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Explaining the evolution of ethnicity differentials in academic achievements: The role of time investments

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Children of Asian immigrants in most English-speaking destinations have better academic outcomes, yet the underlying causes of their advantages are under-studied. We employ panel time-use diaries by two cohorts of children observed over a decade to present new evidence that children of Asian immigrants begin spending more time than their peers on educational activities from school entry; and, that the ethnicity gap in the time allocated to educational activities increases over time. By specifying an augmented value-added model and invoking a quantile decomposition method, we find that the academic advantage of children of Asian immigrants is attributable mainly to their allocating more time to educational activities or their favorable initial cognitive abilities and not to socio-demographics or parenting styles. Furthermore, our results show substantial heterogeneity in the contributions of initial cognitive abilities and time allocations by test subjects, test ages and points of the test score distribution.

Keywords: Migration, Education, Test Score Gap, Time Diary, Quantile Regression, Second-generation Immigrants, Australia.
JEL classifications: C21, I20, J13, J15, J22.

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1. Introduction

It has been well documented that, in most multi-cultural Anglo-Saxon countries,[1] children of Asian immigrants have better academic outcomes than both children of non-immigrant parents and children of other immigrant parents (Dustmann & Glitz 2011; Sweetman & van Ours 2015; Duncan & Trejo 2018). The apparently-high academic performance of children of Asian immigrants raises an important research question: how and why do children of Asian immigrants who were born and raised in the same country as other children have better academic outcomes? While measuring the factors contributing to the academic advantage observed for children of Asian immigrants is imperative for informing policies to promote better academic outcomes in all children, very little is known due to substantial data constraints and endogeneity issues when measuring the causal impact of such factors.

Specifically, the existing studies, which are mostly from the US, have related the remarkable academic performance of Children of Asian immigrants to the "cultural" norms which translate from their parents highlighting the role of education in success in life (Kao & Tienda 1998; Liu & Xie 2016; Watkins *et al.* 2017). Ethnicity differences in parenting styles may also have a role in explaining the academic success of the Asian American children (Huang & Gove 2015; Lundberg 2015). Some studies have gone further to quantify the role of various factors that may contribute to the Asian American students' academic achievements. For instance, Peng & Wright (1994) document that the differences in home environments and educational activities[2] account for a large part of the difference in Grade 8 test scores between Asian American and other minority students. More recently, Hsin & Xie (2014) find that the Asian American educational advantage is attributable

[1] This paper focuses on academic performance of second-generation immigrants, identified as those who were born in the country of review with at least one immigrant parent. In Section 5, we examine relative academic performance of third-generation immigrants who are classified as native-born children of two Australian-born parents where at least one grandparent is foreign-born. The Asian immigrant children's academic advantages have been documented for Australia (Choi et al. 2015; Le & Nguyen 2018), Canada (Hansen & Kuera 2003; Aydemir & Sweetman 2007), the United Kingdom (Algan et al. 2010; Dustmann et al. 2012), the United States (Chiswick & DebBurman 2004; Fryer & Levitt 2006; Clotfelter *et al.* 2009; Choi *et al.* 2015; Figlio *et al.* 2016; Özek & Figlio 2016; Gibbs *et al.* 2017) and New Zealand (May *et al.* 2016). However, such a phenomenon has not been reported in studies using data from other countries, including Ireland, probably due to the small number of second-generation immigrants with an Asian background in these countries. For purposes of focus, this paper only concentrates on studies examining the relative academic performance of Asian immigrant children. Reviews of the literature on academic performance by ethnicity/nativity can be found in Kao & Thompson (2003), Dustmann & Glitz (2011), Sweetman & van Ours (2015) or Duncan & Trejo (2018). Following the literature, we use ethnicity and nativity terms interchangeably in this paper.

[2] They include in the test score regressions a comprehensive list of variables, including student's study effort (measured by the number of hours doing homework and time watching TV), parental assistance (in terms of assistance in schoolwork and discussion about school), parents' educational expectations for their children, and students' participation in additional lessons and schooling activities. Like most studies in this literature (Hsin & Xie 2014; Gibbs *et al.* 2017), Peng & Wright (1994) employ a regression-based approach where the factor of interest is included as an explanatory variable in test score equations to quantify its contribution to the overall ethnicity test score gap. As will be shown in Sections 4, a decomposition approach employed in our study offers a more direct way to do so (Fortin *et al.* 2011).

mainly to Asian students exerting greater academic effort, as measured by teachers' evaluations of Grade 10 students' classroom behavior and attitudes.

In this paper, we investigate the role of a largely unexplored factor: time investment (Heckman & Mosso 2014). The recent literature shows that time investments by parents and their children are prime factors that influence child capability formation (Del Boca *et al.* 2014; Fiorini & Keane 2014; Gayle *et al.* 2015; Del Boca *et al.* 2017; Lee & Seshadri 2018). Building on this literature, our contribution is to explore whether differences in time investments by children of native-born and immigrant parents may help to explain the evolution of nativity differentials in academic achievements. To do so, we employ rich longitudinal time-use diaries by two cohorts of children observed over a decade to show that children of native-born Australian parents and children of Asian immigrant parents spend their time very differently. Furthermore, we provide novel evidence that children of Asian immigrants begin spending more time than their peers on educational activities from around 6-7 years of age; and, that the nativity gap in the time allocated to educational activities increases as students advance through their school years. We also use the results from numerous tests observed over an extended and important period of child development, of 4-5 to 14-15 years of age, showing that such the growing differential pattern in respect of educational time mirrors the growing academic advantages experienced by children of Asian immigrants over time. However, we do not observe significant nativity differences in academic performance or time allocation between third-generation Asian immigrant children and their non-Asian peers, indicating that ethnic attachments tend to fade across generations (Borjas 1992; Özek & Figlio 2016).

To examine whether differences in time investments by children of Australian-born and immigrant parents contribute directly to an explanation of the evolution of nativity differentials in academic achievements, we adopt an "augmented value-added" (AVA) regression model and an unconditional quantile decomposition method. In particular, we follow recent studies (Todd & Wolpin 2007; Fiorini & Keane 2014; Del Boca *et al.* 2017) to model the production of academic achievement in children as a cumulative process that depends on both lagged and contemporaneous time allocations and a rich set of time-varying explanatory variables to examine the impact of children's time allocations on their test scores. The AVA model is employed to address two issues related to the possible endogeneity of children's time investments, namely unobservable individual heterogeneity and reverse causality. By employing this model, this paper improves on what has been possible in most studies on the sources of a nativity academic gap. These studies have relied on cross-sectional data and were unable to address these two issues (Peng & Wright 1994; Hsin & Xie

2014; Gibbs *et al.* 2017), which we can address with panel data econometrics.[3] We then apply an Oaxaca-Blinder (OB) decomposition method to quantify contributions of various factors, including time allocations, initial cognitive abilities and parental styles, to the aggregate nativity gaps in various test subjects at different test ages.

This paper also makes three methodological contributions to related lines of literature. First, it is one of only a few studies that have used a quantile regression approach to study nativity academic achievement gaps over the whole distribution of test scores, rather than focusing on marginal effects at the means (Clotfelter *et al.* 2009; Konstantopoulos 2009). This is important, because analyses that are based solely on means may miss important information in other parts of the distribution. This is particularly relevant to policy considerations, which may focus, not only on the means, but on the tails of test score distributions (Firpo *et al.* 2009). Second, this paper is the first to apply a quantile regression model to examine the impact of time investments on child cognitive skills (Del Boca *et al.* 2014; Fiorini & Keane 2014; Gayle *et al.* 2015; Del Boca *et al.* 2017; Lee & Seshadri 2018). By adopting this approach, we intend to shed light on whether returns to time allocations and existing knowledge vary along the spectrum of students' cognitive abilities. Third, while a few studies have employed a decomposition approach to examine factors contributing to the nativity academic achievement gap (Clotfelter *et al.* 2009; Cobb-Clark & Nguyen 2012), this study is the first to employ a quantile decomposition method. This method allows us to quantify the contribution of each factor of interest to the nativity test score gap, across the entire distribution.

Our quantile regression and decomposition approaches yield several novel findings. For instance, our quantile regression results show that at kindergarten entry, children of Asian immigrants lag behind in language-related skills at all points of the test score distribution and the Asian disadvantage is considerably more pronounced at the lower end of the distribution. We also discover that, at ages 4 or 5, Asian immigrant children nevertheless outperform Australian-born parent children in general cognitive skills over virtually the whole distribution. We also show that the nativity test score gap in favor of Asian immigrant children is larger at the upper end of the distribution. These results suggest that the widening nativity test score gap in numeracy over time, which has been observed at the mean, may have largely been driven by the differential performance of students at the upper end of the test score distribution.

[3] The study by Todd and Wolpin (2007) is an exception as it also uses an AVA model to examine the racial gap in test scores in the US. However, that study focuses on the sources of test score gaps between black, white, and Hispanic children and does not investigate the role of children's time allocation in explaining the ethnicity test score gap like the current paper does.

In addition, while existing work points to the important and positive impact of educational time on cognitive skills for all children (Fiorini & Keane 2014), our quantile regression results show that returns to educational time are greater for children in the higher quantiles of the test score distribution. Moreover, while current studies establish the positive impacts of initial cognitive abilities on subsequent test scores (i.e., the estimates of lagged scores are positive and highly statistically significant) (Fiorini & Keane 2014; Del Boca *et al.* 2017), this study advances the literature by demonstrating that returns to initial cognitive endowments are also greater for students at the upper end of the test score distribution. The latter is particularly true of student performance in mathematics.

Our decomposition results also yield the following salient findings. First, differences in initial cognitive abilities between children of native-born Australians and children of Asian immigrants are the most important factor explaining the nativity test score gap. Second, disparities in the time allocated to educational activities between children of Asian immigrants and children of Australian-born parents also help to explain the Asian-Native test score gap. In contrast, differences in other characteristics of the child or characteristics of the household, including family composition, parental education, family income and parenting styles, explain very little of the nativity academic performance gap.

Third, our decomposition results show marked differences in the contributions of initial cognitive abilities and time allocations to the overall nativity test score gaps by test subjects, children's ages, and percentiles of the test score distribution. For instance, the results show that between the ages of 6-7 and 8-9, children of Asian immigrants spend more time on educational activities to compensate for their significant disadvantage in their initial language function and that they subsequently perform as well as children of Australian-born parents in language-related skills by 8-9 years of age. By contrast, the favorable initial cognitive abilities and greater educational time investments of children of Asian immigrants all contribute to their academic advantages in other non-language-related subjects at ages 8-9 and in all test subjects at older ages. Furthermore, our quantile decomposition results indicate that the increasing contribution of time allocation and initial cognitive abilities to the aggregated nativity gap along the test score distribution help explain why the nativity test score gap is more pronounced at the top of the distribution, especially in spelling and numeracy.

The remainder of the paper is structured as follows. Section 2 documents the evolution of nativity test score gaps, both at the mean and along the distribution, from pre-school to the ninth grade. Section 3 describes the evolution of ethnicity differentials in time allocation of children from infancy

to middle adolescence. Section 4 reports decomposition results of factors contributing to the nativity test score gap. Section 5 represents results from various robustness checks and, finally, Section 6 concludes.

2. The evolution of the nativity test score gap

2.1. Data

The empirical analysis discussed in this paper is based on data from the first six waves of the bi-annual nationally representative Longitudinal Study of Australian Children (LSAC). The LSAC, initiated in 2004, contains comprehensive information about children's test scores and other characteristics of the children and their parents. The LSAC sampling frame consists of all children born between March 2003 and February 2004 (the birth or "B cohort"), and between March 1999 and February 2000 (the kindergarten or "K cohort"). To document the evolution of the nativity test score gap, we focus on test scores of K-cohort children because measures are more widely available for this cohort in the first six waves of the survey.

2.2. The child's ethnicity classification

We use information on countries of birth of both biological parents of the child to determine the child's ethnicity.[4] We rely on the countries of birth of both parents because we find that the father's and mother's birthplace appears to have a separate and similar contribution to the child's academic performance (see Appendix Table B1). This approach is particularly relevant in our context given that for about a quarter of LSAC parent-couples, one of the LSAC parents was born in a different country to the other LSAC parent. This includes cases where one parent is born in Australia. We note that this approach comes at the cost of reducing the sample size because we do not observe the father's birthplace for all of the children surveyed. This concern is, however, lessened by the notable advantage that the LSAC data include information about the birthplace of the biological father of the child irrespective of the current marital or co-residing status of the biological parents. In particular, among all children surveyed in the first wave of the LSAC, we observe birthplace for 99.8% of their mothers and 93.6% of their fathers.

[4] Possibly due to data availability, US studies usually rely on subjective measures of race/ethnic self-identification to clarify the ethnicity of second-generation immigrants (Chiswick & DebBurman 2004; Choi *et al.* 2015). As demonstrated by Duncan & Trejo (2011, 2017), using parents' countries of birth, like the current paper does, would provide arguably more objective measures of the child's ethnicity.

We define three groups of interest. "Asian immigrant children" are those who were born in Australia by at least one Asia-born parent.[5] "Children of Australian-born parents" or "native parent children" are defined as those who were born in Australia by two Australian-born parents. Subsequently, "non-Asian immigrant children" or "other children" are remaining children who were born in Australia by two non-Asian immigrants or by one non-Asian immigrant and one Australian-born parent. Applying these definitions, of the 10,090 children surveyed in the first wave, 6,162 (or 61%) are classified as Australian-born parent children, 2,271 (23%) "non-Asian immigrant children", 992 (10%) Asian immigrant children, and the remaining 665 (7%) "unidentified" due to missing birthplace of both parents. Appendix Table A1 represents compositions of parents' countries of birth by the child's nativity. The table shows most Asian immigrant parents are from China, India, Vietnam, Lebanon, the Philippines, Sri Lanka, Iraq, Malaysia, Pakistan, Turkey, Afghanistan and Indonesia. By contrast, non-Asian immigrant parents are dominantly from English-Speaking-Background (ESB),[6] Pacific (i.e., Papua New Guinea and Fiji) or European (e.g., Germany, Italy, France, Switzerland and the Netherlands) countries.

2.3. Summary statistics

Summary statistics of main socio-economic background variables by the child's nativity are presented in Table 1. From this table it is evident that, as compared to children of Australian-born parents, children of Asian immigrants are more likely to be breastfed at infancy, have mothers with higher qualifications (but fewer working hours),[7] are more likely to live with both parents, and to have fewer siblings on average. Each of these factors may play a role in promoting child development. Conversely, though, Asian immigrant children are less advantaged, compared with Australian-born parent children, in other respects: their families have lower incomes, on average,

[5] While all B-cohort children were born in Australia, about 3.5% of K-cohort children were born overseas. We experimented including students' migration status in their test score equations and found their impact statistically insignificant. This finding is consistent with evidence that migrant children arriving in the host country at young ages have similar academic development as native ones (Özek & Figlio 2016). We also experimented excluding children born overseas from all regressions and found similar results. Therefore, all K-cohort children are considered as "being born in Australia" in this study. We do not disaggregate the child's ethnicity further (e.g., by major source countries such as China or India) to keep the sample size of each ethnicity group reasonably large to obtain reliable estimates and to keep the results, especially decomposition ones, manageable. Section 5.1 presents results using alternative ethnicity classifications.

[6] English-speaking countries include Australia, UK, Ireland, Canada, New Zealand, South Africa and USA.

[7] Similar patterns have been documented in other Australian studies. In particular, immigrants usually have higher qualifications than natives, mainly because Australia maintains a skilled immigrant selection policy (Antecol *et al.* 2006). Furthermore, despite having higher qualifications, Australian female immigrants who are often secondary migrants in skilled-visa streams struggle to join the workforce (Nguyen & Duncan 2017).

and they are more likely to be recorded as being of low birthweight.[8] They are also more likely to live in a rented home than their peers born to Australian-born parents.

[Table 1 around here]

Table 1 additionally indicates significant differences in characteristics between children of Australian-born parents and those of non-Asian immigrants. In particular, non-Asian immigrant children tend to have better resources, as illustrated by the fact that they are more likely to be breastfed at 3 or 6 months, have more educated mothers, are more likely to live with both parents, or have higher household income. However, they are less likely to be male, are older (consistent with a pattern that their mothers are also older) or are more likely to live in a rented home or have fewer siblings.

2.4. Cognitive and academic achievement measures

Three tests of cognitive ability were administered to the study children. We employ test scores from Who Am I (WAI), Adapted Peabody Picture Vocabulary Test (PPVT) and the Matrix Reasoning (MR) subtest of the Weschler Intelligence Scale for Children, 4th edition as indicators of children's early cognitive skills. The WAI test is administered to pre-school age children by an interviewer and assesses their readiness to perform literacy and numeracy tasks (Lemos & Doig 1999). The PPVT test is also an interviewer-administered test to measure a child's knowledge of the meaning of spoken words (i.e., receptive vocabulary) for standard English (Dunn & Dunn 1997). Finally, the Matrix Reasoning (MR) test (which is also conducted by an interviewer) is used to measure a child's non-verbal visuospatial ability. For K cohort children, the WAI test was only administered once, in Wave 1 when the child was 4-5 years old, while the PPVT tests were conducted in Waves 1, 2 and 3 and MR tests in Waves 2, 3, and 4. For ease of interpretation, WAI, PPVT and MR test scores are standardized (with mean 0 and standard deviation 1) by subject and wave throughout the paper.

With respect to academic achievement measures, we employ results from the National Assessment Program – Literacy and Numeracy (NAPLAN) tests. The NAPLAN test was introduced in 2008 and is administered to all Australian students in grades 3, 5, 7 and 9 in the five domains of reading, writing, spelling, grammar and numeracy. The test scores range from 0 to 1000 and are comparable across students and over time (ACARA 2014). The NAPLAN test results were collected via data

[8] The available empirical evidence suggests that (healthy) babies of mothers with Chinese or South Asian heritage in the United States do tend, on average, to be lighter and have smaller head circumference than other children. For this reason, the application of (population-based) low birth-weight thresholds risks misclassifying some children and has led some authors to call for ethnically-specific birth-weight charts and thresholds. See Hanley & Janssen (2013) for a discussion and empirical results obtained for the state of Washington. Our low birthweight classification may be subject to the same criticism in respect of the birthweight of babies of Asian immigrants in Australia.

linkage with the LSAC data (Daraganova *et al.* 2013). At the time of this study, the linkage data for LSAC were mainly available for K cohort students in all four test grades. Because the NAPLAN test dates and LSAC survey dates are usually different, test results and survey data were merged in the way that survey dates pre-date the NAPLAN test dates. Specifically, NAPLAN test scores of K-cohort children in Grades 3, 5, 7 and 9 are merged with survey data in Waves 2, 3, 4, and 5, respectively. Similar to other cognitive outcomes, NAPLAN test scores are also standardized (with mean 0 and standard deviation 1) for ease of interpretation.

2.5. Empirical models

We estimate the "adjusted" nativity test score gap by regressing test scores (Y) of student i in subject j at test grade/age k on a categorical variable (g_i) indicating the nativity groupings previously defined and a list of other covariates (X_{ijk}). Specifically, the following model is employed:

$$Y_{ijk} = \alpha_{0jk} + g_i\alpha_{1jk} + X_{ijk}\alpha_{2jk} + \varepsilon_{ijk} \quad (1)$$

where αs are parameters to be estimated and ε_{ijk} is the idiosyncratic error term. The estimates of α_{1jk} from equation (1) are of interest because they measure the direction and magnitude of the nativity test score gap in various subjects from kindergarten to the ninth grade. In line with other studies examining test scores (Nghiem *et al.* 2015; Le & Nguyen 2018), we include in X_{ijk} the student's characteristics (i.e., gender, age, Indigeneity and low birth weight),[9] early parental investment (as measured by breastfeeding the child at 3 or 6 months), family environment (maternal age, maternal education, maternal working hours, family income, household size, number of siblings at different age groups, living with both parents or living in an owned home) and indicators of neighborhood characteristics.[10] We address the issue of students sitting the NAPLAN test in different years for the same grade by controlling for the age of students at the year they took the test and dummy variables for the test year. Similarly, the differences in the survey time and test time are

[9] Motivated by the idea that some Asian countries have son-preference cultures and that culture may influence academic outcomes of sons and daughters differently (Jayachandran & Kuziemko 2011), we experimented including an interaction term between ethnicity (as previously defined) and the child's gender to test for whether there is any statistical significant difference in test scores by sons and daughters of Asian immigrants in Australia. Because we found no such evidence, we do not include that interaction term in the final regressions. For a similar reason, we do not analyses the nativity gaps in test scores and time allocation by gender. For brevity, the regression results for other covariates are not reported, but are available upon request. We explore the role of covariates further in Section 5.

