report the bound of treatment parameters proposed by Oster (2014) because it relaxes the assumption of no measurement errors and the results are easy to interpret (i.e., robust estimates should not contain zero in the estimated coefficient bound).

3.4. Value-added

The term value-added in this context refers to the differences in students' test scores due to variables of interest (in particular, school type). Thus, in this specification – Eq. (1) – we only include students who did not change their school type over the study period. Value-added effects are then estimated by comparing test scores of students among school types conditioned on previous test scores and other factors. With only two observations per child (at Years 3 and 5) this specification is essentially equivalent to a cross-sectional regression with a lagged dependent variable as one covariate. Unlike the situation of first-differencing in the dynamic model, the lagged dependent variable in this specification is considered a pre-determined variable, and hence is exogenous by construction.

4. Results and discussion

4.1. Cognitive outcomes

The OLS results (Table 3) show that when we use basic controls (the child's age, state and year at the time of the test) children from private schools achieve significantly higher test scores in both Years 3 and 5. Compared to children from public schools, the reading test scores for Years 3 and 5 of students from independent schools are 16.9 and 26.5 points higher, respectively. Yet this significant difference disappears when we use a comprehensive set of controls to militate against selection bias. Indeed, we find that students from Catholic schools have significantly lower test results than students from public schools in spelling, grammar and numeracy and in the MR results for Grade 5. One exception is that the PPVT and MR test scores in Grade 5 are higher for students from independent schools than for those students enrolled in public schools. The magnitudes of these differences are, however, small (0.5 and 0.3 points, respectively), and the parameter of PPVT is statistically significant only at the 10% level.

We use the comprehensive set of controls to compute propensity scores using the kernel method[4] and compare the cognitive test results of students among different school types. We find similar results (see Table 4) to those reported in our OLS results: in particular, we find no

[3] The matching analysis is conducted using the *psmatch2* STATA routine by Leuven & Sianesi (2012).

[4] We also tried other methods such as the nearest neighbors and Caliper approaches but the results are similar: in the interests of brevity we do not report them.

Table 3
Effects of school choices on cognitive outcomes — OLS.

Grade/school type	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
Grade 3—basic controls							
Catholic schools	4.02	3.98	1.52	2.40	−0.85	−0.13	−0.16
	[4.93]	[3.79]	[4.16]	[5.12]	[4.42]	[0.27]	[0.16]
Independent schools	16.89***	15.38***	12.05**	14.38**	15.72***	0.95**	0.40*
	[5.85]	[4.66]	[5.40]	[6.65]	[5.34]	[0.44]	[0.23]
Grade 5—basic controls							
Catholic schools	4.13	5.03	−1.54	−1.59	0.92	−0.08	−0.17
	[3.91]	[3.33]	[3.26]	[3.88]	[3.81]	[0.25]	[0.14]
Independent schools	26.51***	16.55***	10.79**	19.40***	24.05***	1.24***	0.94***
	[5.22]	[4.18]	[4.33]	[5.32]	[4.79]	[0.29]	[0.16]
Grade 3—comprehensive controls							
Catholic schools	1.17	2.15	−0.89	−0.71	−3.88	−0.33	−0.22
	[4.15]	[3.65]	[3.99]	[4.35]	[3.80]	[0.25]	[0.16]
Independent schools	−4.02	1.09	−4.01	−5.63	−2.62	0.09	−0.03
	[5.43]	[4.11]	[5.05]	[6.12]	[4.71]	[0.38]	[0.22]
Grade 5—comprehensive controls							
Catholic schools	−4.56	−1.54	−7.56**	−9.31***	−7.14**	−0.37*	−0.41***
	[3.35]	[3.06]	[2.98]	[3.18]	[3.24]	[0.22]	[0.14]
Independent schools	6.54	−0.13	−4.85	−1.03	5.40	0.45*	0.34**
	[4.39]	[3.69]	[3.81]	[4.59]	[4.04]	[0.26]	[0.15]

