Does School Type Affect Cognitive and Non-Cognitive Development in Children? Evidence from Australian Primary Schools*†

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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 problems associated with individual unobserved heterogeneity by exploiting both the richness of LSAC data and contemporary econometric methods. We find that sending children to Catholic or independent primary schools has no significant effect on their cognitive and non-cognitive outcomes. We now have evidence from three different continents that the returns to attending Catholic primary schools are no different than public schools

Key words: School choice, cognitive/non-cognitive skills, panel data, Australia
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1 Introduction

Some parents send their children to Catholic or private primary schools may be due to the expectation to get greater educational achievement. The existing evidence from the United States (Elder and Jepsen, 2014) and England (Gibbons and Silva, 2011), though, suggests this is not the case. This study investigates whether the previous U.S. and English findings of an insignificant impact of Catholic primary school enrollment on students' academic outcomes are still applied for another country in another continent.

We do so by examining whether attending Catholic and other private schools produces better cognitive and non-cognitive outcomes in Australia. Using the Longitudinal Study of Australia Children (LSAC) data we make several contributions to the literature. First, to the best of our knowledge, this is the first study that investigates the effectiveness of private school choices 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 approach, propensity score matching, and comparisons of selection on unobservables and observables estimators. Third, we also assess effects of school choices on non-cognitive measures of child development. Finally, instead of comparing the performance of public and Catholic schools exclusively, we examine the effects of other types of private schools too.

There is a large literature on the impact of private schooling on academic achievement and attainment. The studies on this topic differ in terms of the methods and identification strategies they use to attempt to overcome the empirical difficulties associated with drawing a causal interpretation of school type on educational achievement/attainment due to the selection bias associated with the choice of school. Broadly, six approaches have been used. The simplest approach tries to address the endogeneity and selection problems by limiting the impact of unobservable factors using a rich set of student, family and school characteristics. The second and closely related approach is to control for students' prior achievement in a value-added framework (Jepsen, 2003; Reardon, Cheadle, and Robinson, 2009). The third approach is to compare students in private and public schools who have similar estimated propensities to attend private schools in a propensity score matching framework (Elder and Jepsen, 2014; Chudgar and Quin, 2012). This propensity score matching approach relies on the assumption that conditional on observable characteristics, students in private and public schools do not systematically differ in unobservable traits. The fourth approach is to take advantage of panel data and control for fixed individual characteristics, leaving the estimate of the change in school sectors in one year and changes in school outcomes in that same year (Lefebvre, Merrigan, and Verstraete, 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 is to use an instrumental variables (IV) method in order to enable a causal impact of private schooling on educational outcomes to be drawn (Vella, 1999)(Cohen-Zada, 2009). However, there is evidence to suggest that most of instruments used in the literature may not be valid Altonji, Elder, and Taber (2005a). The final approach, proposed by Altonji, Elder, and Taber (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. The magnitude of this ratio help researchers assess the degree that school choice affects

school outcomes.

In contrast to a rich literature on private high schools (See Elder and 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 U.S. 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), grades and subjects. 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, maths and general knowledge test scores) among kindergarten students. Lubienski, Crane, and Lubienski (2008) also find a negative effect of Catholic schooling but insignificant effect of other private schooling on fifth grade math test scores. Similarly, Reardon, Cheadle, and Robinson (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. More recently, Elder and 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 behavioral or non-cognitive outcomes. Elder and 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 behavioral and non-cognitive skills. Similarly, Jepsen (2003) uses student compliance, student motivation, and class participation as measures of non-cognitive outcomes.

Using Australian data and various contemporary econometric methods, we show that sending children to Catholic or independent primary schools has no significant effect on their cognitive and non-cognitive outcomes. Our findings are thus in line with two other rigorous econometric studies of primary school students in the U.S. (Elder and Jepsen, 2014) and England (Gibbons and Silva, 2011). The remaining of the paper is structured follows. Section 2 describes the data and Section 3 presents our empirical models. 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 has 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 actual sample sizes for the K cohort in Wave 1, 2, 3 and 4 are 4983, 4464, 4331 and 4169, respectively.