[10] Local variables include percentages of individuals of various ages, year 12 completions, working, speaking English, being born in Australia, identifying as being of Aboriginal/Torres Strait Islander origin in linked areas, percentages of households with household income less than AU$1,000/week in linked areas, and a metropolitan dummy.

controlled for by including dummies for quarters of survey time in regressions. Finally, state dummy variables are included to control for differences in educational jurisdictions by state and territory.[11]

We first apply the Ordinary Least Squares (OLS) method to estimate the mean nativity test score gap using model (1). Unreported statistics from our data show that the mean test score is usually different from the median, indicating that the test score distribution is skewed. This distributional aspect of the test score data provides further motivation to investigate the determinants of test scores not just at the mean but across the entire distribution (Koenker & Bassett 1978; Firpo *et al.* 2009). We then employ an unconditional quantile regression (UQR) method proposed by Firpo *et al.* (2009). The UQR method is selected over the (conditional) quantile regression method developed by Koenker and Bassett (1978) because it provides a way to recover the marginal impact of the explanatory variables on the unconditional quantile of Y without assuming that the rank-preserving condition holds (Firpo 2007; Firpo *et al.* 2009).

2.6. Empirical results

Table 2 reports the adjusted nativity gaps in test scores at means. It shows that, with exceptions of WAI and PPVT test scores at age 4 or 5 years, the academic performance of children of Australian-born parents and those of non-Asian immigrants is not statistically different and this pattern holds for all grades and subjects. In contrast, significant differences in academic performance are observed between children of Asian immigrants and those of Australian-born parents. Furthermore, the relative academic performance of Asian immigrant children varies depending on subjects and ages/grades. Specifically, at pre-school ages of 4 or 5, children of Asian immigrants display higher school readiness (as measured by WAI) but lower language-related test scores (as represented by PPVT) than children of Australian-born parents. The academic disadvantage of Asian immigrant children in language-related subjects is observed until children reach the ages of 8 or 9 (for PPVT) and then disappears at grade 3 when they perform as well as children of Australian-born parents in reading, writing and grammar. From grade 5, children of Asian immigrants then overtake and outperform their peers in all test subjects, including language-related subjects such as reading, writing and grammar. Table 2 also reveals that children of Asian parents outperform their peers in non-verbal visuospatial reasoning (as measured by MR) and in math (as measured by NAPLAN numeracy) as early as the ages of 6 or 7 and that the Asian advantage in these skills appears to widen as students advance through their school years. Specifically, the Asian-Native gap in favor of Asian immigrant children in MR almost doubles between 6-7 (0.18 standard deviations) and 10-11 years

[11] Australia is a federation of six states and two territories. Hence there are eight (mutually-exclusive) state/territory jurisdictions.

of age (0.34 standard deviations). In the same vein, the nativity gap in NAPLAN numeracy test scores increases consistently, but at a decreasing rate, from the third grade (the average Asian immigrant child was ahead of the average Australian-born parent child by 0.25 standard deviations to the ninth grade (by 0.59 standard deviations).

[Table 2 around here]

Our finding of Asian immigrant children's advantage over Australian-born parent children in a non-verbal visuospatial reasoning subject of MR at 6-7 years of age is consistent with the findings of US studies of the Asian-American advantage over whites at the same ages (Fryer & Levitt 2006; Choi *et al.* 2015; Gibbs *et al.* 2017). An important difference is that our results show that, unlike Asian American children who begin school with higher verbal scores than white children (Fryer & Levitt 2006; Choi *et al.* 2015; Gibbs *et al.* 2017), Asian immigrant children in Australia have lower scores at kindergarten entry in the (language-related) PPVT than do Australian-born parent children. Furthermore, while the study by Fryer & Levitt (2006)[12] indicates the Asian American advantage over whites in math skills fluctuates from kindergarten entry to grade 3, our study suggests an apparent widening nativity test score gap in numeracy from about the age of 6 or 7 through to the ninth grade. Our finding is in line with that in another US study by Clotfelter *et al.* (2009) using data on public schools in the state of North Carolina. The results of that study showed an increasing Asian-White gap in math scores between the third and the eighth grades. Clotfelter *et al.* (2009) also found that Asian students surpassed whites in reading at grade 5, and our study indicates that Asian immigrant children in Australia also overtake children of Australian-born parents in reading at the fifth grade.

Next, we explore the heterogeneity in nativity score gaps over the distribution of test scores. Figure 1 and Figure 2 succinctly report adjusted estimates of nativity test score gaps and their respective 95% confidence intervals (CI)[13] along the test score distribution. Both figures show that there is no discernible difference in the academic performance of children of Australian-born parents and those of non-Asian immigrants and that this pattern holds in nearly all quantiles and across all grades and subjects. By contrast, there is noticeable heterogeneity across the distribution when the academic performance by children of Asian immigrants and those of Australian-born parents is compared. Specifically, Figure 1 shows that, at age 4 or 5 years, Asian immigrant children outperform

[12] Fryer & Levitt (2006) use a US dataset which is quite similar to ours. Particularly, they use data from Early Childhood Longitudinal Study Kindergarten Cohort (ECLS-K), a nationally representative survey of over 20,000 children entering kindergarten in 1998.

[13] 95% CIs are obtained using 500 bootstrap repetitions. Visually, 95% CIs which do not include zero indicate a statistically significant (at the 5% level) estimate.

Australian-born parent children in the school readiness test (WAI) over virtually the whole distribution and the nativity test score gap is more pronounced at the upper end of the distribution in favor of the Asian immigrant children. However, at the same ages, children of Asian immigrants lag behind in the language related ability of PPVT at all points of the test score distribution and the Asian disadvantage observed at the mean is mainly driven by students at the lower end of the distribution. Figure 1 also shows that the Asian advantage in MR visuospatial reasoning observed at means is largely driven by high-performance students.

[Figure 1 and Figure 2 around here]

Similarly, Figure 2 suggests that the Asian advantage in all NAPLAN test subjects is more pronounced at the upper tails of the distribution (and is most visible for numeracy and spelling). To this end, our finding is consistent with that in a US study by Konstantopoulos (2009) who also uses a quantile regression approach to show that the Asian American–white gap in favor of Asian students is more visible in the middle and upper tail of the test score distribution, especially in math. Our results also show a widening nativity test score gap in numeracy as students advance through school. Furthermore, the steeper slope of the nativity test score gap line at the higher end of the test score distribution suggests that the observed widening nativity numeracy test score gap favoring Asian students over time may have been driven by high-performing students.

3. The evolution of children's time investments by nativity

3.1. Time-use diaries

This section documents the evolution of time allocation by children from various migration backgrounds using the time-use diaries (TUS) of children. TUDs, associated modules of the LSAC, were surveyed biannually over up to six waves and are collected for children from both cohorts. The existing data allow us to investigate the time allocation of children from 0/1 to 10/11 years old for B-cohort children and from 4/5 to 14/15 years old for K-cohort children.

Because activities that the child performed are recorded differently across waves (see Appendix Figure C1, Appendix Figure C2 and Appendix Figure C3), we follow previous studies (Corey et al. 2014; Fiorini & Keane 2014; Nguyen et al. 2018) to group them into a smaller set of mutually-exclusive activities. We do so in a manner that makes the aggregated activities fairly comparable over a decade of the development of children from both cohorts. Our list of aggregated activities includes: sleep, personal care, school, education, active, chores, media and travel. Specifically, sleep consists of the time allocated to sleeping and napping. We include awaking in bed, eating/drinking, showering/bathing and doing non-active non-educational activities in personal care. School refers

to the time allocated to organized school lessons or playgroup while education relates to the time spent on the child's own educational activities outside school, including reading or being read to or doing homework. "Active" activities consist of the time spent walking, cycling or attending organized physical activities. We assign household chores and work to chores. Media includes time spent on watching TV programs or movies/videos, playing video games, using computer and internet (unrelated to doing homework) and communicating via electronic devices. Finally, travel includes the time spent on transit. Details of each activity aggregation are reported in Appendix Table C1 and Appendix Table C2.

We follow previous studies (Hofferth & Sandberg 2001; Baxter 2007; Nguyen *et al.* 2018) by not distinguishing the child's activities according to who is nearby during each activity, because it is unclear from the data about the actual participation intensity of the present person(s) (if any) with the child. Similarly, we do not impose a qualitative distinction between the main and secondary activities, because respondents were not asked to distinguish between the main activity performed and any activities being performed simultaneously (Fiorini & Keane 2014; Nguyen *et al.* 2018).

3.2. Empirical models

To explore the evolution of time allocated to activity l by the child i from migration background g_i, we adopt the following model:

$$\tau_{ilt} = \beta_{0l} + g_i\beta_{1l} + A_{ilt}\beta_{2l} + (g_i * A_{ilt})\beta_{3l} + W_{ilt}\beta_{4l} + \epsilon_{ilt} \qquad (2)$$

where τ is the amount of time (in minutes per day) allocated to activity l on the observed time t. We include in equation (2) the child's ages (denoted by A and measured as separate indicator variables for every two-year increment) and their interaction with the child's ethnicity (g) so estimates of the interaction term (β_{3l}) capture temporal differentials in time use by children of different ethnicity. It should be noted that the child's ages are included as separate indicators rather than as a continuous variable to capture the evolution of the nativity gap in time allocation in a more flexible way.[14] Finally, in equation (2), W_{ilt} is a set of control variables, ϵ_{ilt} is the random error term and βs are parameters to be estimated.

As has been done elsewhere in the time use literature (Hofferth & Sandberg 2001; Nguyen *et al.* 2018), we include in W_{ilt} a rich list of variables reflecting the child's characteristics, family

[14] Specifically, this approach so does not require any functional assumption about the relationship between ages and time allocation. We introduce the child's ages in two-year increment to accommodate the biannual survey design. We experimented including the child' ages as separate indicator variables in every one-year increment and found estimates for the interaction term (β_{3l}) of some age groups imprecise, probably due to the small number of children in those ages surveyed in our sample.

environment and local environment. These variables are similar to those included in X_{ijk} when we model test scores in equation (1). We also include in W_{ilt} a series of day-of-week dummies to capture possible changes in time allocation throughout the week and month and year indicators to control for trends in time use over seasons and years. We apply equation (2) to the pooled sample of time diaries collected from both cohorts of children. Furthermore, for each of the aforementioned grouped activities, we also estimate equation (2) separately for activities undertaken during weekdays and weekends. The OLS regression method is employed initially, primarily for ease of interpretation.

3.3. Empirical results

Table 1 reports the mean unadjusted differences in time allocation by nativity. It shows that, while there are some statistical differences in time use patterns between children of Australian-born parents and that of non-Asian immigrants, the differences in time allocation between the children of Australian-born parents and the children of Asian immigrants are much more pronounced in terms of both statistical significance and magnitude. In particular, as compared with children of Australian-born parents, children of Asian immigrants spend less time on sleeping, active, chore (weekends only) and travel (weekdays only) and therefore more time on school (weekends only), educational activities (weekdays only), media and travel (weekends only). It is interesting to observe that, as compared with children of Australian-born parents, children of Asian immigrants spend less time on travel on weekdays (10 minutes) but more on weekends (7 minutes). The travel time differential on weekends when viewed with the fact that children of Asian immigrants also spend more time on school on weekends is in line with the idea that they may travel to attend private coaching centers.

[Figure 3 around here]

The findings that children of Asian immigrants spend more time on educational activities, including schooling on weekends, than children of other parents in Australia are consistent with other indicators representing human capital investments available in the data.[15] Specifically, our data show that Asian immigrant children (i) are more likely to be given homework, (ii) are more likely

[15] The differences in time allocated to educational activities between children of natives and children of Asian immigrants are in line with evidence on the differences in time uses between children of NESB immigrants and children of natives as documented in an Australian study by Nguyen *et al.* (2018). Using time use diaries of children in the US, Hofferth & Sandberg (2001) also report that Asian children spend significantly more time on reading than other children. Likewise, studies using data from various countries often document that children living in Asian countries spend much more time in school and studying than children living in other countries (Fuligni & Stevenson 1995; Varkey Foundation 2018). Existing studies only look at the static aspects of the nativity gap in time allocation of children and have not explored temporal dimensions of the gap as we do here.

to have a place designated to do homework at home, (iii) spend about 1.3 hours more on homework each week, and (iv) are much more likely to receive private tutoring outside school hours (See Appendix Table A3).

Next, we explore the temporal dimensions of the nativity gap in time use using Figure 3 which reports the estimated time (and its 95% CIs) allocated to each aggregated activity by three nativity groups of children from birth to 14/15 years old.[16] Several interesting patterns appear from Figure 3. First, the fact that Asian immigrant children sleep less is only observed when they are young (from 0-1 to 8-9 years of age on weekdays and from 0-1 to 2-3 years old on weekends – See Figure 3 – Panel 1). Furthermore, even at some ages such as 14-15 years of age and on weekends, children of Asian immigrants appear to spend more time sleeping than children of other parents. Second, Figure 3 – Panel 3 suggests the difference in the time allocated to schools on weekends observed earlier may have been driven by the difference in school time when children are 6-7 years old (only).

Third, the nativity gap in educational time is even more pronounced when temporal dimensions are taken into consideration (see Figure 3 – Panel 4). In addition, the gap is strikingly different depending on children's ages. Specifically, before reaching the early school age of 6 or 7, children of Asian immigrants are found to spend statistically significantly *less* time on educational activities than children of other parents and this is the case for both weekdays and weekends. As expected and by construction (see Appendix Table C1 and Appendix Table C2), at these young ages, educational activities undertaken by children are often associated with parental involvement in the form of reading a story to the child or teaching the child to read. The fact that Asian immigrant children spend less time on educational activities before they enter school is consistent with the notion that some immigrant parents have language disadvantages in respect of investments in the development of some aspects of their children's human capital (Bleakley & Chin 2008; Cobb-Clark & Nguyen 2012), such as English language skills. A similar pattern is observed in the US as Asian American parents are less likely to engage in reading to their children at kindergarten ages (Gibbs *et al.* 2017). It is also in line with another pattern observed from Figure 3 – Panel 7 that, at the same ages and on both weekdays and weekends, children of Asian immigrants appear to spend significantly more time on media activities. Conversely, Figure 3 - Panel 4 reveals that the nativity gap in educational activities reverses once children enter school as Asian immigrant children now spend statistically significantly *more* time on educational activities on both weekdays and weekends. Thus, despite the mean figures in Table 1 indicating no statistically different nativity gap in the time

[16] Estimates of other covariates (reported in Appendix Table A2) are usually as expected and largely similar to those described in the work by Nguyen et al. (2018).

spent on educational activities on weekends, the temporal investigation suggests statistically significant differences in educational time for the children of Asian immigrants. Furthermore, the nativity gap in the time allocated to educational activities appears to increase as children age and this pattern holds for both weekends and weekdays. For instance, on a typical weekday, the Asian-Native children gap in the time allocated to educational activities is 23 minutes per day at 6-7 years of age, while it is 43 minutes at 14-15 years of age. Likewise, on a normal weekend day, the nativity gap in educational time more than doubles between 6-7 years of age (25 minutes) and 14-15 years of age (64 minutes).

Fourth, as can be seen from Figure 3 – Panel 5, on both weekdays and weekends, Asian immigrant children are less active between the age of 2-3 years and 12-13 years. Fifth, Figure 3 - Panel 6 indicates that, on weekends, Asian immigrant children spend statistically significantly less time on chores from 6-7 years of age and the Asian-Native children gap in the time allocated to chores appears to widen as children grow up. Finally, consistent with the earlier observed travel pattern in Table 1, Figure 3 – Panel 8 shows that, on weekdays, children of Asian immigrants also travel less, especially when they are at the ages between 4-5 and 12-13 years. Similarly, at high school ages of 12-15 years old, Asian immigrant children travel less on weekends. The association between travel and active time observed on both weekdays and weekends suggests that children may travel to engage in active pursuits.

4. The role of children's time investment in explaining the nativity gap

4.1. Regression and decomposition models

We first apply the following equation to examine the impact of children's time allocation (B) on test score (Y) of student i in subject j at test grade/age k:

$$Y_{ijk} = \gamma_{0jk} + \gamma_{1jk} Y_{ij(k-1)} + B_{ijk}\gamma_{2jk} + B_{ij(k-1)}\gamma_{3jk} + X_{ijk}\gamma_{4jk} + \theta_{ijk} \qquad (3)$$

where θ_{ijk} is a vector of unobservable characteristics and γs are parameters to be estimated. As was done with equation (1), we include in X_{ijk} a rich list of variables describing the individual and family characteristics as well as the environment of the local area. Equation (3) is our preferred model because it helps us to address two important issues: namely unobservable factors and reverse causality, relating to the possible endogeneity of the time allocation variables in the test score determinant equation (3). Specifically, in equation (3), a one-period lag of the respective test score ($Y_{ij(k-1)}$) is included to proxy for the child's ability, a commonly unobserved factor which is potentially correlated with both the time allocation decisions and the test scores of the same child.

This "value-added" specification is also consistent with the dynamic theory of skill formation (Cunha *et al.* 2010). While including the child's lagged test score in addition to a rich list of controls (X_{ijk}) helps to ease concerns about unobservable factors, it does not address the possibility of reverse causality because it is unclear whether the allocation of time influences test scores or *vice versa*. We follow the approach of two recent studies (Fiorini & Keane 2014; Del Boca *et al.* 2017) and include the lag of time allocation variables in addition to the contemporaneous time allocation variables in the model to address this issue.[17] This model, called "augmented value-added" (AVA) model, was preferred by Todd and Wolpin (2007) in their examination of the racial gap in test scores in the US. This model is arguably the most robust model employed by current literature examining the impact of children's time allocation on their test scores (Fiorini & Keane 2014; Del Boca *et al.* 2017).[18]

We also apply an OLS and UQR approach to estimate equation (3) to explore the determinants of test scores at the mean and at selected percentiles, respectively. Another appealing feature of the UQR method is that its regression results can be applied directly to an Oaxaca-Blinder (OB) decomposition method (Blinder 1973; Oaxaca 1973) to examine the role that different factors play in contributing to the nativity test score gap across the whole distribution (Fortin *et al.* 2011). Specifically, the factors contributing to the nativity test score gap at the mean and at selected percentiles are examined by applying an OB type of decomposition of the form:

$$\hat{Y}_m - \hat{Y}_n = \underbrace{(\hat{Z}_m - \hat{Z}_n)\hat{\mu}^*}_{\text{"characteristic effect"}} + \left\{\underbrace{\hat{Z}_m(\hat{\mu}_m - \hat{\mu}^*) + \hat{Z}_n(\hat{\mu}^* - \hat{\mu}_n)}_{\text{"return effect"}}\right\} \quad (4)$$

where $\hat{Y}$ is the mean test score of children of migrant (m) or native or Australian-born (n) parents, $\hat{Z}$ is a vector of the mean observed characteristics, $\hat{\mu}_m$ $(\hat{\mu}_n)$ is a vector of the estimated coefficients in the regression of test score on the set of covariates, including the constant, for migrant (native) children sample and $\hat{\mu}^*$ is a vector of the estimated coefficients from the pooled migrant and Australian-born children sample with other covariates and the migrant dummy. The migrant dummy

[17] Our approach to merge LSAC data with NAPLAN test scores in such a way that survey dates pre-date the NAPLAN test dates also helps mitigate the reverse causality issue.

[18] Notwithstanding, some studies use cross-equation covariance restrictions to achieve identification for time allocation variables (Del Boca et al. 2014; Lee & Seshadri 2018). The value-added model has been increasingly employed to deal with the possible endogeneity of some inputs of the cognitive production process such as parental investments (Pavan 2016; Lehmann *et al.* 2018), school choices (Nghiem *et al.* 2015) or parenting styles (Cobb-Clark *et al.* 2018). Fiorini & Keane (2014) note that they choose an AVA model over an alternative instrumental variables model because it is "not feasible" to find a large set of valid instruments for multiple endogenous time use variables. The same reasoning applies to our model choice.

variable is included in estimating the reference structure ($\hat{\mu}^*$) to obtain unbiased estimates of the coefficients on other variables (Fortin *et al.* 2011).