Note: Robust standard errors in brackets.
"Basic controls" include only dummies for state of residence and year of the test.
"Comprehensive controls" include the basic controls plus initial stocks of cognitive skills and productivity shifters (age, sex and ethnic background, current health status and dummy for low birth weight); taste shifters (the age, education level, ethnicity, physical and mental health status of parents), household characteristics (household size, both biological parents present); inputs for child cognitive developments (household incomes, hours work of parents, books and computers at home, index of home and out-of-home activities, and neighborhood characteristics). The remaining regression results from this model are presented in Tables A1-1 and A1-2 in the Appendix.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

significant differences in Grade 3 test scores among students from different school types. However, the PPVT and MR results for students from Catholic schools are significantly worse than those for students enrolled in public schools. The test scores of students from Catholic schools in Year 5 are also lower than those in public schools in all subjects except reading and writing. We also find that the reading, PPVT and matrix reasoning results for Grade 5 students in independent schools are significantly better than those in public schools but the level of statistical significance is low and the magnitudes of the differences are generally modest.

The value-added estimator results (Table 5) are also consistent with the OLS and the propensity score matching results where a comprehensive set of controls is used. In particular, after controlling for the results achieved in Grade 3, students of independent schools achieved PPVT scores that are on average 0.5 points higher than those achieved by students in public schools. We also find that the test scores for spelling, grammar and numeracy of students in Catholic schools are lower than those in public schools, but that the results for reading and writing are not statistically different across school types. The extent to which we control for selection bias in the value-added estimator is, however, just the same as for OLS and propensity matching score estimator: we exploit the richness of the LSAC data as much as possible, but we cannot entirely rule out selection bias. It is therefore possible that the small and positive effects of private schools on Grade 5 reading, PPVT and MR suggested by results of the value-added estimator are attributable to selection on unobservables.

Although the value-added specification militates against the potential problem of selection bias it does not entirely eliminate the possibility that selection bias is still at play. Thus, we estimate the range of estimated parameters using the procedure proposed by Oster (2014) in order to explore this possibility. We find that, for Catholic schools, with the exception of PPVT, the parameter bound for all outcomes includes negative ranges, suggesting that our results are robust and that students from Catholic schools perform worse than their counterparts

Table 4
Effects of school choice on cognitive outcomes—propensity score matching.

School type	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
Grade 3							
Catholic	1.43	3.13	−1.53	−1.43	−3.25	−0.77***	−0.22*
	[4.44]	[3.56]	[4.06]	[4.29]	[4.11]	[0.22]	[0.14]
Independent	−5.44	−0.25	−7.68	−8.93	−6.16	−0.05	0.14
	[5.90]	[4.51]	[5.26]	[6.60]	[5.14]	[0.34]	[0.20]
Grade 5							
Catholic	−5.40	−1.02	−8.04**	−10.60***	−7.53**	−0.64***	−0.41***
	[3.60]	[3.57]	[3.38]	[3.95]	[3.42]	[0.22]	[0.14]
Independent	8.13*	0.33	−4.66	0.12	4.58	0.56**	0.32*
	[4.57]	[3.99]	[4.07]	[4.82]	[4.21]	[0.27]	[0.19]

Note: Results from Kernel matching method with bandwidth = 0.08; standard errors are calculated from bootstrapping with 500 replications the propensity scores were calculated using the comprehensive set of variables (as in the second panel for each test subject in Table 3); robust standard errors in brackets.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table 5
Effects of school choices on cognitive outcomes — value-added.

School type	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
Catholic	−2.31	−1.55	−5.93***	−7.36**	−6.96**	−0.16	−0.27*
	[3.52]	[3.46]	[2.28]	[3.48]	[3.25]	[0.21]	[0.14]
Coef. bound	(−3.1, −0.8)	(−4.2, −1.2)	(−7.0, −4.9)	(−10.4, −7.1)	(−7.2, −5.4)	(−3.7,0.2)	(−1.2, −0.3)
Independent	6.30	1.37	−4.29	1.08	2.43	0.49*	0.26
	[4.72]	[4.39]	[2.81]	[4.72]	[3.87]	[0.28]	[0.17]
Coef. bound	(1.7,7.4)	(−6.6, −0.7)	(−9.8, −3.9)	(−6.4,1.3)	(−5.3,1.8)	(−3.9,0.01)	(−1.0,0.06)
Observations	1657	1657	1666	1664	1654	2258	2302
R^2	0.481	0.374	0.669	0.456	0.520	0.323	0.292