While most previous studies focus on Catholic schools, we also include other private schools in the analysis as they enrol 13 percent of the children we observe. The proportions enrolled in public and Catholic schools are 67 and 20 percent, 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 other private schools 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

Cognitive outcomes

We choose results from the National Assessment Program – Literacy and Numeracy (NAPLAN) test to indicate the latent cognitive skills of children. The NAPLAN test is required 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 NAPLAN test results of children were collected via data linkage with LSAC data. Although the NAPLAN test is available for students in Year 3, 5, 7, and 9, the linkage data for LSAC were mainly available for children in Years 3 and 5 (Daraganova, Edwards, and Sipthorp, 2013). We thus focus on Year 3 and Year 5 NAPLAN test results and use results of all test subjects in order to measure the latent cognitive skills of students.

We also use matrix reasoning and the Peabody Picture Vocabulary Test (PPVT) to measure cognitive outcomes of children. The Matrix Reasoning (MR) test was scored using the Wechsler Intelligence Scale for Children, 4^{th} 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 matrix reasoning 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 required a

child to show the picture that best represents the meaning of a stimuli word spoken by the examiner (Dunn and Dunn, 1997). The sample of words were: sawing, wrapping, cage, exercising, fountain, nest, claw, delivering, frame and envelope. This test was only available in the first three waves of the LSAC.

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 1-2 percent while relative figure of students from independent schools is around 5 percent (see Table 1). This pattern also occur in two other tests: matrix reasoning and the Peabody Picture Vocabulary Test (PPVT).

Non-cognitive outcomes

Schooling facilitates the development of non-cognitive (e.g., social) skills that are also valued by households. Thus, 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, for instance. Thus, the religious or secular orientation of a school, its governance and resource allocation decisions across the curriculum and to extra-curricular activities, may matter to households. 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 Problems Scale and the Prosocial 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 Prosocial Scale, higher scores indicate a greater probability of "caseness", i.e. of underlying mental health disorders. On the Prosocial Scale, lower scores indicate a higher probability of caseness. Essentially, there are two groups of indicators: one refers to "problems" (hence less "problems" is better) and one refers to "good behaviours" like pro-social (hence more prosocial is better). In practice, the "problems" category is presented a summary score, called the Total Difficulties Score, is derived by summing the scores of subscales other than the Prosocial Scale, resulting in a score from zero to 40. Higher values on the Total Difficulties Score indicate a higher probability of "caseness".

The mean scores show that children from Catholic and other private schools are assessed to have significantly better mean behavior (i.e., higher scores on pro-social and lower scores on the remaining measures) than are children in public schools (see Table 1). Except for the pro-social measure, students from other private schools have 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) show no significant differences between three school types, suggesting similar performance of these school children at "baseline" but differences by school type in subsequent years.

2.2.2 Control variables

We group the covariates into three groups: 1) initial stock of cognitive skills; 2) inputs to cognitive and non-cognitive development; and 3) environmental factors that affect the production of those skills (i.e., taste shifters of parents and productivity shifters of children). The first group includes by the Peabody Picture Vocabulary Test (PPVT) and Who Am I (WAI)[1] scores in Wave 1, when the child is 4-5 years old (i.e., before enrolling primary school). The second group includes measures of household market inputs available in our dataset include the numbers of books at home, whether the child has access to computers and the characteristics of their residential neighborhoods (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 by households is the time that parents spend on the development of their children. The third groups 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-birthweight children. Some family characteristics may also affect development outcomes directly via family traits (e.g., genetic inheritance) and indirectly via parents' preferences (as shaped e.g., by family tradition). In this study, we select parental education level, and parents' reported physical and mental health status as factors that may affect the child's 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, as well as a higher likelihood of being in good health themselves. 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–with the exception of the gender distribution of children–these three school types do exhibit statistically significant differences across the controls. In particular, the household incomes for children enrolled in public schools are lower than the household incomes of students enrolled in Catholic schools which, in turn, are lower than the incomes of households for children enrolled in other private schools. Parental education, parental physical health and mental health are highest for children in other private schools, followed by Catholic schools and public schools. The proportion of students who are identified as being from an Aboriginal or Torres Strait Islander