The first term on the right-hand side of equation (4) is the component of the nativity test score gap due to differences in observed characteristics - the "characteristic effect" or "explained part". The second term on the right-hand side is the difference in factors other than the observed characteristics – the "return effect", sometimes interpreted as "unexplained" or "discrimination". We focus on detailed decomposition of the characteristic effect because it is well documented that detailed decomposition results of the return effect are influenced by the arbitrary scaling of continuous variables (Jones 1983; Jones & Kelley 1984). To facilitate the interpretation of the results, we separate the variables that contribute to the academic achievement of children into five groups: (i) their characteristics, (ii) their families' characteristics, (iii) their respective previous test scores, (iv) their time allocations, and (v) other factors.

In equation (3), B is a vector of variables describing weekly time allocated across various activities as defined in 3.1 (with sleeping time set as the omitted activity). The weekly time use measure is derived using time use measures from a weekday (multiplied by 5) and a weekend day (multiplied by 2). The regression model (3) and its corresponding decomposition model (4) are very data demanding as they require panel data in both time-use diaries and test scores. Furthermore, we wish to measure the time allocation on a weekly basis, requiring that each child has two TUDs (one on a weekday and one on a weekend day) per wave to be included in the final sample. In our data, due to the timing of the TUDs and test scores,[19] we can apply model (3) to examine (i) PPVT at age 6-7 and 8-9 years, (ii) MR at age 8-9 years, and (iii) NAPLAN test scores at the fifth grade. In what follows, we focus on the Asian–Native gap since there is no statistically significant difference in test scores or time allocation between children of non-Asian immigrants and those of Australian-born parents.

4.2. Decomposition results

Decomposition results of PPVT at ages 6-7 and 8-9 and MR at 8-9 years

Panel A of Figure 4 presents the aggregate decomposition which proportions the total gap in test scores in PPVT at 6-7 and 8-9 years of age and MR at 8-9 years of age along the test score distribution into the overall characteristic and return components. The results show that, consistent

[19] In particular, from Wave 1 to Wave 3, families were given two TUDs to complete each wave so each child had up to two TUDs. However, from Wave 4 to Wave 6, each child was given one TUD to complete each wave. Furthermore, B-cohort children are not asked to fill in TUD in Waves 4 and 5.

with the "adjusted" gap observed in Figure 1,[20] the nativity gap in favor of Australian-born parent children in the language-related subject of PPVT is only observed (i.e., statistically significant) when children are 6-7 years old and the gap appears more pronounced at the middle of the test score distribution. By contrast, at 8-9 years of age, the Asian immigrant children's advantage in the MR non-verbal visuospatial reasoning is observed over virtually the whole distribution and the gap is more pronounced at the higher end of the distribution. The results also show that, for both PPVT and MR, the return component is substantially larger than the characteristic component and this is the case at almost all points of the test score distribution. Furthermore, the overall characteristic and return components are statistically significant for MR at 8-9 years of age (only).

[Table 3 and Figure 4 around here]

Table 3 reports contributions of various factors to the Asian-Native gap in PPVT and MR, either at the mean or at selected percentiles. Estimates from this table suggest that differences in *previous* test scores between children of Australian-born parents and those of Asian immigrants are the most important factor explaining the nativity test score gap because previous test scores are the only factor, among all grouped characteristics, that is highly statistically significant and typically dominant in magnitude. Additionally, Table 3 shows that differences in the time allocated to all activities between Asian immigrant children and children of Australian-born parents help to explain the Asian-Native gap in PPVT at 8-9 years of age (only). In turn, separate decomposition results of all time allocation variables (reported below the aggregate decomposition results of all time allocation variables in Table 3) suggest that the contribution of time allocation is driven entirely by differences in the time allocated to educational activities.[21] By comparison, conditional on children's previous test scores and time allocations, differences in other characteristics of the child or characteristics of the household, including family composition, parental education and family income, explain very little of the nativity test score gap.[22]

Panel B in Figure 4 reports separate contributions of previous test scores and time allocation to the characteristic part of the nativity gap along the distribution of PPVT and MR test scores. For PPVT,

[20] Notwithstanding the results are from different specifications and samples.
[21] Consistent with a finding in the study by Fiorini & Keane (2014), regression results at means (reported in Appendix Table A4) suggest that time spent on educational activities is the most productive input for academic achievement in children because estimates for educational time variables (current and lagged) are more statistically significant and usually greater in magnitude than that of other time allocation variables. It should be noted that Fiorini & Keane (2014) do not examine NAPLAN test scores which were not available then. Appendix Table A4 also reports estimates of other explanatory variables.
[22] The result on education is particularly important because Australia has a skilled migration program and there is evidence, in our dataset, that children of Asian-immigrants tend to have more highly-educated mothers. The result thus provides some confidence that the results are not driven by higher average levels of parental education.

the estimates on previous test scores are always negative and statistically significant, indicating Asian immigrant children's less favorable initial abilities on the PPVT and the very high persistence in the test score results (see Appendix Table A4 for regression results). Conversely, for MR at 8-9 years of age, estimates of lagged scores are always positive and highly statistically significant, reflecting Asian immigrant children's initial endowment advantages in non-verbal visuospatial reasoning and positive returns to their initial cognitive abilities. Furthermore, also for MR, the contribution of initial cognitive endowment to the characteristic part (and hence to the total gap) is greater at the higher end of the test score distribution, revealing two combining effects: (i) the more pronounced nativity differences in MR test scores at 6-7 years of age at the higher end of the distribution (see Figure 1) and (ii) the increasing returns to the lagged scores along the distribution (see Appendix Figure A1).

Panel B in Figure 4 additionally shows that, for PPVT at age 8-9 years, estimates for time allocation are positive and statistically significant, particularly at the lower end or middle of the test score distribution, indicating Asian immigrant children's greater investment in educational activities and the positive returns to such activities. It is interesting to observe that, between the ages of 6-7 and 8-9 years, children of Asian immigrants spend more time on educational activities than their non-Asian counterparts and that this additional time investment helps to compensate for their significant disadvantage in initial language skills. As a result, they perform as well as children of Australian-born parents in the language-related subject of PPVT by 8-9 years of age.

Decomposition results of grade 5 NAPLAN test scores

Turning to the decomposition results of grade 5 NAPLAN test scores (reported in Table 4 and Figure 5), we continue to observe that Asian immigrant children outperform Australian-born parent children in all subjects and that the nativity test score gap is typically more noticeable at the higher end of the test score distribution. Moreover, estimates of the characteristic and return parts are always positive, either at means or along the entire test score distribution, indicating that nativity differences in observable characteristics and returns predict an advantage in favor of Asian immigrant children in all test subjects.

[Table 4 and Figure 5 around here]

Detailed decomposition results of the characteristic part (Table 4) suggest that nativity differences in initial cognitive abilities again make the most important contribution to this component because estimates of the lagged scores are highly statistically significant and are typically dominant in magnitude. Furthermore, the positive estimates of lagged scores reveal noticeable advantages in

both the initial cognitive abilities of children of Asian immigrants and the positive returns to such abilities. Indeed, the decomposition results at the mean show that the Asian-Native disparities in initial cognitive abilities account for from 27% (in writing) to 62% (in spelling) of the overall nativity test score gaps. The finding that nativity disparities in initial cognitive abilities make the greatest contribution to the aggregated nativity gap in grade 5 spelling is consistent with two observations: (i) the nativity gap in the third grade test score is greatest in spelling (see Table 2) and (ii) the estimate of the coefficient on the lagged score is also the greatest in spelling (see Appendix Table A4). Similar reasons can be applied to explain why nativity differences in lagged scores of writing have the lowest contribution (27%) to the overall nativity test score gap in this subject.

Table 4 also reveals that Asian-Native disparities in time investment can explain a significant part of the nativity gaps in academic performance in reading and numeracy. Specifically, at the mean, the nativity differences in time allocation contribute 19% and 6% to the overall Asian–Native test score gap in reading and numeracy, respectively. Sequentially, detailed decomposition results of all time allocation variables in Table 4 indicate that the contribution of time allocations is mostly attributable to the differences in educational time between Asian immigrant children and Australian-born parent children. By contrast, estimates of the characteristic part of all other factors, including other characteristics of the child and characteristics of the family, are not statistically significant, and do not substantially contribute to illuminating the relative academic performance by children from different (nativity) backgrounds. To this end, our finding of a non-significant contribution of socio-demographics to the Asian-Native test score gap is in line with that in some US studies on test score gaps between Asian American and white students (Clotfelter *et al.* 2009; Hsin & Xie 2014).

Figure 5 – Panel B represents the separate contributions of time allocation and lagged scores to the characteristic component along the distribution of five NAPLAN test subjects at grade 5: it reveals two interesting patterns. First, the contribution of time allocation is more pronounced, in terms of the statistical significance and magnitude, at the higher end of the test score distribution, particularly in reading, spelling and numeracy. For example, while nativity differences in time allocation are statistically significant (at the 5% level) and explain 17% of the observed total gap in numeracy for students at the 90th percentile of the distribution, they contribute nothing to the aggregated gap for those at the 10th percentile. Moreover, while the nativity differences in time allocation do not statistically significantly contribute to the nativity gap in spelling at the mean, the quantile decomposition results suggest that they do so, but only for top-performing students. The increasing contribution of time allocation to the aggregated nativity test score gap for higher performing

students is consistent with two observations: (i) children with higher test scores tend to spend more time on educational activities and (ii) returns to educational time are greater for students at the higher end of the test score distribution, especially for current educational time and in reading, spelling and numeracy (see Appendix Figure A2 – Panel B).

Second, the contribution of initial cognitive endowment is also more apparent at the higher end of the test score distribution, particularly in numeracy, revealing (i) the greater nativity disparities in initial cognitive skills among top-performing students (see Figure 2) and (ii) the greater returns to existing cognitive skills for students at the higher end of the test score distribution (see Appendix Figure A1– Panel B). Overall, the quantile decomposition results indicate that the increasing contribution of time allocation and initial cognitive abilities to the aggregated nativity gap along the test score distribution help explain why the nativity test score gap is more pronounced at the top end of the distribution, particularly in spelling and numeracy.

4.3. Discussion of factors contributing to the widening nativity test score gap over time

While the above quantile decomposition results quantify factors contributing to the widening of the nativity test score gap along the distribution up to grade 5, they do not provide definite answers to why the nativity test score gaps, especially in numeracy, widen from the fifth grade onwards, mainly because our modelling approach and data only allow us to examine the factors contributing to the nativity test score gaps up to year 5. However, four factors could account for the rising test score gaps in favor of Asian immigrant children, particularly in numeracy, that are observed after grade 5. First, the quantile regression results (Appendix Figure A2) show that returns to educational time are greater for students at the higher end of the test score distribution, and these are most visible for the grade 5 NAPLAN numeracy test scores, implying that higher-achieving students are more efficient in transforming their time inputs into better test scores. This new finding is consistent with evidence that returns to college are greater for more able and motivated students (Cameron & Heckman 2001; Carneiro *et al.* 2015; Eisenhauer *et al.* 2015) and demonstrates the principals of dynamic complementarity and self-productivity in capability gains. This finding, when observed with the finding (Section 3) that Asian immigrant children spend increasingly more time on educational activities than their peers from around age 6 or 7 contributes to an explanation of the widening Asian-Native test score gaps observed beyond year 5.

Second, the quantile regression results (Appendix Figure A1) show that the returns to initial cognitive abilities are also higher for students at the upper end of the test score distribution, and are more pronounced in grade 5 NAPLAN numeracy test scores, also suggesting that high-achieving

students are better at utilizing their existing knowledge to gain higher test scores. Coupling this with an earlier finding that Asian immigrant children perform better, on average, than their peers on all test subjects from Grade 5 (see Section 2) onwards, this evidence projects a widening of nativity test score gaps, particularly in numeracy, over time.

Third, in Appendix Table A5 we demonstrate that returns to initial cognitive abilities are increasing in children's ages/grades: a finding consistent with evidence in the literature that self-productivity becomes stronger as children become older (Cunha *et al.* 2010).[23] This evidence combining with an earlier evidence that Asian immigrant children excel in all test subjects from grade 5 and the increasing test score gaps with children's ages contribute to explain the widening of nativity test score gaps over time. Fourth, the accumulated effects of time investment and initial cognitive abilities over time (i.e., the positive and statistically significant estimates of lagged scores and lagged educational time, both are in favor of Asian immigrant children) contribute to the widening nativity test score gap over time.

5. Robustness checks

5.1. Relative academic performance of third-generation Asian immigrant children

Our analysis focused on relative academic performance of second-generation immigrants. LSAC data also allow us to identify whether a child is a third-generation immigrant. Specifically, for children living in married and intact families, LSAC collected grandparent country of birth, reported by the child's parents. Of 10,090 children surveyed in Wave 1 of LSAC data, we have valid information about birthplaces of grandparents for 59% of them. Following Duncan & Trejo (2017) in their US study, we define third-generation immigrants as Australian-born individuals with two Australian-born parents but at least one foreign-born grandparent. We further classify third-generation immigrant children with respect to specific Asian and non-Asian source countries.

Applying these definitions, in Wave 1 of LSAC, of 5,920 children with valid information about birthplaces of their grandparents, 3,361 (57%) are defined as "Australian-born grandparent children", 2,390 (40%) "third-generation non-Asian immigrant children" and 169 (3%) "third-generation Asian immigrant children". The small proportion of third-generation Asian immigrant children in our data is expected because, up to 1973, Australia had maintained a "White Australia"

[23] We reach this finding by estimating a regression similar to model (1) for a pooled sample of test scores available at all ages/grades. To test a hypothesis of increasing returns to initial cognitive endowments, we include an interaction term between lagged scores and survey wave/test grade (as proxy for children's ages) and test for its statistical significance. We found strong evidence supporting such a hypothesis in all test subjects, except writing (see Appendix Table A5 for detail).

policy which aimed to exclude people from Asia and the Pacific Islands from immigrating to Australia. Due to significant missing information of birthplaces of grandparents and the small number of third-generation Asian immigrant children in the data, we have focused on second-generation immigrant children in this study. Nevertheless, we experimented running regression (1) for a sample of K-cohort Australian-born parent children with valid information of birthplaces of all grandparents. Regression results from this experiment (reported in Appendix Table B2) show little differences in academic performance between third-generation Asian immigrants and their peers, suggesting the fading of ethnic and cultural attachments across generations as found in the US literature (Borjas 1994; Özek & Figlio 2016; Duncan & Trejo 2018). Likewise, Appendix Figure B1 shows no apparent nativity differences in time use patterns between them either.[24]

5.2. Sample selection issues

We investigate whether our sample selection criteria on ethnicity/nativity led to any sample selection problems. One particular concern relating to our research design is that the child's ethnicity may affect the probability that an individual child is included in the final sample. Therefore, we ran a probit model where the dependent variable is equal to one if the child is in our sample and zero otherwise. It should be noted that we chose to use birthplaces of both parents to identify the child's ethnicity so our original sample in this section does not include children with invalid or missing information about birthplace of either the father or mother of the child. The explanatory variables are basic demographic characteristics, including the child's ethnicity. Regression results (reported in Appendix Table B3) suggest some evidence of statistically significant selection on some observables. For instance, children in our sample are more likely to come from more advantageous households, come from two-parent households, or live in homes their parents own. However, the pseudo-R^2 values are relatively small, indicating that selection on observable characteristics is quantitatively weak. More importantly, in 8 out of 11 regressions by test subjects and test grades, p-values from a t-test for statistical significance of the ethnicity dummies included in the regression are greater than 0.05, alleviating concern that our sample selection drives the results.

5.3. Alternative classifications of the child's ethnicity

This section checks the sensitivity of the results using alternative classifications of the child's ethnicity.[25] We first redefine Asian immigrant children as those who were born in Australia to two

[24] Applying a slightly different classification of third-generation Asian immigrants as those who were born in Australia by two Australian-born parents with at least two Australian-born grandparents, we found similar results.
[25] For brevity, this section only presents results on nativity test score gaps at means. Other results, including nativity test score gaps along the distribution, nativity gaps in time allocations and decomposition results are available upon requests.

Asian immigrant parents and compare their academic performance with that of children of both Australian-born parents and those of other parents. Regression results (reported in Appendix Table B4) show this new ethnicity classification results in more pronounced Asian-Native test score gaps than previously found in Section 2, suggesting a compound effect of ethnicity on academic performance of children with two Asian immigrant parents. We then follow previous Australian studies to assign children into three nativity groups basing on their parents' English speaking country background (ESB) (Cobb-Clark & Nguyen 2012; Taylor *et al.* 2013; Le & Nguyen 2018). In turn, this classification is based on the idea that parents from ESB countries may share similar socio-economic cultural background and child development expectations as Australian-born parents. It is also likely that parents and their children from ESB countries may not have language disadvantages when integrating into an English-speaking country like Australia as those from NESB countries (Bleakley & Chin 2008). Appendix Table B5 reports results from this experiment, showing that NESB-Native test score gaps are very similar to the Asian-Native test score gaps. The similarity in ethnicity test score gaps from two classifications (i.e., a geographical base as in the baseline analyses and a language base as in this experiment) is as expected since in Australia most immigrants from NESB countries are from Asia (see Appendix Table A1).

In the baseline analyses, we used the United Nations' classification of Asian countries to identify the child's ethnicity. We experiment using the Australian Bureau of Statistics (ABS)' definition of Asian countries where Middle East countries are excluded and found the results (reported in Appendix Table B6) largely unchanged, suggesting that (i) immigrants originating from Middle East countries only represent a small share of Australian immigrants (see Appendix Table A1), and (ii) children of immigrants originating from Middle East countries are not very different from those of other Asian immigrants (as previously defined). Furthermore, we exclude all children with an Indigenous origin who are, by definition, classified as Australian-born parent children and who are usually found to have academic disadvantages relative to their peers (Nghiem et al. 2015; Le & Nguyen 2018). The results (reported in Appendix Table B7) are very similar to the baseline results, suggesting that our results are not driven by the inclusion of Indigenous children in the sample. Finally, we classify the child's ethnicity using income levels (i.e., low or medium versus high) of the parent's home countries. The results (reported in Appendix Table B8) indicate that children of immigrants from low- or middle-income countries (LMIC) perform better than children of Australian-born parents or children of immigrants from high-income countries in almost all subjects and grades/ages, except PPVT at all ages and NAPLAN reading at all grades. However, in terms of the magnitude and statistical significance, the Asian-Native test score gaps are much more

pronounced than the LMIC-Native academic performance gaps, indicating a more important role of culture than income in contributing to academic performance by children in our study.

5.4. Alternative model specifications

In Section 2, we applied equation (1) to document the evolution of "adjusted" ethnicity test score gaps. For brevity, we chose to report these adjusted gaps instead of "raw" gaps because we find little differences between them (see Appendix Table B9 reporting "raw" gaps obtained from regression with ethnicity dummies only). Our finding that ethnicity test score gaps are not substantially different with an exhaustive set of controls is consistent with our decomposition results presented in Section 4, showing that covariates other than previous test scores and time allocations contribute very little to explain the aggregate test score gaps.

We further experiment with two alternative specifications for decomposition analysis. First, we exclude lags of test scores and time allocations from equation (3) and apply results from these modified regressions to the decomposition model (4). Decomposition results (reported in Appendix Figure B2 – Panels A1 and B1) show the disparities in observable characteristics between Asian immigrant children and Australian-born parent children now contribute significantly less, in terms of the magnitude and statistical significance, to explain the aggregate test score gap. By contrast, ethnicity differences in time allocations, especially in the time allocated to educational activities, appear to contribute more to the overall Asian-Native test score gaps (see Appendix Figure B3 – Panels A2 and B2).

Second, we investigate the contribution of parenting styles to the observed ethnicity test score gaps. To do this, we follow Fiorini & Keane (2014) to employ a principal component method to construct two indicators of maternal parenting styles, namely warmth and effective discipline parenting style (see Appendix Table C3 for details). Appendix Table A3 indicates that Asian immigrant mothers are less warm and less strict than Australian-born mothers when interacting with their children. We then include these two maternal parenting style indicators as additional variables to model (3) and (4) to quantify their contribution to the Asian-Native test score gaps. The detailed decomposition results are reported in Appendix Figure B3 and indicate that ethnicity differences in parenting styles do not contribute to the aggregate test score gaps in any significant way. This is true at all points of the test score distribution. In fact, the contribution of time allocations remains unchanged when we include parenting styles in regressions, suggesting that the role of children's time allocation to the nativity test score gap is not mediated by parenting practices.