Note: Robust standard errors in brackets; remaining regression results are reported in Appendix Table A2. Coefficient bounds refer to the range of estimated parameters when the ratio of unobservables to observables varies from zero to one. The calculation of the coefficient bounds was conducted using the "psacalc" package written for STATA by Oster (2014).
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

in public schools in academic tests, *ceteris paribus*. For independent schools, though, only the results on reading, writing and spelling are robust, suggesting that selection bias may still exist for the parameters estimated on grammar, numeracy, PPVT and MR. Note, though, that it is expected that selection bias would give rise to an over-estimation of parameters on these indicators of learning. Given that all parameters for independent schools were statistically insignificant (except in the case of PPVT outcome where the estimate is statistically significant at the 10% level), it is reasonable to interpret the results as indicating that attendance at independent schools confers no advantage on the cognitive development of children at the primary school level.

Detailed results from OLS (Appendix Tables A1-1 and A1-2) and value-added (Appendix Table A2) estimators show that other significant determinants of children's cognitive outcomes include measures of initial stock of cognition, inputs to child cognitive production, productivity shifters and taste shifters. As expected, the initial stock of cognitive skills (proxied by PPVT and WAI test scores in Wave 1) is the most significant determinant of current cognitive outcomes. This finding is also the most consistent among all three estimators and test subjects: an increase of one point in the PPVT or WAI test score results in a 1–4 point increase in mean test scores in the OLS model. Similar results are found for the role of the previous cognitive achievements in the value-added model. This finding is in line with those of Walker et al. (2004) who studied the performance of 7-year-old identical and fraternal twins on mathematics and English and found that test results of identical twins were twice as likely to be similar than those of fraternal twins (because identical twins share the same genetic inheritance).

We also find that significant inputs for the production of cognitive skills include numbers of books, place of residence and family income. In particular, children in families with more books at home have consistently higher test scores in most subjects under OLS estimates but the magnitude of those effects is smaller when the value-added approach is used. The parameter estimates on the home- and out-of-home activity indices produce the opposite effects: the coefficients are negative for the former and positive for the latter. The results from the value-added estimator, for example, suggest that the marginal effect on the Grade 5 writing test score of home and out-of-home activities are −6.3 and 2.4, respectively.[5] This may point to an "input congestion" problem with respect to the effect of home-based activities on outcomes. The logarithm of household income (proxied for other purchased inputs not listed in our specifications) is positive and significant only in the OLS results. Regarding choice of residence, we find that children from families in neighborhoods with higher ratio of people who completed high school achieved higher test scores. Other indicators of neighborhood characteristics including the proportion of the population that is Australian-born and the proportion that identifies as of ATSI origin are not associated with any substantive differences on child cognitive development. Regarding parental time inputs, we find that students with mothers who work longer hours have significantly lower test scores in all subjects except numeracy. However, the working hours of the father have no statistically significant effect.

Among the indicators of taste shifters we examined, parental education had statistically significant effects on cognitive achievement. In particular, children from mothers and fathers with a Year 12 education have significantly higher test scores on all subjects although the magnitudes and significance levels of these are substantially lower in the value-added estimates.

Statistically significant productivity shifters identified in the OLS and value-added regressions include gender, ATSI status, health and age. In particular, we found that boys achieved higher scores on numeracy and PPVT but lower scores on grammar and punctuation. This result is consistent across all estimators. We also find that the mean test scores are lower for all students who identified as ATSI in Year 3 than for their non-indigenous peers. It is encouraging, though, that the results for indigenous children improved considerably between Years 3 and 5 so that only the reading and numeracy (OLS estimates) and numeracy (value-added estimates) scores for indigenous students were lower than those of their non-indigenous counterparts by Year 5.

Students with an initially low stock of health (as indicated by birth weight of less than 2500 g) also achieved significantly lower test scores, especially in grammar and numeracy. We did not, however, find consistent results for parent-reported child health status. One possible explanation is that low birth weight may be correlated with longer-run developmental delays while perhaps self-reported health is more likely to reflect the contemporary health state. Finally, compared to students who sat their tests earlier (i.e., than the reference year), those who took the test later achieved scores that were, on average, 20–50 points higher, although these parameter estimates are not statistically significant when the value-added estimator is invoked.