[1] The Who Am I (WAI) test is 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). The WAI seems to achieve this objective: the reliability scores of WAI range from 0.89 (Adams and Khoo, 1998) to 0.91 (de Lemos and Doig, 1999; Doig, 2005). Owing to their high reliability, these non-cognitive skill measures have been used widely to proxy child development in recent economic literature (Chen, Claessens, and Msall, 2014).

(ATSI) background in other private 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 other private schools have higher self-reported health and receive more parental inputs (as indicated by 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, mployment 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 percent) than other private schools (48 percent), this difference is not statistically significant.

3 Methodology

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

$$A_{it} = \beta_0 + \beta_1 A_{i0} + \beta_2 A_{i,t-1} + \beta_3 SC_{it} + \beta_4 X_{it} + \beta_5 Z_{it} + \eta_i + \varepsilon_{it} \quad (1)$$

where A_{it} is a set of the child development outcomes at the current period and A_{i0} is the endowment (or initial outcomes); SC_{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 the βs are parameters to be estimated.

One problem with the estimation of Equation 1 in our study is that only two (time) observations (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 effects of selection on observables with selection on unobservables; and using the value-added approach to measuring the impact of school choice.[2] These strategies are discussed in more detail, below.

a. Comprehensive controls

When the data are rich enough, one can argue that the effects of unobservables 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 data set by comparing

[2]We also 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 percent of students changed school during the study period: FE results on this small subsample are probably of little, if any, interest.

the estimated parameters of interest (β_3) 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 two tests (which we discuss below) 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 the latent parental investment in the child's education (e.g., number of books at home, access to computers, an index for "quality time" that parents and child 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 the removal of the lagged dependent variable and family fixed effects) as follows:

$$A_{it} = \beta_0 + \beta_1 A_{i0} + \beta_3 SC_{it} + \beta_4 X_{it} + \beta_5 Z_{it} + \varepsilon_{it} \tag{2}$$

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 and Spinath, 2004), as does nurture in the household environment (Bradley and Corwyn, 2002).

b. Propensity score matching

This approach is based on the assumption that, conditional on observed characteristics, there is no systematically 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 other private schools with those in public schools who have a similar propensity to attend non-government schools . The propensity scores are estimated as:

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

where 1(.) is a function that takes the value of 1 if its arguments are true and zero otherwise and other notation is as previously defined defined. In order to compare our results with previous studies by Elder and Jepsen (2014), we estimated Equation (3) using the probit estimator with three popular matching methods: the kernel density, nearest neighbor, and caliper approaches.[3]

c. Selection on observables and unobservables

This approach, developed by Altonji, Elder, and Taber (2005b), uses the degree of selection on observables as a guide to determine the amount of selection on unobservables. 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.

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

Under the null hypothesis that school choice has no significant effects to academic outcomes, Equation (2) can be estimated via an Ordinary Least Squares (OLS) regression as:

$$A_{it} = \beta_0 + \beta_1 A_{0i} + \beta_4 X_{it} + \beta_5 Z_{it} + \varepsilon_{it} \tag{4}$$

The effect of selection bias in (4) is then represented by:

$$bias = \frac{cov(\tilde{SC}_{it}, \varepsilon_{it})}{var(\tilde{SC}_{it})} \tag{5}$$

where $\tilde{SC}_{it}$ is the residuals from the regression of school types (SC_{it}) on the covariates (X_{it} and Z_{it}) and ε_{it} is the residuals from the constrained regression where the null hypothesis that school type has no effect on outcomes is imposed. The OLS estimation of Equation (4) implies that ε_{it} is uncorrelated with X_{it} and Z_{it}, and hence all components in the above bias ratio are identified. The ratio between parameters of school types estimated using OLS on Equation (2) and the bias ratio above represents the "implied ratio", at which the difference between selection on unobservables and selection on observables is large enough to cancel out any significant effects of school types estimated from Equation (2).[4]