6. Conclusion

In this paper, we investigate whether differences in time investments by children of Australian-born and immigrant parents can explain the evolution of nativity differentials in academic achievements. We present four main findings. First, we document that, compared to children of Australian-born parents or those of other immigrants, children of Asian immigrants lag behind in language skills until grade 3 but outstrip their school peers in other subjects from as early as 4-5 years of age. Moreover, the academic advantages of children of Asian immigrants are more pronounced at the higher end of the test score distribution and tend to increase over time, especially in math skills. Second, we employ panel time-use diaries by two cohorts of children observed over a decade to show that before school entry, children of Asian immigrants spend significantly less time on educational activities but more time on media activities. At school entry ages, though, Asian immigrant children begin spending more time on educational activities and the nativity gap in educational time widens as children age. We additionally find evidence of a fading of ethnic and cultural attachments across generations as we observe no significant nativity differences in academic performance or time allocation between third-generation Asian immigrant children and their peers.

Third, the decomposition results indicate that ethnicity disparities in initial cognitive abilities and time allocations explain a large part of the differences in academic performance. In contrast, ethnicity differences in other socioeconomic factors such as parental marital status, education, income and parenting styles explain very little of the nativity test score gap conditional on initial cognitive abilities and time investments. Fourth, our decomposition results show marked differences in the contributions of initial cognitive abilities and time allocations to the aggregate nativity test score gaps by test subjects, test ages and across points of the test score distribution. For instance, between the ages of 6-7 and 8-9 years, Asian immigrant children spend more time on educational activities and their time investment compensates for their significant initial disadvantage in language skills: consequently, they catch up with Australian-born parent children in language skills by the ages of 8-9 years. From ages of 10-11 years onwards, the Asian immigrant children's greater educational time investment, coupled with their apparent advantages in initial cognitive endowment are the prime factors contributing to their superior academic achievements in language skills. Similarly, the Asian immigrant children's favorable initial cognitive abilities and greater educational time investments all contribute to their academic advantages in all other non-language related subjects such as spelling and math from ages of 8-9 years. Furthermore, our quantile decomposition results suggest that the increasing contribution of time allocations and initial

cognitive abilities to the overall nativity gap along the test score distribution explain why the nativity test score gap is more pronounced at the upper end of the distribution, particularly in spelling and numeracy.

The results presented in this study may have several important implications for policies that aim to improve the academic performance of children from different ethnic groups. For instance, one of our main findings that time allocations, especially educational time, play a significant role in explaining the ethnicity test score gap. This result suggests that policies aiming at increasing the time spent on educational activities by children of Australian-born and non-Asian immigrant parents could reduce the ethnicity test score gap. The heterogeneity in cognitive abilities and time allocations along the test score distribution highlights the need for individual monitoring of students' progress and teaching that is targeted to students' abilities (Goss & Hunter 2015). We caution against interpreting this finding as lending support to an educational tracking/streaming approach which assigns students to differing-ability classes/schools. This is because the weight of evidence shows that streaming has negative effects on the educational achievement of some students and entrenches inequalities in educational achievement (Betts 2011). However, schools may be in a position to positively influence the study patterns and learning choices of low- and middle-performing students in such a way that they maximize their potential without limiting the potential of higher performing students in the same classroom.

This study has uncovered the significant role of time allocation contributing to the Asian immigrant children's academic advantages. It is beyond the scope of this paper to determine whether or not greater academic achievements, and investments of time in this pursuit, come at the expense of other aspects of human capital development (e.g., social skills and the ability to build relationship-capital). In particular, it would be beneficial for future research to investigate the impact of time allocation on other (e.g., non-cognitive) skills, later human capital formation and labor market outcomes of children from different ethnic groups.

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Table 1: Summary statistics by nativity

Variables	Native	Others	Asian	Others-Native	Asian-Native
Male	0.51	0.50	0.52	-0.02***	0.00
Child age (years)	6.94	7.04	6.91	0.11***	-0.03
Indigenous	0.04	0.01	0.00	-0.03***	-0.04***
Low birth weight	0.06	0.06	0.08	0.00	0.02***
Breastfed at 3 or 6 months	0.71	0.76	0.75	0.05***	0.04***
Mother age	37.34	39.11	38.45	1.77***	1.11***
Mother has a certificate	0.31	0.28	0.22	-0.03***	-0.08***
Mother has an advanced diploma	0.10	0.12	0.10	0.02***	0.00
Mother has bachelor degree	0.18	0.20	0.22	0.02***	0.04***
Mother has graduate diploma	0.07	0.09	0.07	0.01***	0.00
Mother has postgraduate degree	0.07	0.09	0.11	0.02***	0.04***
Mother's weekly working hours	18.45	18.40	16.29	-0.05	-2.16***
Living with both parents	0.84	0.86	0.91	0.01***	0.06***
Home owner	0.76	0.75	0.77	-0.01***	0.01
Household yearly income ($100,000)	1.04	1.12	0.88	0.08***	-0.16***
Household size	4.52	4.51	4.65	0.00	0.13***
Number of siblings	1.52	1.48	1.44	-0.04***	-0.07***
Time allocation variables (minutes per day):					
Bed - Weekday	638.84	631.59	615.04	-7.24***	-23.8***
Bed - Weekend	669.16	665.65	655.22	-3.51	-13.95***
Personal care - Weekday	313.15	312.34	311.24	-0.82	-1.91
Personal care - Weekend	318.74	320.76	318.33	2.02	-0.41
School - Weekday	174.46	181.57	178.82	7.11***	4.35
School - Weekend	8.03	9.55	16.01	1.52*	7.98***
Education - Weekday	97.04	104.86	111.37	7.82***	14.33***
Education - Weekend	105.82	108.11	109.61	2.29	3.79
Active - Weekday	139.12	137.31	113.57	-1.81	-25.56***
Active - Weekend	244.55	235.75	187.68	-8.79***	-56.87***
Chore - Weekday	19.57	18.76	18.06	-0.81	-1.51
Chore - Weekend	19.25	19.30	14.43	0.05	-4.82***
Media - Weekday	131.89	133.28	147.80	1.39	15.92***
Media - Weekend	150.69	151.12	170.13	0.42	19.44***
Travel - Weekday	79.42	79.45	69.10	0.03	-10.32***
Travel - Weekend	89.70	93.61	96.83	3.91**	7.13***

Notes: Tests are performed on the significance of the difference between the sample mean for each group. Statistics are reported for the pooled sample of B- and K-cohort children who have valid parental country of birth in any wave. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Table 2: Nativity test score gap over ages/grades at means

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Non-Asian immigrant children	0.07**	-0.17***	-0.05	-0.06*	0.01	0.03	0.02	-0.01	-0.00	-0.00	0.02	-0.01	0.01	-0.03	0.01
	[0.03]	[0.03]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]
Asian immigrant children	0.35***	-0.61***	-0.28***	-0.15***	0.18***	0.30***	0.34***	0.10	0.18***	0.17***	0.23***	0.18***	0.33***	0.28***	0.20***
	[0.05]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.07]	[0.06]	[0.06]	[0.06]	[0.07]
Observations	4,440	4,033	4,003	3,980	4,094	3,977	3,817	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared	0.26	0.17	0.16	0.14	0.07	0.10	0.09	0.16	0.18	0.19	0.21	0.14	0.18	0.21	0.19

Test subject	Spelling				Grammar				Numeracy			
Age/Grade	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
Non-Asian immigrant children	0.06	0.03	0.04	0.04	-0.01	0.05	0.01	0.04	0.03	0.01	-0.05	0.00
	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]
Asian immigrant children	0.50***	0.56***	0.54***	0.54***	0.10	0.30***	0.29***	0.33***	0.25***	0.46***	0.52***	0.59***
	[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.07]	[0.08]
Observations	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared	0.14	0.16	0.16	0.13	0.17	0.17	0.22	0.21	0.15	0.19	0.19	0.24

Notes: Children of both Australian-born parents are the base group. Estimates for each subject-level are obtained from a separate regression using model (1). Other variables include child characteristics (gender, age, Indigeneity, birth weight, and breastfed at birth), household characteristics (mother's characteristics (age and its square, completed qualification, and working hours), household size, number of siblings, living with both biological parents, living in an owned home, household income), urban, local socio-economic background variables, state/territory dummies, and survey quarters. For NAPLAN test scores, test states (in place of state/territory dummies), test years and test ages are also included. Robust standard errors are in square brackets. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Table 3: Contributions to the Asian-Native gap at mean and selected percentiles - PPVT and MR

	PPVT - Age 6/7				PPVT - Age 8/9				MR - Age 8/9			
	Q10th	Q50th	Q90th	Mean	Q10th	Q50th	Q90th	Mean	Q10th	Q50th	Q90th	Mean
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimated total gap	-0.20**	-0.54**	0.00	-0.26**	-0.19*	0.20	0.09	0.04	0.33	0.47***	0.62***	0.49***
Characteristic part (total)	0.01	-0.20	-0.03	-0.11	-0.06	0.06	-0.11	-0.03	0.03	0.13**	0.27*	0.14**
Child	-0.00	0.05	0.03	0.02	-0.01	-0.02	0.01	-0.01	0.00	0.00	-0.00	0.00
Household	0.05	0.27**	0.08	0.06	0.02	0.09*	0.02	0.04*	-0.00	0.01	0.07	0.01
Others	0.02	-0.20	0.01	-0.04	-0.06	0.07	-0.07	-0.03	-0.02	0.03	0.05	0.03
Initial	-0.08***	-0.38***	-0.15***	-0.16***	-0.06**	-0.18**	-0.11**	-0.10**	0.09***	0.11***	0.18***	0.12***
Time allocation (all)	0.03	0.05	0.01	0.01	0.06**	0.10	0.04	0.06**	-0.04	-0.01	-0.02	-0.01
Personal care	-0.00	0.01	0.01	0.00	-0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00
School	0.00	-0.00	-0.00	-0.00	-0.00	0.00	-0.00	0.00	0.00	-0.00	-0.00	-0.00
Education	0.02	0.03	0.01	0.01	0.03*	0.06	0.03	0.03**	-0.02	-0.00	-0.03	-0.00
Active	0.02	0.03	-0.01	0.01	0.00	-0.02	0.01	-0.00	-0.01	-0.02	0.01	-0.01
Chore					-0.01	-0.02	-0.02	-0.01	-0.02*	0.00	-0.02	-0.00
Media	-0.00	0.01	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00
Travel	0.00	0.00	0.01	0.00	0.00	-0.00	-0.00	-0.00	0.00	-0.00	0.00	-0.00
Personal care - lag	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00
School - lag	-0.00	-0.00	-0.01	-0.00	0.02*	-0.02	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00
Education - lag	-0.00	0.00	0.00	0.00	0.02*	0.08**	0.01	0.03**	0.01	0.01	0.01	0.01
Active - lag	-0.00	-0.04	-0.02	-0.02	0.00	0.00	-0.01	0.00	0.00	-0.00	-0.01	-0.00
Chore - lag					0.01	0.02	0.01	0.01	0.00	0.00	0.01	0.00
Media - lag	0.00	0.00	-0.00	0.00	-0.02	0.00	0.01	-0.00	-0.00	-0.00	-0.00	-0.01
Travel - lag	0.00	0.00	0.01	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00
Return part (total)	-0.21*	-0.34	0.03	-0.15	-0.13	0.14	0.20	0.07	0.30	0.34***	0.35	0.35***

Notes: Estimates from model (3) are used. Grouped variables: Child: age, Indigeneity, birth weight, breastfed at birth; Household: mother's characteristics (age, completed qualification, working hours), household size, number of siblings, living with both biological parents, living in an owned home, household income; Others: states, urban, local socio-economic background variables, and survey quarters; Initial: Lag of respective test score; Time allocation: Current and lagged time allocation among various grouped activities. Standard errors (not reported for brevity) are obtained using 500 bootstrap replications. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Table 4: Contributions to the Asian-Native gap at mean and selected percentiles - Grade 5 NAPLAN

	Reading				Writing				Spelling			
	Q10th	Q50th	Q90th	Mean	Q10th	Q50th	Q90th	Mean	Q10th	Q50th	Q90th	Mean
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Estimated total gap	0.75***	0.54***	0.56***	0.47***	0.66***	0.62***	0.74***	0.64***	0.75***	0.77***	1.27***	0.81***
Characteristic part (total)	0.23**	0.36***	0.34**	0.29***	0.29**	0.23***	0.41***	0.27***	0.55***	0.50***	0.65***	0.52***
Child	-0.00	0.03	-0.00	0.01	-0.01	0.02	0.01	0.01	-0.02	0.01	-0.00	0.00
Household	0.05	0.01	0.02	0.01	0.10*	0.05	0.03	0.06**	0.04	0.00	0.01	-0.00
Others	0.05	-0.04	0.02	-0.02	0.05	-0.01	0.15	0.03	0.02	-0.00	0.07	0.00
Initial	0.20***	0.23***	0.17***	0.20***	0.20***	0.15***	0.19***	0.17***	0.57***	0.46***	0.50***	0.50***
Time allocation (all)	-0.05	0.12***	0.13*	0.09***	-0.05	0.01	0.03	-0.00	-0.06	0.02	0.07	0.02
Personal care	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	-0.00	0.00	0.01	0.00
School	0.01	0.01	-0.00	0.00	0.00	0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00
Education	-0.02	0.06**	0.03	0.04**	0.02	0.04	0.04	0.02	-0.04	0.01	0.04	0.02
Active	-0.00	-0.00	0.04	0.00	-0.02	-0.00	0.04	0.00	-0.03	0.01	0.01	0.00
Chore	-0.02	0.02	-0.01	-0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02	0.01
Media	0.01	0.01	0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.00	0.00
Travel	0.00	-0.00	0.00	0.00	-0.00	-0.00	0.00	0.00	-0.00	0.00	-0.00	0.00
Personal care - lag	-0.01	0.00	0.01	0.00	-0.01	-0.00	0.00	-0.00	-0.01	0.01	0.01	0.00
School - lag	0.00	-0.00	0.01	0.00	-0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Education - lag	0.00	0.00	0.02	0.01	-0.03	-0.02	-0.01	-0.02	-0.00	-0.02	0.01	-0.01
Active - lag	-0.02	0.02	0.03	0.01	-0.00	-0.00	-0.01	-0.00	0.01	0.01	0.01	-0.00
Chore - lag	-0.01	-0.00	0.01	0.01	-0.02	-0.01	0.00	-0.01	-0.00	-0.01	-0.01	-0.01
Media - lag	-0.00	0.01	-0.02	0.00	0.01	-0.01	-0.04	-0.01	-0.00	-0.00	-0.03	0.00
Travel - lag	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	-0.00	0.00	0.00	0.00
Return part (total)	0.52***	0.19	0.22	0.19**	0.37**	0.39***	0.33	0.37***	0.20	0.28*	0.61***	0.30***

Notes: See Table 3.

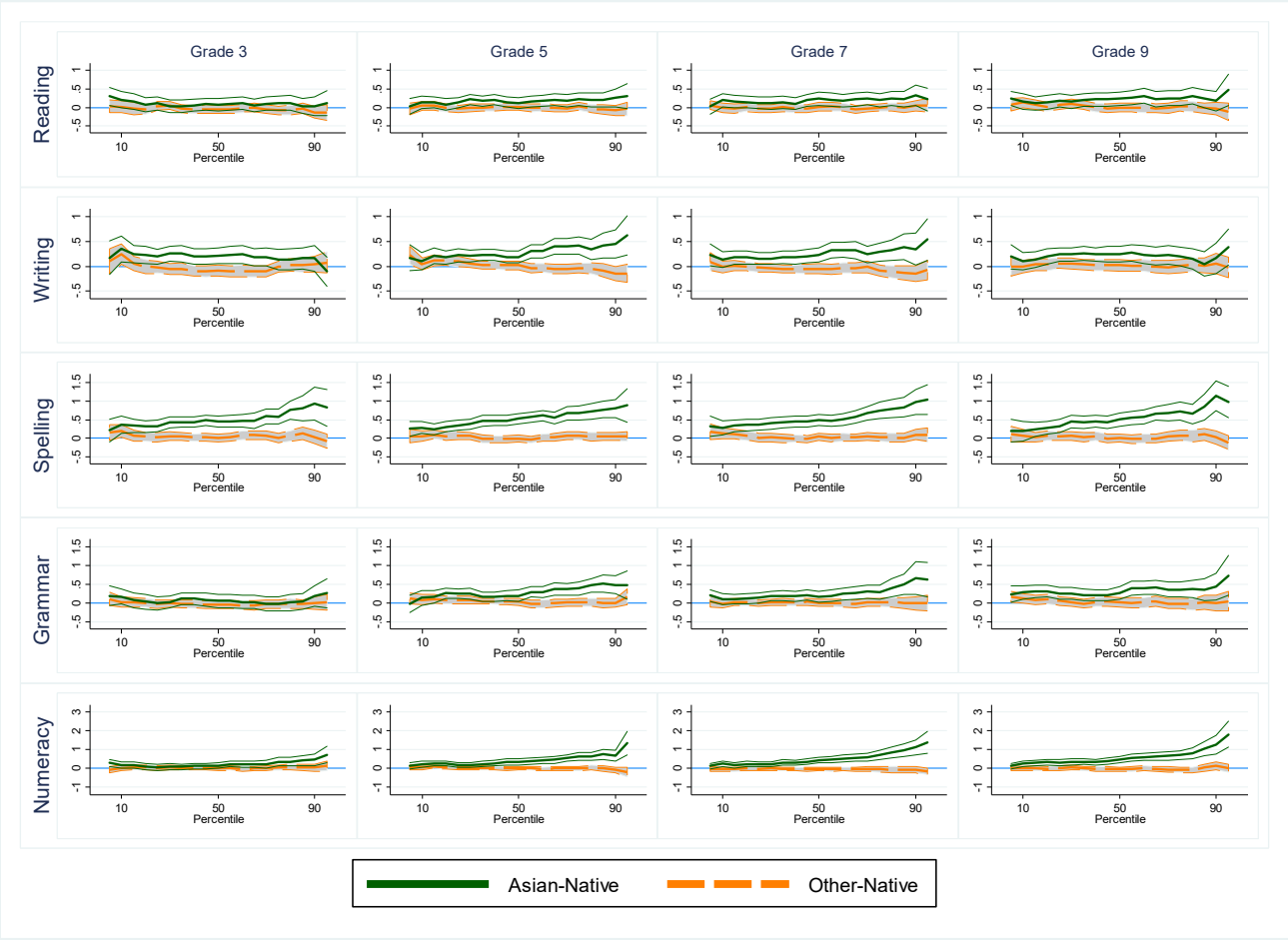
Table 4: Contributions to the Asian-Native gap at mean and selected percentiles - Grade 5 NAPLAN (continued)

	Grammar				Numeracy			
	Q10th	Q50th	Q90th	Mean	Q10th	Q50th	Q90th	Mean
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Estimated total gap	0.35**	0.52***	0.73***	0.50***	0.57***	0.82***	1.14***	0.85***
Characteristic part (total)	0.31**	0.33***	0.32**	0.27***	0.26***	0.44***	0.72***	0.44***
Child	-0.08	-0.03	-0.06	-0.03	-0.01	-0.02	-0.04	-0.02
Household	0.07	0.04	0.07	0.05*	0.01	-0.00	-0.00	0.01
Others	0.16	0.10*	0.02	0.06	-0.01	0.05	0.11	0.02
Initial	0.20***	0.20***	0.21***	0.19***	0.28***	0.39***	0.46***	0.38***
Time allocation (all)	-0.05	0.01	0.07	-0.00	0.00	0.02	0.19**	0.05*
Personal care	-0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00
School	-0.00	0.00	0.00	0.00	-0.00	-0.00	0.01	0.00
Education	-0.02	0.02	0.01	0.00	0.01	0.02	0.10*	0.04**
Active	-0.03	-0.01	0.01	-0.01	0.02	-0.01	-0.00	-0.01
Chore	-0.01	0.00	-0.00	-0.01	0.02	-0.01	0.03	0.01
Media	0.00	0.00	0.00	0.00	-0.00	-0.00	0.01	0.00
Travel	-0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00
Personal care - lag	0.00	-0.00	0.01	0.00	0.00	0.00	0.00	-0.00
School - lag	0.01	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.00
Education - lag	0.01	-0.00	0.01	0.00	-0.00	-0.01	-0.00	-0.00
Active - lag	-0.01	-0.02	-0.01	-0.01	-0.02	-0.01	0.04*	0.00
Chore - lag	0.00	-0.01	0.02	0.00	-0.00	0.00	0.01	0.00
Media - lag	0.00	0.02	-0.01	0.01	0.00	0.02	-0.03	-0.00
Travel - lag	-0.00	0.00	0.01	0.00	-0.00	0.00	0.00	0.00
Return part (total)	0.03	0.19	0.42*	0.23***	0.31**	0.37***	0.42*	0.41***