In short, the results from OLS, value-added and propensity score matching analyses suggest that the choice between public and private—either Catholic or independent—schools has no significant effect on children's academic achievement with the exception of reading scores at Grade 5. These three estimators rely on the richness of the LSAC data to militate against the probable effect, otherwise, of unobserved heterogeneity. Nevertheless, we cannot rule out a role for unobserved heterogeneity. Thus, we also apply the "selection on unobservables versus observables" approach by Altonji et al. (2005b) and Oster (2014) which can determine the range of estimate parameters when the proportion of selection on unobservables and selection on observables increases from zero through one. The results suggest that even if the degree of selection on unobservables is as much as that of selection on observables, students from Catholic schools perform worse than those from public schools while attending independent schools provides no significant gain on academic tests.

[5] Home and out-of-home activities indices respectively refer to the averages of 3-point Likert scale questions regarding bonding activities at home (e.g., reading together) and outside home (e.g., go to sport events or going to cinema together). For descriptive statistics on these variables, see Table 2.

Table 6
Effects of school choices on non-cognitive outcomes — OLS and value-added.

School type	Pro-social skills	Hyperactivity	Emotional problem	Conduct problem	Peer problem
OLS					
Catholic	0.09	−0.02	0.06	−0.03	−0.16***
	[0.06]	[0.06]	[0.04]	[0.04]	[0.04]
Independent	−0.05	0.00	0.09	0.03	−0.11**
	[0.06]	[0.08]	[0.06]	[0.05]	[0.05]
Value added					
Catholic	0.03	0.06	0.04	−0.004	−0.11***
	[0.04]	[0.04]	[0.04]	[0.03]	[0.03]
Coef. bound	(−0.04, 0.03)	(0.06, 0.15)	(0.04, 0.08)	(−0.001, 0.06)	(−0.1, −0.06)
Independent	0.03	0.09	0.09*	0.01	−0.06
	[0.05]	[0.06]	[0.05]	[0.04]	[0.04]
Coef. bound	(−0.001, 0.03)	(0.08, 0.26)	(0.1, 0.19)	(0.002, 0.1)	(−0.06, 0.019)
Observations	8374	8371	8373	8376	8373
R^2	0.348	0.509	0.335	0.372	0.341

Note: In the interest of brevity, estimates for other covariates are not presented. Data in square brackets are robust standard errors. Data in parentheses are coefficient bounds that refer to the range of parameter estimates that is obtained when the ratio of unobservables to observables is increased from zero to one. Coefficient bounds are estimated using the approach proposed by Oster (2014).
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

4.2. Non-cognitive outcomes

In this section we address non-cognitive outcomes using measures of behavioral skills and behavioral problems using the following five subscales of the SDQ: (1) pro-social, (2) hyperactivity, (3) emotional problems, (4) conduct problems, and (5) peer problems.

The OLS results for our model with a comprehensive set of covariates (see Table 6) suggest that students at Catholic and independent schools experience a lower incidence of peer problems, as indicated by the negative coefficients. However, the OLS estimates ignore the cumulative effects of skill formation. The results from the value-added estimator, which controls for the initial stock of non-cognitive skills, show that children from only Catholic schools still have a statistically significantly lower incidence of peer problems than their public school counterparts. The coefficient bound, estimated using the procedure by Oster (2014), includes negative ranges, confirming that students attending Catholic have less problems interacting with peers.

5. Concluding remarks

This study has examined the effects of school choice on the cognitive and non-cognitive skills of primary school-aged children in Australia. Using cognitive test scores and SDQ behavior measures, we found that independent schooling did not confer any significant advantage on students, while the cognitive outcomes for students in Catholic schools were worse than those for students in public schools when individual unobserved heterogeneity is taken into account. Our results accord with the evidence produced by two other rigorous econometric studies of primary school children in the US (Elder & Jepsen, 2014) and the UK (Gibbons & Silva, 2011). This is an important result because it suggests that selection bias accounts for the differences in child development outcomes across school types, and this finding has now been established for three different continents. We find that significant determinants of child development outcomes include age, gender, health status and initial stock of skills of the child, parental educations, working hours of mother, ethnicity and cultural background of the household, the number of books at home, choice of residential neighborhood and income.