Oster (2014) made further developments on the estimator introduced by Altonji, Elder, and Taber (2005b) to take into account the movements of the R^2 due to the presence of unobserved individual heterogeneity. Using data from randomized papers published in economics journals, the author revealed that the R^2 in regressions with potential unobserved heterogeneity ($\tilde{R^2}$) is bounded in $[\tilde{R^2}, min(2.2\times\tilde{R^2}, 1)]$; and the proportion of observables and unobservables ($\tilde{\delta}$) is bounded in [0,1]. Implicitly, the author suggests that it is unlikely that it is either negative or greater than unity. Specifically, $\tilde{\delta}$ is negative when unobserved heterogeneity has the adverse effect to that of observables; while $\tilde{\delta}$ is greater than unity when the effects of unobserved heterogenetiy is greater than that attributable to observables. Armed with this information, one may thus estimate the proportion of observables to unobservables that renders the effect of school choices in Equation (2) equal to zero; or, alternatively, estimate the bound of coefficients (or the "identified set") of school choice parameters as a form of sensitivity analysis. We choose to report the bounds of coefficients to examine the degree to which selection on observables and unobservable affects school outcomes because it is easier to interpret; a bound of parameter that does not include zero suggests that it is a robust estimate.

d. 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–Equation (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. Unlike the situation of first-differencing in the dynamic model, the lagged dependent variable

[4]For more detailed discussion of this approach, see Altonji, Elder, and Taber (2005b) and Elder and Jepsen (2014).

in this specification is considered a pre-determined variable, and hence is exogenous by construction. Due to the difficulty of finding a good instrument from the data set, we exploit the richness of LSAC data (i.e., using a comprehensive set of controls) as the way to address the suspected endogeneity problem in this specification.

4 Results and discussion

4.1 Cognitive outcomes

The OLS results (Table 3) from our naive model 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 test scores for reading for Years 3 and 5 of students from other private 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 matrix reasoning (MR) for Grade 5. One exception is that the PPVT and MR test scores in Grade 5 are higher for students from private 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 percent level.

We use the comprehensive set of controls to compute propensity scores using the kernel method[5] 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 significant differences in Grade 3 test scores among students from different school types. However, the PPVT and matrix reasoning of students from Catholic schools are significantly lower than those for students enrolled in public schools. The test scores of students from Catholic schools in Year 5 are significantly lower than those in public schools in all subjects except reading and writing. We also find that the reading, PPVT and matrix reasoning for Grade 5 of students in other private schools are significantly higher than those in public schools but the level of statistical significance is low and the magnitudes of the differences are generally modest.

[5]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 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]
Private	-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]
Private	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. The number of observations in Grade 3 is about 1800 and that in Grade 5 is about 2400.*

The value-added estimator results (Table 5) are also consistent with the OLS and 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 other private 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 significantly 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: 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, the parameter ranges do not include zero–rather, they are positive for PPVT and negative for the remaining indicators–thus suggesting that our results are robust. Specifically, using the value-added measure, results for this estimator are as robust as if students were randomly allocated to Catholic schools. For other private schools, though, only the results on writing and spelling are robust, suggesting that selection bias may still exist for the parameters estimated on reading, 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 other independent schools were statistically insignificant (except in the case of PPVT outcome where the estimate is statistically significant at the 10 percent level), it is reasonable to interpret the results as indicating that attendance at other independent schools confers no advantage on the cognitive development of children at the primary

school level.

Detailed results from OLS (Appendix Table A1) and value-added (Appendix Table A2) estimators show that other significant determinants of children's cognitive outcomes include the initial stock measure, inputs to child cognitive production, productivity shifters and taste shifters. As expected, the initial stock of cognitive skills (proxied by PPVT and WAI tests 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 PPVT or WAI test score results in a 1-4 points 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[6]. 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 schools 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 is lower for all students who identified as ATSI in Year 3 than for their non-indigenous peers. It is encouraging, though, that the results

[6]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.