Figure 1: Nativity test score gaps along the distribution by test subject and age – WAI, PPVT and MR

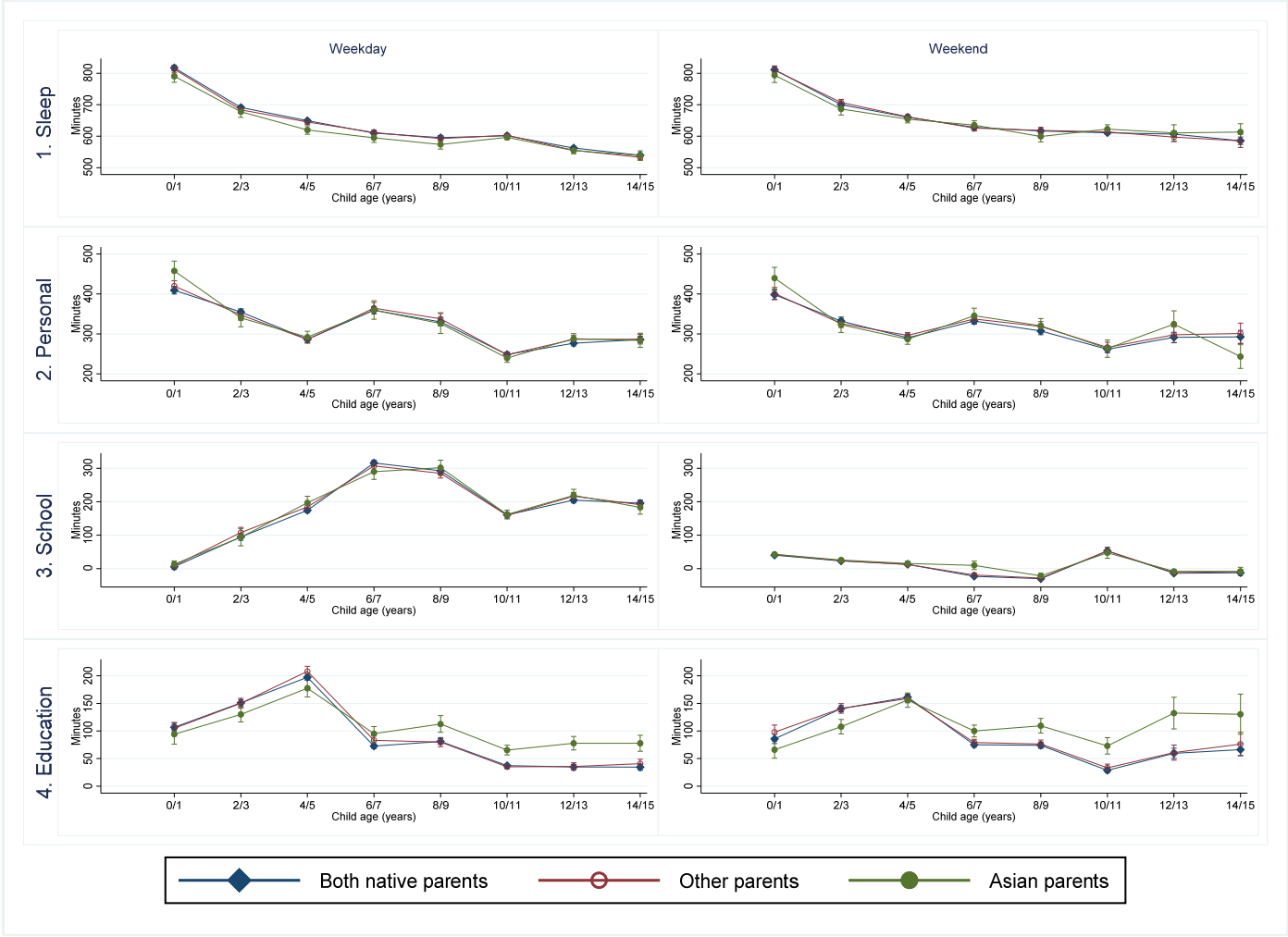
Notes: This figure reports adjusted nativity test score gaps in standardized scores. Estimates are based on unconditional quantile regressions using model (1). Thick (thin) solid green line indicates test score gap estimates (95% CIs) between children of Asian immigrant parents and children of both Australian-born parents. Thick (thin) long dash orange line indicates test score gap estimates (95% CIs) between children of non-Asian immigrant parents and children of both Australian-born parents. CIs are obtained using 500 bootstrap replications.

Figure 2: Nativity test score gaps along the distribution by test subject and grade - NAPLAN



Notes: See Figure 1.

Figure 3**:** The evolution of children's time investment by nativity



Notes: This figure reports estimated time use by children's ages and nativity background. Results are from model (2). Other explanatory variables: see Appendix Table A2.

Figure 3**:** The evolution of children's time investment by nativity (continued)

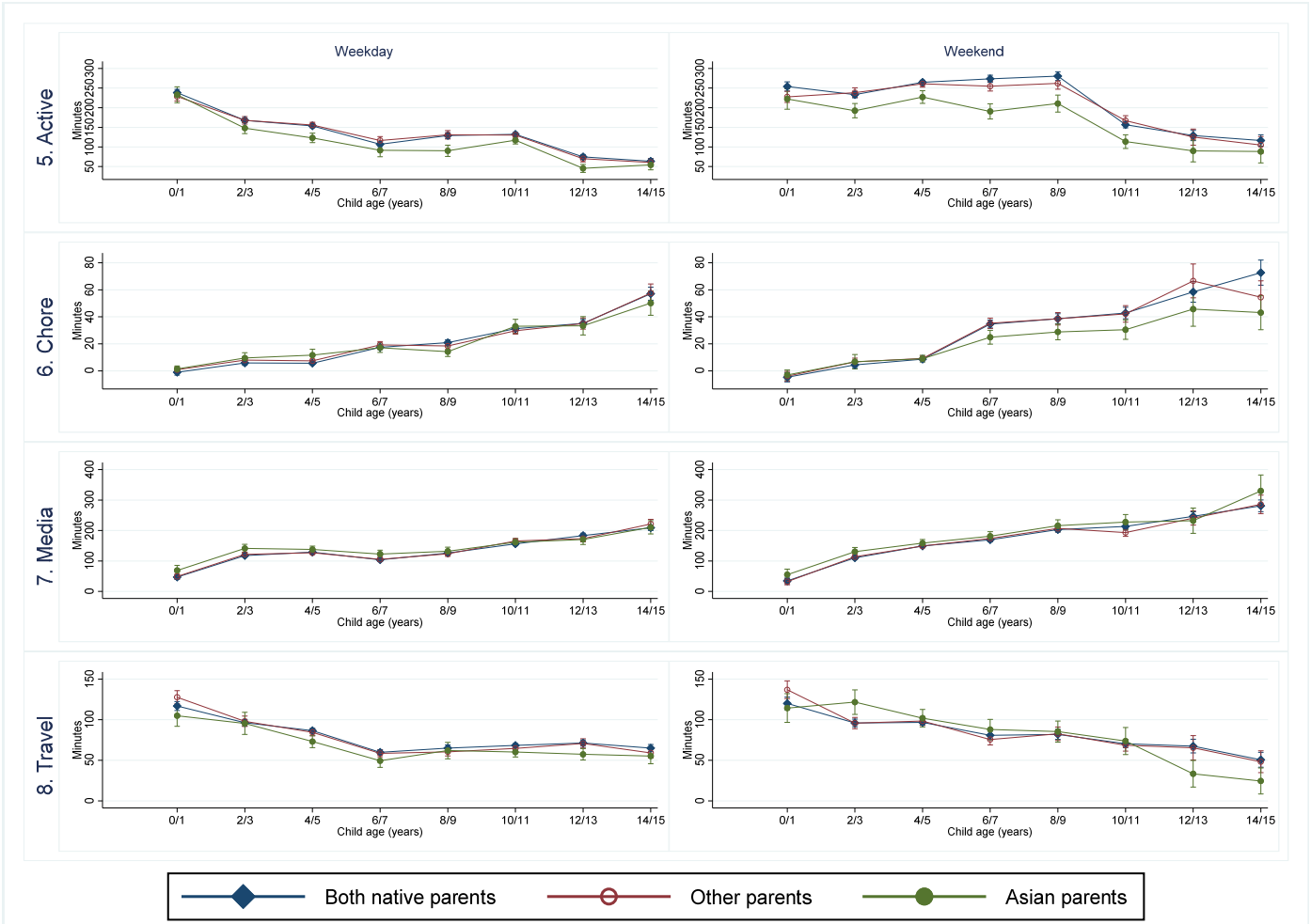
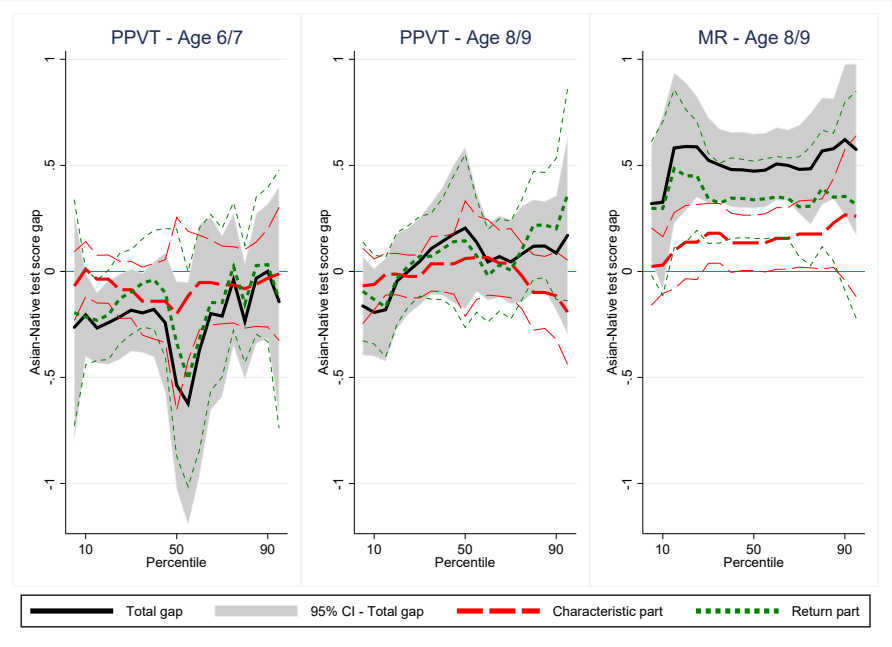


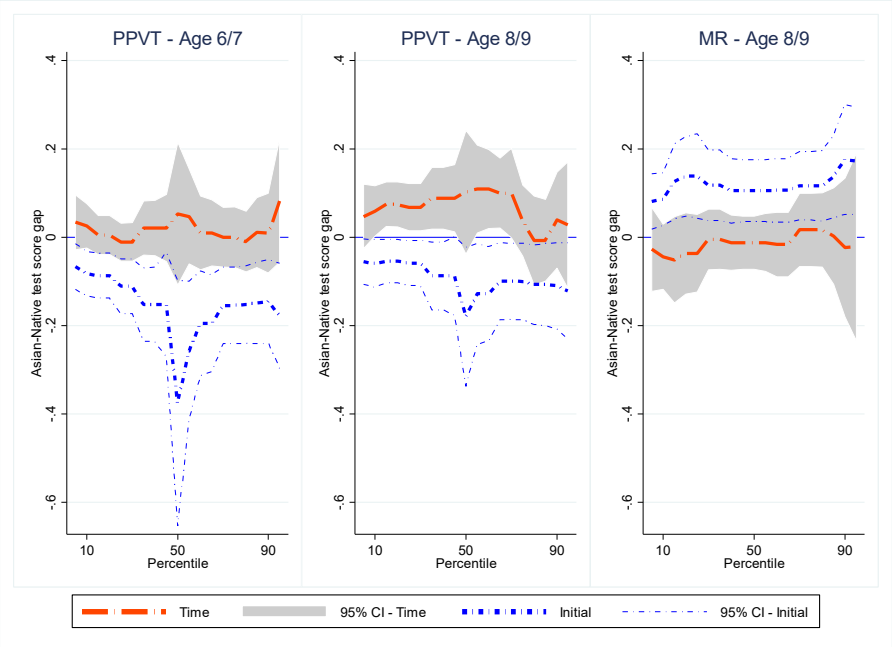
Figure 4: Decomposition of Asian–Native test score gap - PPVT and MR

Panel A: Aggregated decomposition



Notes: This figure reports aggregated decomposition of test score gaps in standardized scores between Asian immigrant and Australian-born parent children. Thick solid black line (grey shaded area) indicates total test score gap estimates (95% CIs). Thick red long dash (thick green short dash) line shows the total explained (unexplained) effect with its respective 95% CIs in thin lines.

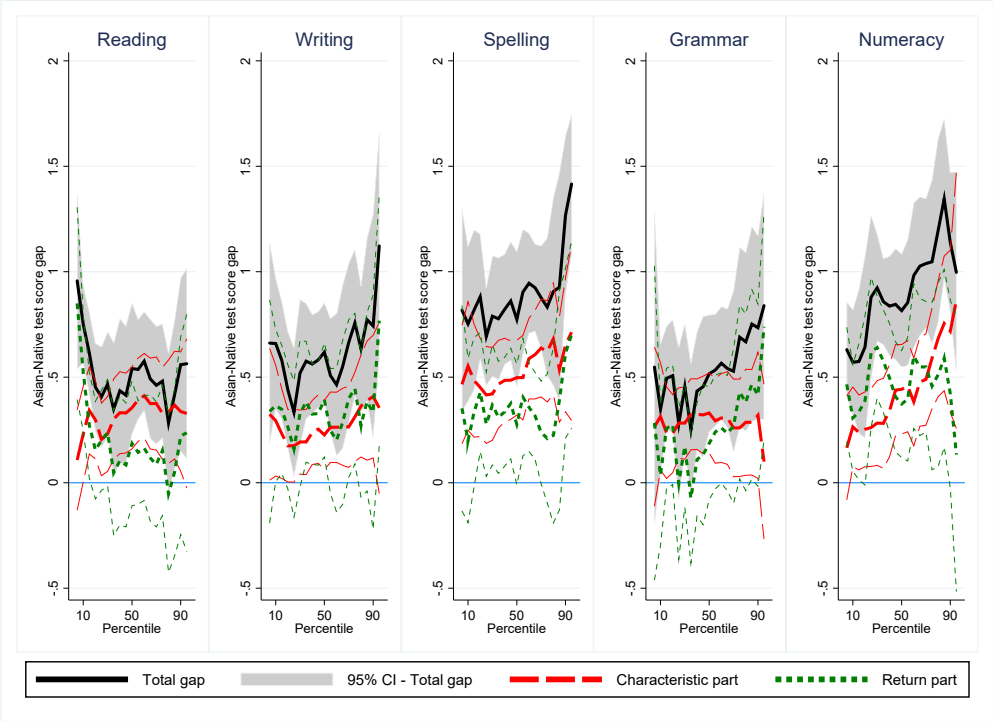
Panel B: Detailed decomposition of the characteristic part



Notes: This figure reports detailed decomposition of test score gaps in standardized scores between Asian immigrant and Australian-born parent children. Thick long dash dot orange line (grey shaded area) indicates explained effect due to time allocation (95% CIs). Thick (thin) blue short dash line shows the explained effect due to initial test score (95% CIs).

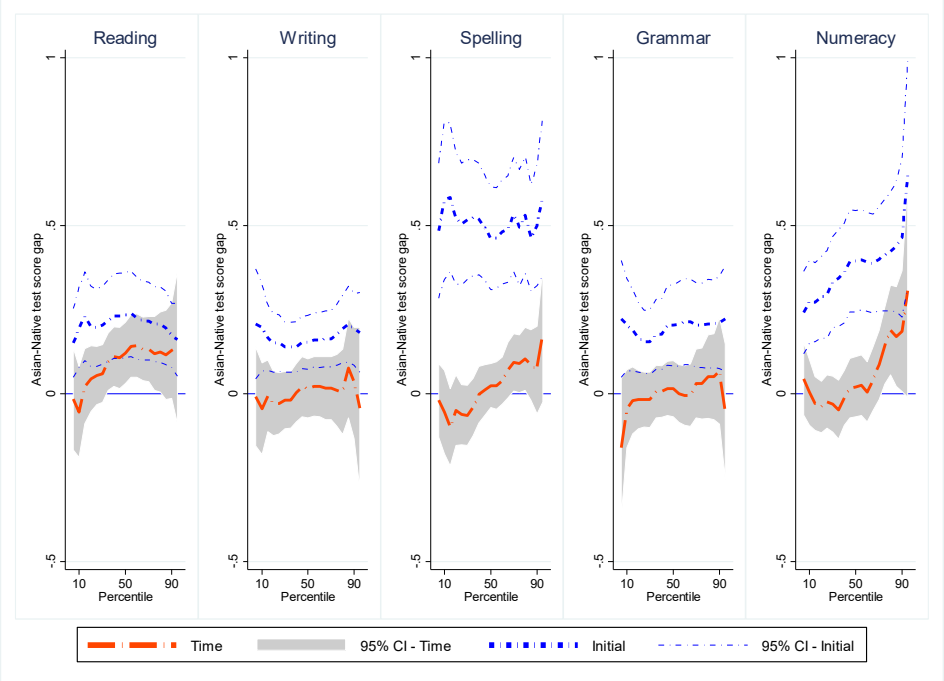
Figure 5: Decomposition of Asian–Native test score – Grade 5 NAPLAN

Panel A: Aggregated decomposition



Notes: See Figure 4 – Panel A.

Panel B: Detailed decomposition of the characteristic part



Notes: See Figure 4 – Panel B.

Online Appendices

Appendix A: Additional statistics and results

Appendix B: Robustness checks

Appendix C: Data description

Appendix Table A1: Composition of parents' countries of birth by nativity grouping

Asian immigrant parents			Non-Asian immigrant parents		
Mother COB and father COB	Count	Freq	Mother COB and father COB	Count	Freq
China China	462	9.8	Australia United Kingdom	2119	18.1
India India	379	8.0	United Kingdom Australia	1421	12.1
Viet Nam Viet Nam	368	7.8	Australia New Zealand	947	8.1
Lebanon Lebanon	202	4.3	New Zealand Australia	787	6.7
Philippines Australia	176	3.7	United Kingdom United Kingdom	721	6.1
Sri Lanka Sri Lanka	161	3.4	New Zealand New Zealand	316	2.7
Philippines Philippines	158	3.3	Papua New Guinea Australia	181	1.5
Australia Lebanon	130	2.7	Germany Australia	167	1.4
Iraq Iraq	129	2.7	South Africa South Africa	154	1.3
Australia Malaysia	99	2.1	Canada Australia	150	1.3
Malaysia Australia	86	1.8	Australia South Africa	135	1.2
Malaysia Malaysia	86	1.8	United States of America Australia	126	1.1
Pakistan Pakistan	82	1.7	United Kingdom New Zealand	124	1.1
China Australia	81	1.7	Australia United States of America	120	1.0
Bangladesh Bangladesh	69	1.5	Australia Canada	110	0.9
Sri Lanka Australia	69	1.5	Australia Ireland	109	0.9
Turkey Turkey	68	1.4	Australia Germany	105	0.9
Australia India	66	1.4	Australia Italy	98	0.8
Lebanon Australia	57	1.2	Australia Netherlands	96	0.8
Afghanistan Afghanistan	50	1.1	South Africa Australia	93	0.8
Indonesia Indonesia	48	1.0	Australia Papua New Guinea	89	0.8
Singapore Australia	48	1.0	Fiji Fiji	85	0.7
Viet Nam Australia	46	1.0	New Zealand United Kingdom	80	0.7
Thailand Australia	45	1.0	Australia France	77	0.7
Japan Australia	44	0.9	Samoa Samoa	77	0.7
Australia Philippines	43	0.9	Ireland Australia	73	0.6
Australia Israel	42	0.9	Switzerland Australia	63	0.5
India Australia	42	0.9	Australia Malta	60	0.5
Philippines United Kingdom	40	0.8	Netherlands Australia	59	0.5
East Timor East Timor	37	0.8	Italy Australia	53	0.5
Others	1317	27.8	Others	2934	25.0
Total	4730	100	Total	11729	100

Notes: This table reports the composition (in terms of the number of observations and frequency (freq.) of parents' country of birth (COB). Statistics are reported for the sample of B- and K-cohort children who have valid parental country of birth in any wave.