The results presented in this study should still be interpreted with some care. First, with the exception of PPVT, we have only two observations per child for our indicators of cognitive outcomes so it is difficult to address the unobserved heterogeneity issue using dynamic panel data methods. Second, although the main methods used in this study (i.e., OLS, propensity matching and value-added) may militate against resulting endogeneity problems, using a comprehensive set of covariates does not enable us to rule out the effects of unobserved heterogeneity entirely. In addition, our application of robustness tests by Altonji et al. (2005b) and Oster (2014) demonstrated that academic outcomes of students from Catholic schools are worse than those attending public schools, and that attending independent schools provides no significant academic benefit. The only positive effects of school choices found in this study were that students from Catholic schools exhibited significantly less problem interacting with peers. This result suggests that significant effects found in naive estimates (OLS) may be due entirely to selection bias. Econometric extensions to our work will be possible as further waves of data become available. The availability of these longer panels will enable us to test the veracity of our results as these Australian children progress through their primary and secondary schooling.

Appendix A

Table A1-1
Effects of school choices on cognitive outcomes—OLS (Year 3).

Variables	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
WAI scores in Wave 1	2.59***	2.56***	3.00***	3.23***	2.98***	0.06***	0.09***
PPVT scores in Wave 1	4.12***	1.96***	2.07***	3.05***	3.06***	0.33***	0.08***
Test year = 2009	36.02***	15.16**	32.24***	36.47***	18.43**	−1.44***	0.45
Test ages	0.26	0.13	−0.87	0.27	0.36	0.05	−0.11***
Male	−2.64	−8.53***	1.81	−5.35	24.13***	1.06***	−0.06
English at home	−19.05***	−4.25	−20.02***	−18.94***	−13.28**	1.35***	−0.51
Indigenous status	−26.26**	−27.24**	−35.94**	−41.65***	−35.95**	0.48	−1.03**
Child health = very good[(a)]	7.53**	0.74	−2.06	−0.52	4.78	0.36*	0.13

Table A1-1 (*continued*)