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 birthweight of less than 2,500 grams) 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 birthweight 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 other private—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 pioneered by Altonji, Elder, and Taber (2005b) which can determine the relative magnitudes of selection on unobservables and selection on observables that is required for the entire effect of school choice on child development outcomes to be explained by selection alone. The results suggest that the only possible outcomes for which selection bias could be responsible are the positive results from OLS and propensity score estimates for reading scores of Grade 5, PPVT and MR at other private schools (although these results are different only at the 10 percent level of significance). Thus, we focus on estimating the ratio of unobservables and observables that is needed to explain away any positive effects of school choice on these particular measures. The reason for focusing on these three measures is that it is not meaningful to find the explanation for selection bias if the parameters estimates for the selection variable are not, themselves, statistically significant. Also, it is difficult to argue the case that selection on observables and unobservables should run in different directions (i.e., resulting in statistically significant negative results of test scores for Year 5 in Catholic schools).

We find that the implied ratios of selection on unobservables and observables for Year 5 reading, PPVT and MR test scores of other private schools are 0.88, -1.37 and 1.04, respectively. Thus, if the strength of selection on unobservables is 88 percent of that of selection on observables, the significant effects of Year 5 reading results would be zero. The effects of school choice on MR would be zero if selection on unobservables was 4 percent larger than that of selection on observables. The negative implied ratio on PPVT suggests that unobservables have the opposite effects to those of observables, which is unlikely. Although the first two of these ratios appear to be substantively different from unity, which indicates the amount of selection on observables equals to that of unobservables, bootstrapped confidence intervals do not lead to a rejection of the null hypothesis of no effect of school type on these three outcomes.[7] In short, when unobserved heterogeneity is accounted for, we find no significant effects of school type on the cognitive outcomes for schoolchildren in our sample.

[7]Detailed results are not reported for brevity but are available from the authors upon request.

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, left panel) suggest that students at Catholic and other private schools experience a lower incidence of peer problems, as indicated by the negative coefficients . However, the estimates on the left panel ignore the cumulative effects of skill formation. The right panel of Table 6 shows the value-added results that are obtained by controlling for the stock of non-cognitive skills. The results accord with the OLS results: children from Catholic and other private schools still have a significantly lower incidence of peer problems than their public school counterparts. The value-added results suggest, though, that children from other private schools exhibit significantly higher mean scores on the hyperactivity (for Wave 2) and emotional problems SDQ sub-scales (for Wave 3).

Table 6: Effects of school choices on non-cognitive outcomes - OLS and Value-added

Skills/wave	OLS				Value-added			
	Catholic		Independent		Catholic		Independent	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Pro-social								
Wave 2	0.10	0.08	0.06	0.08	0.05	0.07	0.10	0.08
Wave 3	0.10	0.08	-0.00	0.1	0.03	0.07	-0.03	0.09
Wave 4	0.08	0.07	-0.15*	0.09	-0.07	0.06	0.01	0.07
Hyper-activity								
Wave 2	-0.05	0.08	-0.05	0.13	0.10	0.07	0.22**	0.11
Wave 3	0.01	0.09	-0.08	0.12	0.06	0.08	-0.06	0.1
Wave 4	0.02	0.09	0.13	0.12	0.03	0.08	0.07	0.09
Emotional problem								
Wave 2	0.05	0.06	0.03	0.09	0.01	0.06	0.13	0.09
Wave 3	0.10	0.08	0.15	0.1	0.07	0.07	0.23**	0.09
Wave 4	0.02	0.07	0.06	0.09	0.02	0.08	0.01	0.09
Conduct problem								
Wave 2	-0.05	0.06	-0.01	0.07	0.02	0.05	0.04	0.07
Wave 3	-0.01	0.06	-0.05	0.07	0.03	0.05	-0.07	0.06
Wave 4	-0.03	0.06	0.01	0.08	-0.02	0.05	0.01	0.07
Peer problem								
Wave 2	-0.06	0.06	-0.07	0.08	-0.05	0.06	0.06	0.08
Wave 3	-0.21***	0.06	0.02	0.09	-0.16***	0.06	0.03	0.08
Wave 4	-0.23***	0.06	-0.22**	0.09	-0.12**	0.06	-0.19***	0.07