Appendix Table A2: Determinants of children's time allocation

	Bed		Personal care		School		Education	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Male	0.1	-5.1***	-15.7***	-13.9***	-1.1	-1.3*	-6.2***	-4.8***
	[1.4]	[1.8]	[1.9]	[2.0]	[2.0]	[0.7]	[1.4]	[1.6]
Indigenous	0.3	-3.1	1.7	-0.6	-1.0	8.0**	-13.8***	-5.8
	[4.9]	[7.1]	[7.0]	[7.7]	[6.8]	[3.6]	[4.6]	[5.6]
Low birthweight	3.3	5.3	0.8	-1.1	-5.9	0.5	-7.0**	-5.0
	[3.0]	[4.0]	[4.3]	[4.4]	[4.5]	[1.8]	[3.0]	[3.6]
Breastfed at 3 or 6 months	-1.4	-4.3**	7.5***	4.2*	-0.2	0.2	11.2***	11.8***
	[1.7]	[2.1]	[2.3]	[2.4]	[2.5]	[0.9]	[1.7]	[1.9]
Mother's age (years)	-0.9***	-0.8***	-0.4*	0.7***	-0.0	-0.1	1.2***	1.0***
	[0.2]	[0.2]	[0.2]	[0.2]	[0.2]	[0.1]	[0.2]	[0.2]
Mother has a certificate [(a)]	-0.4	-0.5	4.5*	0.7	-0.7	-0.6	2.8	3.1
	[1.9]	[2.5]	[2.6]	[2.9]	[2.8]	[1.1]	[1.9]	[2.2]
Mother has an advanced diploma [(a)]	-1.7	0.0	4.7	2.8	-4.0	-1.0	11.2***	7.0**
	[2.6]	[3.4]	[3.5]	[3.8]	[3.8]	[1.4]	[2.7]	[3.0]
Mother has bachelor degree [(a)]	1.9	3.3	16.1***	6.9**	-5.5*	-2.2**	23.8***	19.4***
	[2.1]	[2.7]	[3.0]	[3.1]	[3.3]	[1.1]	[2.4]	[2.6]
Mother has graduate diploma [(a)]	3.4	-0.2	13.6***	13.5***	-4.2	1.9	22.4***	19.7***
	[2.7]	[3.6]	[3.9]	[4.3]	[4.2]	[1.7]	[3.1]	[3.5]
Mother has postgraduate degree [(a)]	-3.0	1.8	21.8***	15.6***	-14.0***	-0.3	27.3***	23.1***
	[2.9]	[3.7]	[4.1]	[4.2]	[4.5]	[1.7]	[3.3]	[3.7]
Mother weekly working hours	-0.2***	-0.0	-0.1	-0.2***	1.1***	0.0	-0.1**	-0.1**
	[0.0]	[0.1]	[0.1]	[0.1]	[0.1]	[0.0]	[0.0]	[0.1]
Living with both parents	1.4	-0.7	1.4	-4.9	-17.8***	-0.2	5.6**	4.7*
	[2.2]	[3.4]	[3.3]	[4.0]	[3.6]	[1.6]	[2.3]	[2.8]
Owned home	4.4**	2.7	-1.9	-5.9**	1.6	-1.4	5.8***	6.3***
	[1.8]	[2.4]	[2.5]	[2.7]	[2.7]	[1.0]	[1.9]	[2.1]
Household yearly income	-1.6*	-1.7	-2.6**	-2.4*	4.4***	-0.7	0.5	-1.2
	[0.9]	[1.2]	[1.1]	[1.3]	[1.4]	[0.5]	[1.0]	[1.0]
Number of household members	2.8*	1.5	3.4	0.6	-5.4**	-0.8	-1.9	-2.0
	[1.6]	[2.0]	[2.2]	[2.6]	[2.2]	[0.8]	[1.5]	[1.6]
Number of siblings	-6.5***	-4.3*	-4.2*	-1.6	1.8	0.4	-2.4	-0.2
	[1.8]	[2.3]	[2.5]	[2.8]	[2.5]	[0.8]	[1.7]	[1.9]
Number of younger siblings	-1.7	-1.6	-0.4	4.4**	6.5***	-0.2	12.3***	12.2***
	[1.1]	[1.5]	[1.6]	[1.8]	[1.7]	[0.7]	[1.1]	[1.4]
Number of same age siblings	6.4	7.8*	7.6	6.4	12.6**	-0.2	4.3	6.3
	[3.9]	[4.5]	[5.6]	[5.8]	[6.1]	[2.0]	[3.9]	[4.6]
Observations	26,840	18,487	26,840	18,487	26,840	18,487	26,840	18,487
R-squared	0.277	0.192	0.125	0.112	0.208	0.034	0.123	0.111

Notes: Results are from model (2). Other explanatory variables include parental countries of birth and children's ages (results are reported in Figure 3), urban, local socio-economic background variables, state/territory dummies, month dummies, day-of-week dummies, and cohort dummy. [(a)] denotes no qualification as the base group. Robust standard errors are in square brackets. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table A2: Determinants of children's time allocation (cont.)

	Active activity		Chores		Media		Travel	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Male	10.3***	14.4***	-3.5***	-3.2***	23.8***	15.5***	-1.7*	0.1
	[1.5]	[2.3]	[0.5]	[0.6]	[1.4]	[1.7]	[0.9]	[1.4]
Indigenous	7.3	3.6	-2.2	0.7	0.6	14.9**	-4.1	-6.5
	[6.0]	[8.9]	[2.2]	[2.3]	[4.8]	[6.5]	[3.1]	[5.1]
Low birthweight	1.8	-7.3	-2.6**	-1.7	-1.2	3.7	-2.5	-7.7***
	[3.3]	[5.1]	[1.1]	[1.3]	[3.2]	[4.0]	[1.9]	[3.0]
Breastfed at 3 or 6 months	6.6***	6.9**	1.0*	3.3***	-11.6***	-11.4***	3.6***	0.3
	[1.8]	[2.7]	[0.6]	[0.7]	[1.7]	[2.1]	[1.1]	[1.7]
Mother's age (years)	0.1	-0.0	-0.1	-0.0	0.3*	0.2	0.2**	0.1
	[0.2]	[0.3]	[0.1]	[0.1]	[0.2]	[0.2]	[0.1]	[0.2]
Mother has a certificate [(a)]	-0.4	1.0	0.8	-0.1	-2.3	1.4	1.6	1.3
	[2.1]	[3.3]	[0.7]	[0.9]	[2.0]	[2.4]	[1.3]	[2.0]
Mother has an advanced diploma [(a)]	4.3	1.4	2.1**	-1.2	-5.0*	-2.6	0.8	7.0***
	[2.7]	[4.2]	[0.9]	[1.1]	[2.7]	[3.2]	[1.7]	[2.6]
Mother has bachelor degree [(a)]	10.9***	11.1***	3.6***	2.2**	-18.1***	-14.1***	4.4***	5.8***
	[2.4]	[3.6]	[0.8]	[1.0]	[2.2]	[2.5]	[1.5]	[2.2]
Mother has graduate diploma [(a)]	4.9*	9.1*	2.7**	2.5*	-14.8***	-14.3***	2.3	-0.9
	[3.0]	[4.9]	[1.1]	[1.3]	[2.9]	[3.5]	[1.8]	[2.7]
Mother has postgraduate degree [(a)]	12.8***	3.3	2.3**	1.6	-18.0***	-22.6***	3.4*	6.3**
	[3.2]	[4.7]	[1.1]	[1.3]	[2.9]	[3.4]	[2.0]	[2.9]
Mother weekly working hours	-0.3***	0.0	0.0	0.1***	-0.3***	-0.0	-0.1**	0.2***
	[0.0]	[0.1]	[0.0]	[0.0]	[0.0]	[0.1]	[0.0]	[0.0]
Living with both parents	9.0***	12.1***	2.0**	3.2**	-3.6	-5.2	-0.3	1.6
	[2.5]	[4.3]	[1.0]	[1.3]	[2.8]	[3.6]	[1.5]	[2.6]
Owned home	-0.8	5.8*	0.6	-0.1	-9.8***	-5.7**	0.7	0.5
	[2.0]	[3.1]	[0.6]	[0.8]	[1.9]	[2.2]	[1.3]	[1.8]
Household yearly income	-0.8	1.1	-1.0***	-0.6	-1.5*	-0.1	2.0***	0.3
	[0.9]	[1.4]	[0.3]	[0.5]	[0.9]	[1.1]	[0.6]	[0.9]
Number of household members	-1.1	-8.5***	0.8	0.8	0.5	0.1	-0.9	0.8
	[1.6]	[2.4]	[0.5]	[0.7]	[1.7]	[2.1]	[1.0]	[1.7]
Number of siblings	3.1*	11.0***	0.5	-0.4	-0.8	-0.1	2.8**	-5.4***
	[1.8]	[2.8]	[0.6]	[0.8]	[1.9]	[2.3]	[1.2]	[1.9]
Number of younger siblings	-0.3	1.5	0.7	0.2	-4.4***	-4.7***	-3.4***	0.5
	[1.2]	[2.0]	[0.5]	[0.6]	[1.2]	[1.5]	[0.7]	[1.2]
Number of same age siblings	5.3	-4.5	0.1	0.6	-13.5***	-14.3***	-8.0***	0.6
	[4.6]	[6.6]	[1.5]	[1.6]	[3.8]	[4.3]	[2.6]	[3.7]
Observations	26,840	18,487	26,840	18,487	26,840	18,487	26,840	18,487
R-squared	0.114	0.075	0.123	0.129	0.134	0.180	0.046	0.041

Appendix Table A3: Other measures of human capital investments by nativity background

Variables		Native	Others	Asian	Others-Native	Asian-Native
(1)	Talks to study child (SC) about school daily [(a)]	0.88	0.88	0.81	0.00	-0.07***
(2)	Help SC with homework daily [(a)]	0.35	0.36	0.34	0.00	-0.01
(3)	The SC is given homework from the school [(a)]	0.96	0.96	0.97	0.00	0.01***
(4)	The SC is given homework daily (if SC is given homework) [(a)]	0.68	0.68	0.73	0.00	0.05***
(5)	A place to do homework [(a)]	0.77	0.79	0.83	0.02*	0.06***
(6)	Weekly hours on homework	2.45	2.66	3.73	0.2***	1.27***
(7)	The SC received tutoring [(a)]	0.13	0.13	0.25	0.00	0.11***
(8)	The SC received tutoring more than once a week (if received) [(a)]	0.28	0.28	0.27	0.00	-0.02
(9)	The SC is expected to complete university degree or higher [(a)]	0.63	0.72	0.87	0.09***	0.24***
(10)	Mother warm parenting [(b)]	0.02	0.07	-0.27	0.05***	-0.28***
(11)	Mother discipline parenting [(b)]	0.06	0.00	-0.24	-0.06***	-0.3***

Notes: Tests are performed on the significance of the difference between the sample mean for each group. Statistics are reported for the pooled sample of B- and K-cohort children who have valid parental country of birth in any wave. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level. [(a)] indicates binary variables. [(b)] See Appendix Table C3 for details about construction of these variables.
(1) Response "Daily" to the question "How often do you and study child talk about his/her school activities?"
(2) Response "Daily" to the question "During this school year, how often have you or another family member (or adult in the household) helped child with his/her homework?"
(3) Response "Yes" to the question "Is the child given homework from the school such as specific reading tasks, spelling, project work or math tasks?"
(4) Response "Daily" to the question "How often does study child do homework (given to (him/her) by the school, such as specific reading tasks, spelling, project work, or math tasks)?"
(5) Response "Yes" to the question "Is there a place in your home set aside for the child to do homework?"
(6) Response to the question "In an average week, how many hours does the child spend on homework outside of school?"
(7) Response "Yes" to the question "During the previous school year did study child receive any additional help or tutoring from anyone outside the household?"
(8) Response "More than once a week" to the question "In the last 12 months has the child received any additional help or tutoring from anyone outside the household?"
(9) Response "Go to university and complete a degree" or "Obtain post-graduate qualifications at a university" to the question "Looking ahead, how far do you think study child will go in his/her education?"

Appendix Table A4: Determinants of test scores – Pooled regression results at means

	PPVT		MR	Reading	Writing	Spelling	Grammar	Numeracy
Variables	Age 6/7	Age 8/9	Age 8/9	Grade 5	Grade 5	Grade 5	Grade 5	Grade 5
Asian immigrant children	-0.15	0.07	0.35***	0.18**	0.37***	0.30***	0.24***	0.41***
	[0.12]	[0.08]	[0.09]	[0.08]	[0.10]	[0.07]	[0.09]	[0.09]
Personal care	0.04	0.03	0.03	0.00	0.05	0.03	0.03	0.05
	[0.04]	[0.03]	[0.03]	[0.03]	[0.04]	[0.03]	[0.04]	[0.03]
School	-0.07	0.03	-0.01	0.10**	0.03	-0.03	0.02	0.03
	[0.06]	[0.05]	[0.05]	[0.04]	[0.05]	[0.04]	[0.05]	[0.04]
Education	0.05	0.13**	-0.01	0.16**	0.08	0.07	0.01	0.18**
	[0.10]	[0.06]	[0.07]	[0.07]	[0.08]	[0.05]	[0.07]	[0.07]
Active	-0.07	0.01	0.05	-0.02	-0.01	-0.01	0.06	0.03
	[0.06]	[0.05]	[0.04]	[0.04]	[0.05]	[0.03]	[0.04]	[0.04]
Chore	0.00	0.23	0.07	0.05	-0.13	-0.18	0.17	-0.17
	[0.24]	[0.18]	[0.18]	[0.17]	[0.22]	[0.16]	[0.18]	[0.19]
Media	0.01	0.02	0.05	0.09	-0.04	0.04	0.10	0.07
	[0.09]	[0.07]	[0.06]	[0.08]	[0.07]	[0.06]	[0.07]	[0.07]
Travel	-0.06	-0.12	0.02	-0.06	-0.02	-0.00	-0.20**	-0.05
	[0.11]	[0.09]	[0.08]	[0.09]	[0.11]	[0.07]	[0.09]	[0.08]
Personal care - lag	-0.06	0.03	0.02	0.03	-0.05	0.03	0.03	-0.00
	[0.08]	[0.03]	[0.03]	[0.04]	[0.04]	[0.03]	[0.04]	[0.03]
School - lag	-0.05	0.00	0.03	-0.04	-0.04	-0.02	0.03	-0.03
	[0.05]	[0.05]	[0.04]	[0.05]	[0.05]	[0.04]	[0.05]	[0.04]
Education - lag	0.04	0.21***	0.08	0.06	-0.13	-0.09	0.03	-0.01
	[0.04]	[0.07]	[0.07]	[0.07]	[0.10]	[0.05]	[0.09]	[0.08]
Active - lag	0.08	-0.03	0.05	-0.06	0.01	0.01	0.03	-0.01
	[0.06]	[0.06]	[0.04]	[0.04]	[0.06]	[0.04]	[0.07]	[0.04]
Chore - lag		-0.42**	-0.14	-0.23	0.24	0.19	-0.09	-0.00
		[0.18]	[0.20]	[0.23]	[0.25]	[0.16]	[0.22]	[0.19]
Media - lag	0.09	-0.04	-0.07	0.03	-0.09	0.01	0.06	-0.01
	[0.08]	[0.08]	[0.07]	[0.07]	[0.08]	[0.06]	[0.07]	[0.07]
Travel - lag	-0.08	-0.02	0.11	-0.10	-0.17	-0.09	-0.13	-0.20**
	[0.08]	[0.09]	[0.09]	[0.10]	[0.11]	[0.07]	[0.10]	[0.10]
Lagged scores	0.36***	0.46***	0.43***	0.63***	0.49***	0.74***	0.56***	0.66***
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.02]	[0.03]	[0.03]
Observations	968	1,422	1,451	977	977	977	977	977
R-squared	0.26	0.32	0.29	0.51	0.40	0.68	0.45	0.57

Notes: Estimates for each subject-level are obtained from a separate regression using model (3). Time use variables are measured in days per week. Other variables include urban, local socio-economic background variables, state/territory dummies, and survey quarters. For NAPLAN test scores, test states (in place of state/territory dummies), test years and test ages are also included. Robust standard errors are in square brackets. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table A4: Determinants of test scores – Pooled regression results at mean (cont.)

	PPVT		MR	Reading	Writing	Spelling	Grammar	Numeracy
Variables	Age 6/7	Age 8/9	Age 8/9	Grade 5	Grade 5	Grade 5	Grade 5	Grade 5
Male	0.17***	0.04	-0.07	-0.16***	-0.15***	-0.07*	-0.18***	0.08*
	[0.06]	[0.04]	[0.05]	[0.05]	[0.05]	[0.04]	[0.05]	[0.04]
Child age (months)	0.04***	0.03***	-0.00	-0.04	-0.03	-0.01	0.05	0.04
	[0.01]	[0.01]	[0.01]	[0.03]	[0.03]	[0.02]	[0.03]	[0.03]
Indigenous	-0.14	0.02	-0.25**	-0.00	-0.16	0.02	-0.01	0.04
	[0.12]	[0.12]	[0.12]	[0.18]	[0.24]	[0.10]	[0.15]	[0.16]
Low birthweight	-0.05	-0.12	-0.12	-0.21*	-0.18**	-0.00	-0.22***	-0.38***
	[0.10]	[0.09]	[0.10]	[0.11]	[0.09]	[0.08]	[0.08]	[0.10]
Breastfed at 3 or 6 months	0.14**	-0.01	0.08	0.02	0.04	-0.03	0.00	0.02
	[0.07]	[0.05]	[0.06]	[0.06]	[0.07]	[0.05]	[0.06]	[0.06]
Mother's age (years)	0.02	-0.06	0.07	0.08	0.04	0.02	0.15**	0.08
	[0.07]	[0.05]	[0.06]	[0.06]	[0.05]	[0.03]	[0.06]	[0.05]
Mother's age squared	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00**	-0.00
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Mother has a certificate [(a)]	-0.02	-0.03	-0.03	0.06	-0.06	-0.02	0.07	0.17***
	[0.08]	[0.06]	[0.06]	[0.06]	[0.07]	[0.05]	[0.07]	[0.06]
Mother has an advanced diploma [(a)]	0.08	0.02	0.04	0.12	0.08	0.01	0.01	0.10
	[0.11]	[0.08]	[0.09]	[0.08]	[0.09]	[0.06]	[0.08]	[0.08]
Mother has bachelor degree [(a)]	0.08	-0.05	0.05	0.10	0.10	-0.04	0.11	0.10
	[0.09]	[0.07]	[0.07]	[0.07]	[0.08]	[0.06]	[0.08]	[0.07]
Mother has graduate diploma [(a)]	-0.01	0.10	0.12	0.18	-0.02	-0.15**	0.00	0.09
	[0.13]	[0.09]	[0.09]	[0.11]	[0.11]	[0.07]	[0.10]	[0.09]
Mother has postgraduate degree [(a)]	0.15	0.13	-0.00	0.08	0.06	0.06	0.24**	0.22**
	[0.12]	[0.10]	[0.10]	[0.10]	[0.11]	[0.08]	[0.11]	[0.09]
Mother weekly working hours	0.00	-0.00	-0.00	-0.00*	-0.00	-0.00	-0.00**	0.00
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Number of household members	-0.04	0.02	-0.02	-0.14	0.02	-0.11**	-0.05	-0.08
	[0.11]	[0.06]	[0.06]	[0.10]	[0.07]	[0.05]	[0.07]	[0.07]
Number of siblings	-0.08	-0.02	0.01	0.10	-0.08	0.07	-0.04	0.08
	[0.11]	[0.06]	[0.06]	[0.10]	[0.07]	[0.05]	[0.07]	[0.07]
Number of younger siblings	0.05	0.01	-0.01	0.08**	0.06	0.06**	0.05	0.03
	[0.05]	[0.03]	[0.03]	[0.04]	[0.04]	[0.03]	[0.04]	[0.04]
Number of same age siblings	-0.09	0.16	0.36***	-0.05	0.19**	-0.04	-0.06	0.13
	[0.17]	[0.18]	[0.13]	[0.14]	[0.09]	[0.11]	[0.16]	[0.11]
Living with both parents	0.25**	0.10	-0.03	-0.01	0.05	-0.07	-0.11	0.04
	[0.12]	[0.08]	[0.08]	[0.09]	[0.09]	[0.07]	[0.09]	[0.09]
Owned home	-0.03	-0.00	0.04	-0.00	-0.02	-0.07	0.09	-0.01
	[0.09]	[0.06]	[0.07]	[0.07]	[0.08]	[0.06]	[0.07]	[0.07]
Household yearly income ($100,000)	0.08*	0.06*	0.09***	0.03	0.11***	0.06**	0.00	0.05*
	[0.04]	[0.03]	[0.03]	[0.03]	[0.04]	[0.03]	[0.04]	[0.03]

Notes: [(a)] denotes no qualification as the base group.