Variables	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
Child health = good[(a)]	2.52	0.43	−0.96	−6.36	2.47	0.23	−0.24
Child health = fair[(a)]	7.36	−12.00	0.77	−2.17	−9.26	0.13	0.80*
Low birth weight	−14.99***	−7.72	−1.45	−8.91	−16.21***	−0.80**	−0.70***
Mother's age	0.28	0.14	0.38	−0.01	0.17	0.02	−0.01
Mother's completed Year 12	19.21***	10.47***	10.45***	17.22***	15.06***	0.24	0.52***
Mother from an English-speaking country	−1.09	−2.37	−6.83	−0.93	−4.10	0.19	−0.02
Mother's average hours worked	−0.23*	−0.21**	−0.35***	−0.29**	−0.06	0.00	−0.00
Mother have excellent health	3.94	2.49	6.10	6.64	5.80	0.00	−0.13
Mother's depression scale	1.27	−1.33	−5.41	−1.14	−2.81	0.16	−0.19
Father's age (years)	0.46	0.23	0.23	0.11	0.52*	−0.03	0.01
Father completed Year 12	17.22***	11.10***	14.24***	16.26***	13.46***	0.51**	0.15
Father from an English-speaking country	2.69	−0.19	1.26	0.23	0.02	0.18	−0.07
Father's-average hours worked	−0.11	0.00	−0.01	0.07	0.00	0.01	0.01
Number of book at home	5.86**	−0.43	−3.97	7.09**	1.55	0.27	0.04
Having a computer at home	4.24	0.56	6.13	8.20	2.60	−0.95**	0.07
Home activities index	−1.09	−6.00**	−7.85**	−4.69	−7.55***	0.30	−0.33**
Out of home activities index	0.04	−0.29	0.13	−0.58	1.57	0.10	0.06
Household size	3.11*	−0.60	0.52	1.44	3.80**	−0.20*	0.05
Biological parents are at home	15.02	27.77***	9.70	26.82*	9.35	1.17*	0.19
Log of household income	6.04**	4.76	7.77**	5.38	7.37***	0.34	−0.03
% completed year 12 for linked area	0.28	−0.59*	−0.62	0.26	0.53	0.08***	−0.02
% working in linked area	−0.51	−0.67**	−0.43	−0.47	−0.41	0.01	−0.01
Metropolitan status	−7.05	−0.68	−1.89	−1.76	−6.57	0.02	−0.35
% Australian born in linked area	−0.38	−0.78***	−0.85***	−0.18	−0.01	0.05**	−0.01
% Indigenous in linked area	0.37	0.24	0.24	0.30	0.06	−0.00	−0.00
Index of advantage/disadvantage	0.08	0.18***	0.14**	0.06	0.05	−0.01**	0.01**
State = Victoria[(b)]	4.87	−4.37	−1.05	−1.73	7.48*	0.56*	0.51**
State = Queensland[(b)]	−8.19	−4.03	−19.01***	−17.57**	−9.14	−0.38	0.33
State = South Australia[(b)]	4.93	−10.47	14.64**	−5.58	−10.74*	0.94	0.50
State = Western Australia[(b)]	−3.08	−14.79***	−18.39***	−25.64***	−8.20	−0.45	0.26
State = Tasmania[(b)]	3.38	6.85	8.83	−11.63	0.95	0.58	0.57
State = Northern Territory[(b)]	−98.93***	−47.46**	−76.07***	−74.79***	−32.48*	−3.68*	−0.62
State = Australian Capital Territory[(b)]	−8.96	−11.25	−18.47*	−19.22	−16.12*	0.78	0.43
Constant	−199.88**	15.90	116.45	−128.15	−185.64**	35.95***	8.35**
N	1790	1792	1794	1792	1785	1776	1821
R^2	0.293	0.247	0.243	0.271	0.292	0.283	0.149

Note: Standard errors are not reported for brevity. [(a)]: Child health = poor and [(b)]: State = New South Wales are set as the base group, respectively.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table A1-2
Effects of school choices on cognitive outcomes — OLS (Year 5).

Variables	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
WAI scores in Wave 1	2.07***	2.42***	2.73***	2.88***	3.25***	0.07***	0.11***
PPVT scores in Wave 1	2.96***	1.44***	1.03***	2.25***	1.82***	0.23***	0.05***
Test year = 2009							
Test year = 2010	15.08***	26.67***	21.08***	31.77***	31.10***	−0.36	1.36***
Test year = 2011	30.66***	36.28***	35.37***	51.18***	49.69***	−0.59	2.11***
Test ages	−0.11	−0.14	−0.42	−0.32	−0.19	−0.02	−0.12***
Male	−12.55***	−3.05	−1.82	−10.22***	20.50***	1.00***	0.18
English spoken at home	−12.04**	−11.71**	−27.50***	−14.29**	−13.83**	−0.13	−0.52**
Indigenous status	−25.78**	−6.61	−9.47	−18.82	−27.01***	−0.02	−0.86
Child health = very good[(a)]	−3.39	−5.33*	−3.07	−3.13	0.09	−0.30*	0.07
Child health = good[(a)]	−1.25	−5.15	−1.72	−1.80	1.15	−0.58*	−0.14
Child health = fair[(a)]	−16.58	−28.85**	−16.43	−13.44	−17.28	−0.60	0.02
Low birth weight (1 = yes)	−7.63	−3.98	−0.06	−14.86**	−10.55**	−0.65*	−0.59**
Mother's age	0.20	0.10	0.05	0.46	0.61*	0.05*	0.00
Mother completed Year 12	16.81***	9.86***	9.98***	17.01***	12.57***	0.45***	0.45***
Mother from an English-speaking country	6.09	2.09	0.02	−1.36	5.14	0.22	0.01
Mother's average hours worked	−0.18**	−0.07	−0.17**	−0.18**	−0.05	−0.01	0.00
Mother have excellent health	1.78	3.17	5.47*	1.97	1.19	−0.61***	−0.04
Mother's depression scale	0.86	−1.33	1.64	2.49	3.47	−0.12	−0.13
Father's age (years)	0.45	0.54*	0.30	0.45	0.25	−0.03	0.02
Father completed Year 12	12.19***	10.10***	9.31***	11.70***	10.59***	0.53**	0.24*
Father from an English-speaking country	−5.42	−4.78	−4.89	1.26	−7.69*	−0.20	−0.05
Father's-average hours worked	−0.02	0.06	−0.02	−0.03	0.02	−0.00	0.01
Number of book at home	9.62***	8.70***	6.65***	10.41***	7.18***	0.69***	0.24**
Having a computer at home	4.70	−0.19	1.44	12.66*	4.18	0.11	0.35
Home activities index	−2.72	−6.18**	−7.12**	−1.32	−6.13**	−0.04	−0.57***
Out of home activities index	4.31***	3.24***	2.99***	2.82*	3.54***	0.04	0.11**
Household size	1.09	0.16	0.43	−0.53	3.42***	−0.23***	0.04
Biological parents are at home	2.47	6.77	6.77	2.93	−0.27	0.20	0.25