*Note: *** p<0.01, ** p<0.05, * p<0.1; Other covariates are skipped for brevity. The number of observations for each wave is about 3000.*

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. We found that test scores and SDQ behavior measures of students from independent schools did not provide signficant advantage on whilst cognitive outcomes of students from Catholic schools can be worse than those in public schools when individual unobserved heterogeneity is taken into account. Our results are in accordance with two other rigorous econometric studies of primary school children in the U.S. (Elder and Jepsen, 2014) and England (Gibbons and Silva, 2011). This is an important result because it suggests that selection bias accounts for the differences in child development outcomes across school types, across three continents. We find that significant determinants of child development outcomes include some market and time inputs supplied by parents (e.g., books, working hours of mother, choice of residential neighborhoods and household incomes), some variables that we classified as productivity shifters (age, gender, health status, initial stock of skills) and some we classified as taste shifters (parental educations, family ethnicity and cultural background).

The results presented in this study should still be interpreted with some care. First, we have only two observations of cognitive outcomes per child, thus, it is generally difficult to address the unobserved heterogeneity issue econometrically (e.g., using the system GMM approach). 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 Altonji, Elder, and Taber (2005b)'s approach demonstrated that positive effects of private school choices in this study 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.

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Table 1: Child outcomes by school type

Variables	Public	Catholic	Independent	Differences (percent)	
	(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 one percent level.

Table 2: Descriptive statistics for selected covariates by school types

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 birthweight (1=birthweight less than 2500grams)	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

Note: Robust tests for the difference of means and variance between school types are mostly significant at the 5 percent level. Some exceptions include the child's gender, whether English was spoken at home, and low birth weight (for the mean test); and the child's gender, PPVT, Matrix reasoning, and test scores at Year 3 for numeracy and grammar (for the variance test)

[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.*

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]
Private 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]
Private 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]
Private 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]
Private 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 ,*** p<0.01, ** p<0.05, * p<0.1;*
"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 birthweight);
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 Table A1-1 and Table A1-2 at the Appendix. 2400.

Table 5: Effects of school choices on cognitive outcomes – Value-added

School type	Reading	Writing	Spelling	Gram-mar	Numer-acy	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	(-9.6,	(-13.2,	(-8.4,	(-19.8,	(-11.0,	(.1,	(-.3,
	-.8)	-1.4)	-5.0)	-7.1)	-5.4)	.2)	-.25)
Private	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	(-13.7,	(-24.5,	(-13.4,	(-28.5,	(-20.8,	(-.08,	(-.2,
	7.4)	-.7)	-3.9)	1.3)	2.9)	.49)	.26)
Observations	1,657	1,657	1,666	1,664	1,654	2,258	2,302
R^2	0.481	0.374	0.669	0.456	0.520	0.323	0.292

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

Appendix

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
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 birthweight	-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

*Note: Standard errors are not reported for brevity,*** p<0.01, ** p<0.05, * p<0.1*

Table A1-1: continued

VARIABLES	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
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	1,790	1,792	1,794	1,792	1,785	1,776	1,821
R^2	0.293	0.247	0.243	0.271	0.292	0.283	0.149

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

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 birthweight (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

*Note: Standard errors are not reported for brevity,*** p<0.01, ** p<0.05, * p<0.1*

Table A1-2: continued

VARIABLES	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
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
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	2,399	2,398	2,402	2,402	2,395	2,452	2,452
R^2	0.276	0.242	0.249	0.269	0.291	0.237	0.191

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

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 birthweight (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*

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

Table A2: (continue)

Variables	Reading	Writing	Spelling	Grammar	Numeracy	PPVT	MR
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	1,657	1,657	1,666	1,664	1,654	2,258	2,302
R^2	0.481	0.374	0.669	0.456	0.520	0.323	0.292

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