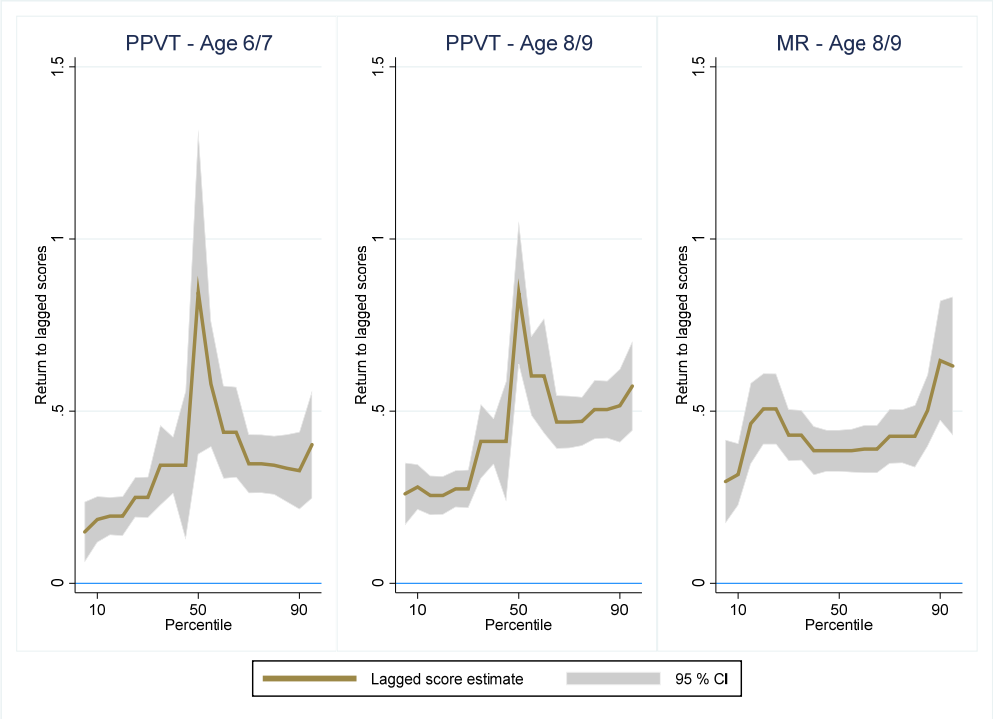
Appendix Table A5: Are returns to initial cognitive abilities increasing with children's ages/grades?

Variables	PPVT	MR	Reading	Writing	Spelling	Grammar	Numeracy
Non-Asian immigrant children[(a)]	-0.01	0.02	-0.01	-0.02	-0.01	0.00	-0.01
	[0.02]	[0.02]	[0.02]	[0.02]	[0.01]	[0.02]	[0.02]
Asian immigrant children[(a)]	-0.05	0.19***	0.08***	0.13***	0.10***	0.16***	0.23***
	[0.04]	[0.04]	[0.03]	[0.03]	[0.02]	[0.03]	[0.03]
Lagged scores	0.40***	0.44***	0.66***	0.49***	0.79***	0.59***	0.68***
	[0.02]	[0.01]	[0.02]	[0.02]	[0.01]	[0.02]	[0.02]
Wave 3	-0.68***						
	[0.10]						
Wave 4/Grade 7		0.00	0.31	0.52**	0.34**	0.34	0.19
		[0.08]	[0.19]	[0.24]	[0.17]	[0.21]	[0.18]
Wave 5/Grade 9			0.55	0.67	0.60*	0.98**	0.28
			[0.37]	[0.48]	[0.33]	[0.43]	[0.34]
Lagged scores x Wave 3	0.05**						
	[0.02]						
Lagged scores x Wave 4/Grade 7		0.05**	0.05**	-0.00	0.05***	0.02	0.10***
		[0.02]	[0.02]	[0.02]	[0.02]	[0.02]	[0.02]
Lagged scores x Grade 9			0.11***	0.00	0.10***	0.10***	0.14***
			[0.02]	[0.03]	[0.02]	[0.02]	[0.02]
Observations	7,354	7,535	7,830	7,830	7,830	7,830	7,830
R-squared	0.30	0.29	0.60	0.38	0.73	0.50	0.66

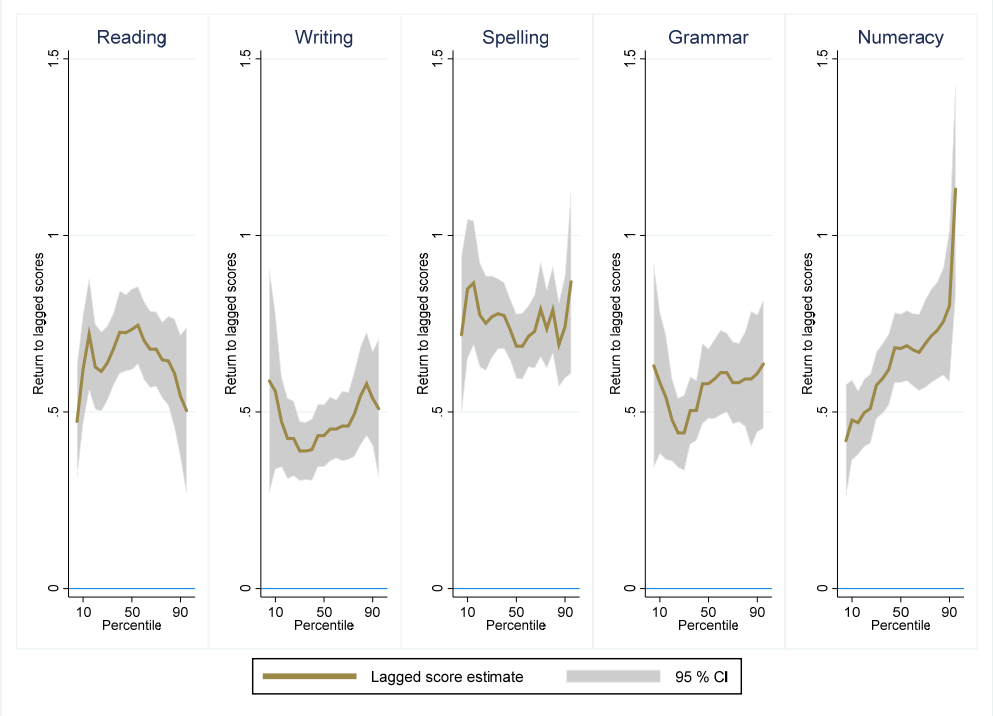
Notes: [(a)] denotes children of both Australian-born parents are the base group. Estimates for each subject are obtained from a separate regression using an OLS model for a pooled sample of test scores available at all ages/grades. Other variables include child characteristics (gender, age, Indigeneity, birth weight, and breastfed at birth), household characteristics (mother's characteristics (age and its square, completed qualification, and working hours), household size, number of siblings, living with both biological parents, living in an owned home, household income), urban, local socio-economic background variables, state/territory dummies, and survey quarters. For NAPLAN test scores, test states (in place of state/territory dummies), test years and test ages are also included. Robust standard errors are in square brackets. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Figure A1: Returns to lagged scores along the test score distribution

Panel A: PPVT and MR



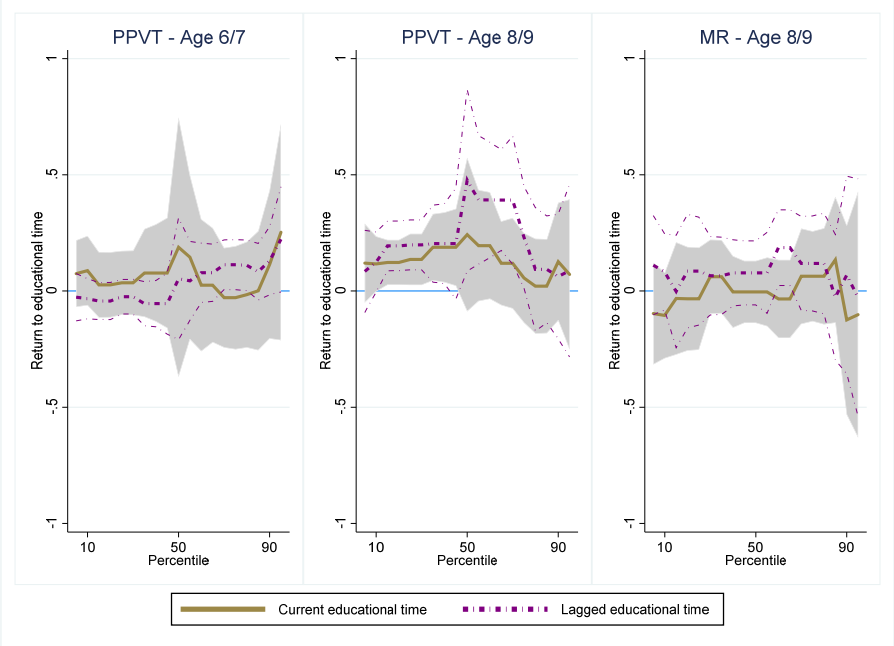
Panel B: Grade 5 NAPLAN



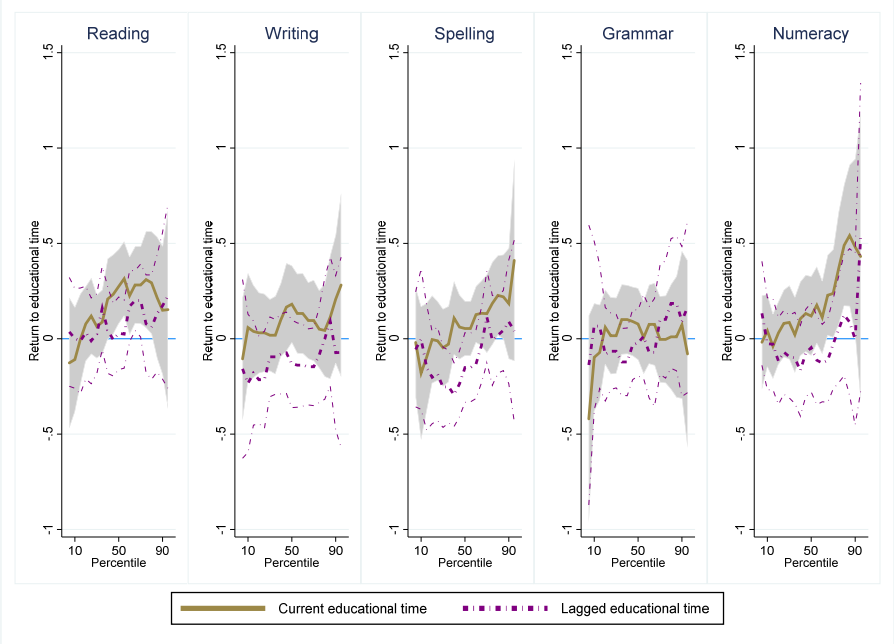
Notes: This figures report estimates of lagged scores from unconditional quantile regressions using model (3) for a pooled sample of Asian immigrant and Australian-born parent children. CIs are obtained using 500 bootstrap replications.

Appendix Figure A2: Returns to educational time along the test score distribution

Panel A: PPVT and MR



Panel B: Grade 5 NAPLAN



Notes: This figures report estimates of educational time variables from unconditional quantile regressions using model (3) for a pooled sample of Asian immigrant and Australian-born parent children. Thick brown line (grey shaded area) indicates estimates of current educational time (95% CIs). Thick (thin) purple short dash dot line shows estimates of lagged educational time (95% CIs). CIs are obtained using 500 bootstrap replications.

Appendix Table B1: Robustness checks – Alternative classifications of the child's ethnicity – Interaction between mother and father

Test subject	WAI	PPVT			MR			Reading			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Other migrant mother	0.06	-0.15***	0.01	-0.02	0.09	0.05	0.03	0.08	0.05	0.02	-0.02
	[0.05]	[0.05]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.07]	[0.06]	[0.06]	[0.07]
Asian migrant mother	0.26***	-0.29*	-0.23**	-0.12	0.04	0.18	0.31**	-0.12	0.06	0.26**	-0.05
	[0.10]	[0.15]	[0.11]	[0.12]	[0.12]	[0.14]	[0.15]	[0.16]	[0.14]	[0.13]	[0.17]
Other migrant father	0.07*	-0.07	-0.01	-0.03	-0.09*	0.01	0.03	-0.06	-0.05	-0.00	0.01
	[0.04]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.06]	[0.05]	[0.05]	[0.06]
Asian migrant father	0.34***	-0.09	-0.02	-0.10	0.01	-0.07	0.01	0.41***	0.10	0.13	0.05
	[0.12]	[0.13]	[0.16]	[0.13]	[0.13]	[0.14]	[0.14]	[0.15]	[0.13]	[0.11]	[0.16]
Other migrant mother & Other migrant father	-0.04	-0.14	-0.18*	-0.12	0.07	-0.02	-0.04	-0.08	0.02	-0.05	0.14
	[0.08]	[0.09]	[0.09]	[0.10]	[0.10]	[0.10]	[0.10]	[0.11]	[0.09]	[0.10]	[0.11]
Other migrant mother & Asian migrant father	-0.36	-0.43	-0.18	0.08	0.04	0.20	0.29	-0.56**	0.02	-0.32	0.56**
	[0.22]	[0.32]	[0.22]	[0.29]	[0.26]	[0.24]	[0.27]	[0.22]	[0.26]	[0.26]	[0.26]
Asian migrant mother & Other migrant father	-0.20	-0.07	0.22	0.05	-0.06	-0.06	-0.25	0.20	0.23	-0.20	0.21
	[0.20]	[0.25]	[0.23]	[0.23]	[0.21]	[0.22]	[0.26]	[0.25]	[0.23]	[0.24]	[0.28]
Asian migrant mother & Asian migrant father	-0.17	-0.47**	-0.17	0.03	0.26	0.33	0.15	-0.17	0.08	-0.21	0.34
	[0.17]	[0.21]	[0.20]	[0.19]	[0.19]	[0.21]	[0.22]	[0.23]	[0.20]	[0.18]	[0.24]
Observations	4,440	4,033	4,003	3,980	4,094	3,977	3,817	2,687	3,542	3,307	2,484
R-squared	0.26	0.19	0.16	0.14	0.07	0.10	0.10	0.16	0.18	0.20	0.21

Notes: This table reports nativity test score gaps at mean. Children of both Australian-born parents are the base group. Other notes: see Table 2.

Appendix Table B1: Robustness checks – Alternative classifications of the child's ethnicity – Interaction between mother and father (cont.)

Test subject	Writing				Spelling				Grammar				Numeracy			
Age/Grade	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
Other migrant mother	0.02	0.02	-0.04	-0.08	0.07	0.02	0.04	0.05	-0.03	0.09	-0.01	-0.01	0.04	0.05	-0.04	-0.07
	[0.06]	[0.06]	[0.05]	[0.08]	[0.07]	[0.06]	[0.06]	[0.07]	[0.06]	[0.06]	[0.05]	[0.07]	[0.06]	[0.05]	[0.06]	[0.06]
Asian migrant mother	0.25	0.32***	0.08	-0.00	0.24	0.44***	0.41***	0.10	-0.03	0.24*	0.29**	0.04	0.14	0.30**	0.34**	0.19
	[0.18]	[0.11]	[0.12]	[0.14]	[0.16]	[0.12]	[0.15]	[0.17]	[0.17]	[0.12]	[0.12]	[0.14]	[0.17]	[0.14]	[0.15]	[0.19]
Other migrant father	-0.01	-0.01	-0.03	0.00	0.04	-0.01	-0.00	-0.04	0.04	-0.00	0.04	0.05	0.07	-0.03	-0.03	-0.01
	[0.06]	[0.05]	[0.05]	[0.06]	[0.06]	[0.06]	[0.05]	[0.06]	[0.06]	[0.06]	[0.05]	[0.06]	[0.06]	[0.05]	[0.05]	[0.06]
Asian migrant father	0.19	0.11	0.04	-0.15	0.65***	0.26*	0.37***	0.16	0.33***	0.33**	0.12	0.03	0.35**	0.01	0.08	0.10
	[0.14]	[0.16]	[0.15]	[0.21]	[0.18]	[0.15]	[0.14]	[0.17]	[0.13]	[0.16]	[0.14]	[0.18]	[0.14]	[0.12]	[0.13]	[0.15]
Other migrant mother & Other migrant father	-0.05	0.03	0.06	0.23**	-0.05	0.09	0.08	0.18	-0.07	0.00	-0.04	0.05	-0.18*	-0.00	0.00	0.21*
	[0.11]	[0.09]	[0.09]	[0.11]	[0.11]	[0.10]	[0.10]	[0.11]	[0.11]	[0.10]	[0.09]	[0.11]	[0.11]	[0.09]	[0.09]	[0.11]
Other migrant mother & Asian migrant father	-0.35	0.27	0.21	0.20	-0.83**	0.09	-0.31	0.48	-0.46	-0.35	-0.33	0.23	-0.45	0.02	-0.01	0.22
	[0.29]	[0.27]	[0.24]	[0.38]	[0.35]	[0.27]	[0.25]	[0.36]	[0.29]	[0.22]	[0.22]	[0.33]	[0.31]	[0.20]	[0.18]	[0.19]
Asian migrant mother & Other migrant father	-0.11	0.02	0.29	0.44*	0.07	-0.13	-0.12	0.23	-0.13	0.15	-0.20	0.03	-0.25	-0.00	-0.00	0.20
	[0.25]	[0.23]	[0.23]	[0.24]	[0.27]	[0.22]	[0.23]	[0.29]	[0.30]	[0.21]	[0.23]	[0.22]	[0.26]	[0.23]	[0.27]	[0.32]
Asian migrant mother & Asian migrant father	-0.26	-0.05	0.29	0.47*	-0.27	0.02	-0.09	0.53**	-0.17	-0.24	-0.02	0.43*	-0.19	0.36*	0.32	0.57**
	[0.23]	[0.20]	[0.20]	[0.26]	[0.25]	[0.20]	[0.21]	[0.25]	[0.22]	[0.21]	[0.20]	[0.24]	[0.23]	[0.20]	[0.21]	[0.26]
Observations	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared	0.14	0.18	0.21	0.20	0.15	0.17	0.16	0.14	0.18	0.18	0.22	0.21	0.16	0.20	0.20	0.25

Appendix Table B2: Robustness checks – Relative academic performance of third-generation immigrants

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Non-Asian grandparents	0.04	0.00	0.01	0.03	-0.03	0.04	0.02	0.00	-0.01	0.01	0.02	0.04	-0.02	0.00	-0.00
	[0.03]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.05]	[0.05]	[0.04]	[0.04]	[0.05]
Asian grandparents	-0.02	-0.16	-0.08	0.08	-0.00	0.15	0.04	-0.11	0.02	-0.03	0.10	-0.23	0.01	-0.24*	-0.16
	[0.11]	[0.13]	[0.13]	[0.15]	[0.13]	[0.13]	[0.14]	[0.14]	[0.12]	[0.14]	[0.14]	[0.15]	[0.13]	[0.12]	[0.15]
Observations	2,721	2,509	2,479	2,476	2,542	2,474	2,401	1,725	2,225	2,082	1,553	1,725	2,225	2,082	1,553
R-squared	0.26	0.15	0.13	0.13	0.07	0.10	0.09	0.16	0.17	0.18	0.21	0.14	0.17	0.20	0.20
Test subject					Spelling			Grammar				Numeracy			
Age/Grade				Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
Non-Asian grandparents				0.03	0.02	0.01	0.05	0.06	-0.03	-0.01	0.03	0.07	0.00	0.02	0.01
				[0.05]	[0.04]	[0.04]	[0.05]	[0.05]	[0.04]	[0.04]	[0.05]	[0.05]	[0.04]	[0.04]	[0.05]
Asian grandparents				-0.13	-0.13	-0.11	-0.08	-0.16	0.06	-0.09	-0.07	-0.07	-0.05	-0.04	-0.03
				[0.12]	[0.11]	[0.13]	[0.16]	[0.15]	[0.12]	[0.15]	[0.13]	[0.14]	[0.11]	[0.12]	[0.14]
Observations				1,725	2,225	2,082	1,553	1,725	2,225	2,082	1,553	1,725	2,225	2,082	1,553
R-squared				0.12	0.13	0.13	0.11	0.18	0.18	0.20	0.20	0.14	0.17	0.16	0.20