(continued on next page)

Table A1-2 (*continued*)

Variables	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
Log of household income	4.88*	4.75*	3.80*	3.05	6.05**	0.17	0.17*
% completed year 12 for linked area	0.72***	0.24	0.12	0.85***	0.58**	0.07***	0.02*
% working in linked area	−0.18	−0.56**	−0.43*	−0.46	−0.77***	−0.01	−0.00
Metropolitan status	−1.29	−4.08	0.64	−4.95	−5.67	−0.53**	−0.18
% Australian born in linked area	−0.18	−0.52*	−0.56**	−0.21	−0.35	0.06***	−0.00
% Indigenous in linked area	−0.39	−0.49	−0.11	−0.78*	0.03	−0.02	−0.02
Index of advantage/disadvantage	−0.05	0.03	0.03	−0.05	0.01	−0.00	−0.00
State = Victoria[(b)]	−15.31***	10.45***	−7.29**	−10.03**	4.81	0.68**	−0.18
State = Queensland[(b)]	−5.52	2.96	−8.38*	−1.44	4.75	−0.16	−0.14
State = South Australia[(b)]	−11.82**	−0.22	−8.85*	−18.24**	−21.32***	1.34***	−0.05
State = Western Australia[(b)]	−5.63	0.53	−12.66***	−9.62	−1.97	0.70	0.47*
State = Tasmania[(b)]	2.33	−17.27***	2.12	−9.17	−7.26	2.32***	0.53
State = Northern Territory[(b)]	−10.31	−7.55	−17.63	−8.76	−14.88**	1.03*	−0.61
State = Australian Capital Territory[(b)]	−12.21	−9.60	−13.98	−13.88	−5.85	−0.93**	−0.70*
Constant	105.72	185.86**	267.38***	152.74*	55.02	51.48***	11.66***
N	2399	2398	2402	2402	2395	2452	2452
R^2	0.276	0.242	0.249	0.269	0.291	0.237	0.191

Note: Standard errors are not reported for brevity [(a)]: Child health = poor and [(b)]: State = New South Wales are set as the base group, respectively.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table A2
Effects of school choices on cognitive outcomes — value-added (Year 5).

Variables	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
Lag of test scores	0.50***	0.42***	0.68***	0.51***	0.58***	0.33***	0.36***
WAI in Wave 1	0.64***	1.37***	0.56***	1.10***	1.32***	0.04***	0.08***
PPVT in Wave 1	1.36***	1.33***	0.15	1.50***	0.48*	0.12***	0.02*
Test year = 2011	−2.72	11.52	−3.06	9.18	9.86	−0.07	1.42***
Test age	−0.29	−0.61	−0.10	−0.76	−0.13	−0.02	−0.07***
Male	−12.94***	1.49	−1.52	−8.49***	5.74**	0.60***	0.09
English spoken at home	−7.06	−8.46	−9.10**	−13.13**	−14.14**	−0.46	−0.31
Indigenous status	−11.31	−4.00	9.59	12.10	−15.46*	0.05	−0.61
Child health = very good[(a)]	−0.34	−4.54	0.39	0.32	1.20	−0.22	0.04
Child health = good[(a)]	−0.84	−5.86	8.19*	8.11	7.54	−0.61*	−0.08
Child health = fair[(a)]	1.60	−22.18*	−3.35	−8.71	−9.23	−0.40	−0.28
Low birth weight (1 = yes)	−3.07	−9.52*	−1.48	−13.63**	−6.51	−0.48	−0.49**
Mother's age	0.02	−0.20	−0.37	0.11	0.87**	0.02	−0.00
Mother completed Year 12	7.11**	4.38	1.99	11.20***	5.26*	0.20	0.29**
Mother from an English-speaking country	−1.63	−3.27	−3.66	−11.00*	−0.26	0.21	−0.13
Mother's average hours worked	−0.14	−0.03	−0.05	−0.20**	−0.12	−0.01	0.00
Mother have excellent health	0.66	2.16	−1.26	0.17	0.46	−0.65***	−0.14
Mother's depression scale	1.76	−5.03**	−0.09	2.16	0.30	−0.25	−0.16
Father's age (years)	0.28	0.52*	0.20	0.49	−0.29	−0.02	0.02
Father completed Year 12	3.55	8.83***	4.46**	5.41*	0.92	0.27	0.20
Father from an English-speaking country	−2.65	−3.67	0.21	6.94	−2.52	−0.20	0.08
Father's-average hours worked	−0.03	0.08	0.01	−0.06	−0.06	0.00	0.00
Number of book at home	2.37	6.81**	3.70**	7.34***	2.47	0.60***	0.19*
Having a computer at home	4.94	2.82	−4.44	15.32**	5.18	0.24	0.37
Home activities index	−3.98	−6.32**	−4.78**	−2.13	−3.52	−0.13	−0.34***
Out of home activities index	2.60**	2.46**	0.45	−0.24	2.87***	0.00	0.05
Household size	0.66	1.33	−0.24	−1.44	3.32**	−0.16*	0.04
Biological parents are at home	−0.30	−5.26	6.88	−11.35*	0.61	−0.19	0.09
Log of household income	3.70	4.23	1.19	0.69	3.27	0.13	0.15
% completed year 12 for linked area	0.26	−0.06	−0.03	0.52*	0.11	0.05***	0.02*
% working in linked area	0.14	−0.11	0.10	−0.07	−0.36	−0.01	−0.00
Metropolitan status	3.09	−1.11	−0.05	−0.14	−2.70	−0.41*	−0.04
% Australian born in linked area	−0.18	−0.60*	−0.15	−0.05	−0.45*	0.05**	−0.01
% Indigenous in linked area	−0.24	−0.45	−0.44	−0.70	−0.03	−0.03	−0.01
Index of advantage/disadvantage	−0.03	−0.01	0.01	−0.07	0.02	−0.00	−0.00
State = Victoria[(b)]	−20.16***	16.20***	−7.43***	−12.57***	1.51	0.49*	−0.28
State = Queensland[(b)]	−6.30	7.01	0.94	3.00	10.38**	−0.23	−0.18
State = South Australia[(b)]	−11.83**	6.28	−15.13***	−12.75*	−5.08	0.90*	−0.18
State = Western Australia[(b)]	−4.55	1.59	0.37	−4.41	4.68	0.61	0.41
State = Tasmania[(b)]	−2.15	−20.28***	−3.14	−8.96	−9.33	1.93***	0.33
State = Northern Territory[(b)]	−17.29	−11.55	−9.60	−18.86	−13.55	0.39	−0.90
State = Australian Capital Territory[(b)]	−4.97	−12.81	−7.85	−15.70	3.00	−1.22**	−0.74*
Constant	165.96**	232.73***	175.14***	250.64***	125.71*	38.09***	7.00**
N	1657	1657	1666	1664	1654	2258	2302
R^2	0.481	0.374	0.669	0.456	0.520	0.323	0.292

Note: Standard errors are not reported for brevity. [(a)]: Child health = poor and [(b)]: State = New South Wales are set as the base group, respectively.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

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