Notes: This table reports estimates of test score using model (1) for a sample of K-cohort Australian-born parent children with valid information of birthplaces of all grandparents. Children of "All Australian-born grandparents" include Australian-born children by two Australian-born parents and four Australian-born grandparents. Children of Asian grandparents (or third-generation Asian immigrant children) consist of Australian-born children by two Australian-born parents but at least one Asia-born grandparent. Children of "Non-Asian grandparents" include remaining Australian-born grandparent children. Other variables include child characteristics (gender, age, Indigeneity, birth weight, and breastfed at birth), household characteristics (mother's characteristics (age and its square, completed qualification, and working hours), household size, number of siblings, living with both biological parents, living in an owned home, household income), urban, local socio-economic background variables, state/territory dummies, and survey quarters. For NAPLAN test scores, test states (in place of state/territory dummies), test years and test ages are also included. Robust standard errors are in square brackets. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table B3: Differences between original and selected samples

	WAI	PPVT			MR			NAPLAN			
	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Other parents [(a)]	-0.00	-0.02*	-0.00	0.00	0.00	0.00	-0.01*	-0.04**	-0.03**	-0.01	-0.01
At least one Asian parent [(a)]	-0.01	-0.06***	0.01	-0.00	-0.00	0.00	-0.00	-0.15***	-0.03*	0.01	0.04*
Male	-0.01*	-0.01	0.00	-0.00	-0.00	0.00	-0.00	0.03**	-0.01	-0.04***	-0.05***
Child age	0.00	-0.01***	-0.00	-0.00***	-0.00***	-0.00**	-0.00	-0.05***	-0.01***	0.00	0.02***
Indigenous	-0.02*	-0.06**	-0.02	0.01	-0.01	0.01	0.01	-0.05	-0.08***	-0.03	-0.07*
Low birth weight	-0.01*	-0.04***	-0.02*	-0.01**	-0.01	-0.01*	-0.01**	-0.01	-0.01	-0.06***	-0.04
Breastfed at 3 or 6 months	0.01**	0.03***	0.00	0.00	-0.00	0.00	0.00	0.02*	0.01	0.03**	0.05***
Mother age	0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00**	0.00	0.00*	0.00
Mother has a certificate [(b)]	0.01**	-0.01	-0.00	0.00	-0.00	-0.00	-0.00	0.01	-0.00	-0.02	-0.03
Mother has an advanced diploma [(b)]	0.00	0.01	0.01	-0.00	0.01	-0.00	0.01	0.05**	0.00	-0.02	-0.04
Mother has bachelor degree [(b)]	0.01	0.02	-0.00	-0.00	-0.00	-0.00	-0.01*	0.04*	-0.01	-0.01	0.04*
Mother has graduate diploma [(b)]	0.01	-0.02	-0.00	-0.00	0.00	-0.01	0.00	-0.01	0.01	0.00	-0.02
Mother has postgraduate degree [(b)]	0.01	0.02	-0.02*	0.00	-0.00	0.00	-0.01	0.04	-0.01	-0.03	0.04
Mother's weekly working hours	-0.00	-0.00*	0.00	0.00*	-0.00	0.00**	-0.00	0.00	0.00**	0.00*	0.00***
Household size	-0.00	-0.02**	0.01	0.00	0.00	-0.00	0.00	0.02	-0.01	-0.01	-0.01
Number of siblings	-0.00	0.01	-0.01	-0.00	-0.00	0.00	-0.00	-0.02	0.01	0.00	0.01
Number of younger siblings	0.01	0.02**	0.00	0.00	0.00	-0.00	0.00	0.01	0.00	0.02**	0.01
Living with both parents	-0.01	0.04**	-0.00	0.00	0.00	0.00	-0.01	0.02	0.05***	0.04**	0.10***
Living in an owned home	0.01**	0.02*	0.00	0.01***	0.01**	0.01***	0.02***	0.04**	0.03**	0.03*	0.02
Metropolitan region	0.00	-0.02**	0.03***	0.02***	0.01**	0.02***	0.02***	-0.02	-0.00	-0.00	0.02
Observations	4,524	4,524	4,138	4,036	4,138	4,036	3,884	4,138	4,036	3,884	3,569
Number in selected sample	4,440	4,033	4,003	3,980	4,094	3,977	3,817	2,687	3,542	3,307	2,484
Pseudo R2	0.07	0.04	0.07	0.21	0.11	0.16	0.14	0.22	0.04	0.03	0.09
P t test	0.57	0.00	0.84	0.80	0.98	0.89	0.21	0.00	0.05	0.81	0.17

Notes: Results (marginal effects) are from a probit model. Marginal effects are calculated at the means of continuous variables. The dependent variable is equal to one if the child is in our sample and zero otherwise. [(a)] and [(b)] denote Australian-born parents and no qualification as the base group, respectively. P t test: P value of a t test for whether estimates of "Other parents" and "At least one Asian parent" are equal to zero. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table B4: Robustness checks – Alternative classifications of the child's ethnicity – Both Asian parents

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Other parents	0.10***	-0.19***	-0.06*	-0.07*	0.01	0.04	0.04	-0.01	0.01	0.02	0.03	0.01	0.05	-0.01	0.02
	[0.03]	[0.03]	[0.03]	[0.03]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.03]	[0.03]	[0.04]
Both Asian parents	0.42***	-0.84***	-0.40***	-0.19***	0.31***	0.44***	0.46***	0.13	0.23***	0.19**	0.33***	0.19**	0.37***	0.40***	0.31***
	[0.07]	[0.07]	[0.08]	[0.07]	[0.08]	[0.07]	[0.08]	[0.08]	[0.07]	[0.08]	[0.08]	[0.08]	[0.08]	[0.08]	[0.07]
Observations	4,440	4,033	4,003	3,980	4,094	3,977	3,817	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared	0.26	0.18	0.16	0.14	0.07	0.10	0.10	0.16	0.18	0.19	0.21	0.14	0.18	0.21	0.19
Test subject					Spelling			Grammar				Numeracy			
Age/Grade				Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
Other parents				0.09**	0.07*	0.08**	0.06	-0.00	0.08**	0.03	0.04	0.04	0.04	-0.01	0.03
				[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.03]	[0.04]	[0.04]	[0.03]	[0.04]	[0.04]
Both Asian parents				0.61***	0.70***	0.68***	0.77***	0.13	0.32***	0.39***	0.50***	0.31***	0.66***	0.74***	0.85***
				[0.09]	[0.07]	[0.07]	[0.09]	[0.08]	[0.07]	[0.08]	[0.09]	[0.09]	[0.08]	[0.09]	[0.09]
Observations				2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared				0.14	0.16	0.16	0.14	0.17	0.17	0.22	0.21	0.15	0.19	0.20	0.24

Notes: This table reports nativity test score gaps at mean. Children of both Australian-born parents are the base group. Other notes: see Table 2.

Appendix Table B5: Robustness checks – Alternative classifications of the child's ethnicity – By English speaking background

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
ESB parents	0.09***	-0.07*	0.01	-0.02	0.01	0.05	0.07*	0.02	0.03	0.03	0.05	0.03	0.03	-0.04	-0.01
	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.05]	[0.05]	[0.04]	[0.04]	[0.05]
NESB parents	0.20***	-0.49***	-0.22***	-0.15***	0.09*	0.14***	0.13***	0.01	0.05	0.04	0.10*	0.04	0.15***	0.13***	0.13**
	[0.04]	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.05]	[0.05]	[0.04]	[0.05]	[0.05]	[0.05]	[0.05]	[0.04]	[0.05]
Observations	4,440	4,033	4,003	3,980	4,094	3,977	3,817	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared	0.26	0.18	0.16	0.14	0.07	0.09	0.09	0.16	0.18	0.19	0.21	0.14	0.18	0.20	0.19
Test subject					Spelling			Grammar				Numeracy			
Age/Grade				Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
ESB parents				0.08	0.04	0.09**	0.09	0.03	0.07*	0.05	0.03	0.04	0.03	-0.01	0.04
				[0.05]	[0.05]	[0.04]	[0.05]	[0.05]	[0.04]	[0.04]	[0.05]	[0.05]	[0.04]	[0.04]	[0.05]
NESB parents				0.23***	0.27***	0.23***	0.25***	0.01	0.15***	0.11**	0.20***	0.12**	0.21***	0.18***	0.26***
				[0.05]	[0.05]	[0.05]	[0.06]	[0.05]	[0.05]	[0.04]	[0.05]	[0.05]	[0.05]	[0.05]	[0.06]
Observations				2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared				0.13	0.15	0.14	0.12	0.17	0.17	0.21	0.20	0.15	0.18	0.18	0.22

Notes: This table reports nativity test score gaps at mean. Children of both Australian-born parents are the base group. "NESB parents" are defined as either parent from a NESB country. "ESB parents" include remaining parents. English-speaking countries include UK, Ireland, Canada, New Zealand, South Africa and USA. Other notes: see Table 2.

Appendix Table B6: Robustness checks – Alternative classifications of the child's ethnicity – ABS's definition of Asia

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Other parents	0.08**	-0.22***	-0.08**	-0.09**	0.00	0.03	0.02	-0.03	-0.02	-0.02	0.01	-0.01	0.00	-0.03	0.01
	[0.03]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]
Asian parents	0.40***	-0.52***	-0.18***	-0.05	0.24***	0.35***	0.40***	0.16**	0.25***	0.25***	0.30***	0.24***	0.39***	0.33***	0.24***
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.06]	[0.07]
Observations	4,440	4,033	4,003	3,980	4,094	3,977	3,817	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared	0.26	0.17	0.15	0.14	0.07	0.10	0.10	0.16	0.18	0.20	0.21	0.15	0.18	0.21	0.19
Test subject					Spelling			Grammar				Numeracy			
Age/Grade				Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
Other parents				0.06	0.03	0.04	0.04	-0.02	0.04	0.00	0.03	0.02	-0.01	-0.05	-0.01
				[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]
Asian parents				0.54***	0.61***	0.59***	0.60***	0.16**	0.37***	0.36***	0.39***	0.31***	0.57***	0.61***	0.68***
				[0.07]	[0.06]	[0.06]	[0.08]	[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.07]	[0.08]
Observations				2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared				0.14	0.17	0.16	0.14	0.17	0.18	0.22	0.21	0.16	0.20	0.20	0.24

Notes: This table reports nativity test score gaps at mean. Children of both Australian-born parents are the base group. Australian Bureau of Statistics (ABS)'s classification of Asia: UN's classification excludes Middle East countries (Bahrain, Gaza Strip and West Bank, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates and Yemen). Other notes: see Table 2.

Appendix Table B7: Robustness checks – Alternative classifications of the child's ethnicity – Excluding children with an Indigenous origin

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Other parents	0.07**	-0.18***	-0.05	-0.07*	0.00	0.03	0.02	-0.02	-0.01	-0.01	0.01	-0.01	0.00	-0.04	-0.00
	[0.03]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]
At least one Asian parent	0.35***	-0.62***	-0.29***	-0.16***	0.18***	0.29***	0.34***	0.10	0.18***	0.16***	0.23***	0.19***	0.32***	0.27***	0.19***
	[0.05]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.06]	[0.07]
Observations	4,286	3,904	3,873	3,867	3,961	3,864	3,705	2,615	3,453	3,215	2,421	2,615	3,453	3,215	2,421
R-squared	0.26	0.17	0.15	0.14	0.06	0.09	0.08	0.16	0.17	0.18	0.20	0.13	0.17	0.20	0.18
Test subject					Spelling			Grammar				Numeracy			
Age/Grade				Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
Other parents				0.05	0.03	0.03	0.03	-0.01	0.04	0.00	0.03	0.03	0.01	-0.06	-0.01
				[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.04]	[0.04]
At least one Asian parent				0.51***	0.56***	0.53***	0.53***	0.10	0.30***	0.28***	0.32***	0.25***	0.46***	0.51***	0.59***
				[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.07]	[0.08]
Observations				2,615	3,453	3,215	2,421	2,615	3,453	3,215	2,421	2,615	3,453	3,215	2,421
R-squared				0.13	0.16	0.15	0.13	0.16	0.16	0.20	0.20	0.14	0.17	0.18	0.22

Notes: This table reports nativity test score gaps at mean. Children with an Indigenous origin are defined as Australian-born individuals by two Australian-born parents and a least one parent has an Indigenous origin. Children of both Australian-born parents are the base group. Other notes: see Table 2

Appendix Table B8: Robustness checks – Alternative classifications of the child's ethnicity – By country income level

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
High income country parents	0.14***	-0.20***	-0.10***	-0.06	0.03	0.07*	0.09**	-0.00	0.04	0.03	0.07*	0.02	0.05	0.03	0.04
	[0.03]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]
LMIC parents	0.19***	-0.55***	-0.08	-0.15**	0.10	0.21***	0.15**	0.04	0.04	0.09	0.09	0.12*	0.24***	0.15**	0.15**
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.07]	[0.07]	[0.07]	[0.06]	[0.07]	[0.07]	[0.07]	[0.07]	[0.06]	[0.07]
Observations	4,391	3,990	3,958	3,936	4,049	3,933	3,782	2,660	3,503	3,277	2,461	2,660	3,503	3,277	2,461
R-squared	0.25	0.17	0.15	0.14	0.07	0.09	0.09	0.16	0.18	0.19	0.21	0.14	0.18	0.20	0.19

Test subject	Spelling				Grammar				Numeracy			
Age/Grade	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
High income country parents	0.13***	0.10***	0.13***	0.12***	0.02	0.08**	0.07*	0.08*	0.07*	0.07**	0.06	0.09**
	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]
LMIC parents	0.28***	0.37***	0.30***	0.34***	0.01	0.22***	0.13*	0.25***	0.09	0.30***	0.23***	0.36***
	[0.08]	[0.07]	[0.07]	[0.08]	[0.08]	[0.07]	[0.07]	[0.08]	[0.08]	[0.07]	[0.07]	[0.08]
Observations	2,660	3,503	3,277	2,461	2,660	3,503	3,277	2,461	2,660	3,503	3,277	2,461
R-squared	0.13	0.15	0.14	0.12	0.17	0.17	0.21	0.20	0.15	0.18	0.18	0.22

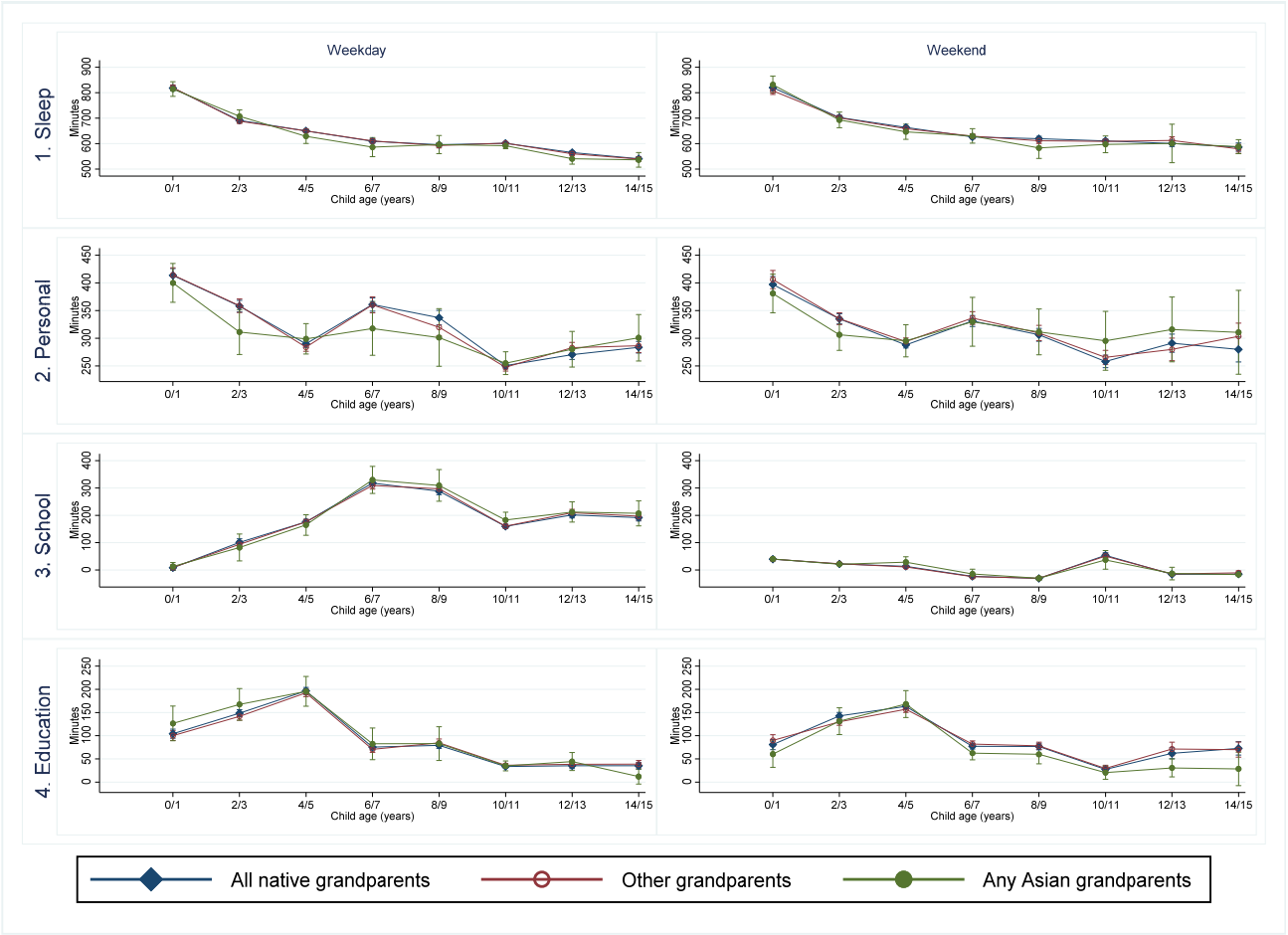
Notes: This table reports nativity test score gaps at mean. Children of both Australian-born parents are the base group. "Low Middle Income Country (LMIC) parents" are defined as at least one parent from a LMIC. The World Bank's 2016 country income grouping is used. Other notes: see Table 2.

Appendix Table B9: Robustness checks – Alternative model specifications – Raw test score gaps

Test subject	WAI	PPVT			MR			Reading				Writing			
Age/Grade	Age 4/5	Age 4/5	Age 6/7	Age 8/9	Age 6/7	Age 8/9	Age 10/11	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Non-Asian immigrant children	0.14***	-0.12***	-0.01	0.02	0.06	0.12***	0.10***	0.03	0.07*	0.10**	0.12***	0.03	0.09**	0.08**	0.12***
	[0.03]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.05]	[0.05]	[0.04]	[0.04]	[0.05]
Asian immigrant children	0.43***	-0.61***	-0.32***	-0.17***	0.21***	0.35***	0.38***	0.21***	0.29***	0.26***	0.33***	0.30***	0.48***	0.43***	0.36***
	[0.06]	[0.06]	[0.06]	[0.05]	[0.05]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.07]	[0.06]	[0.06]	[0.06]	[0.06]
Observations	4,440	4,033	4,003	3,980	4,094	3,977	3,817	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared	0.02	0.03	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Test subject					Spelling			Grammar				Numeracy			
Age/Grade				Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9	Grade 3	Grade 5	Grade 7	Grade 9
Non-Asian immigrant children				0.08*	0.08**	0.12***	0.12***	0.02	0.12***	0.11***	0.14***	0.05	0.07*	0.04	0.08*
				[0.04]	[0.04]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.05]	[0.04]	[0.04]	[0.04]	[0.05]
Asian immigrant children				0.62***	0.71***	0.65***	0.67***	0.19***	0.41***	0.37***	0.43***	0.33***	0.58***	0.61***	0.69***
				[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.06]	[0.07]	[0.07]	[0.06]	[0.07]	[0.08]
Observations				2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484	2,687	3,542	3,307	2,484
R-squared				0.03	0.04	0.04	0.04	0.00	0.01	0.01	0.02	0.01	0.03	0.03	0.04

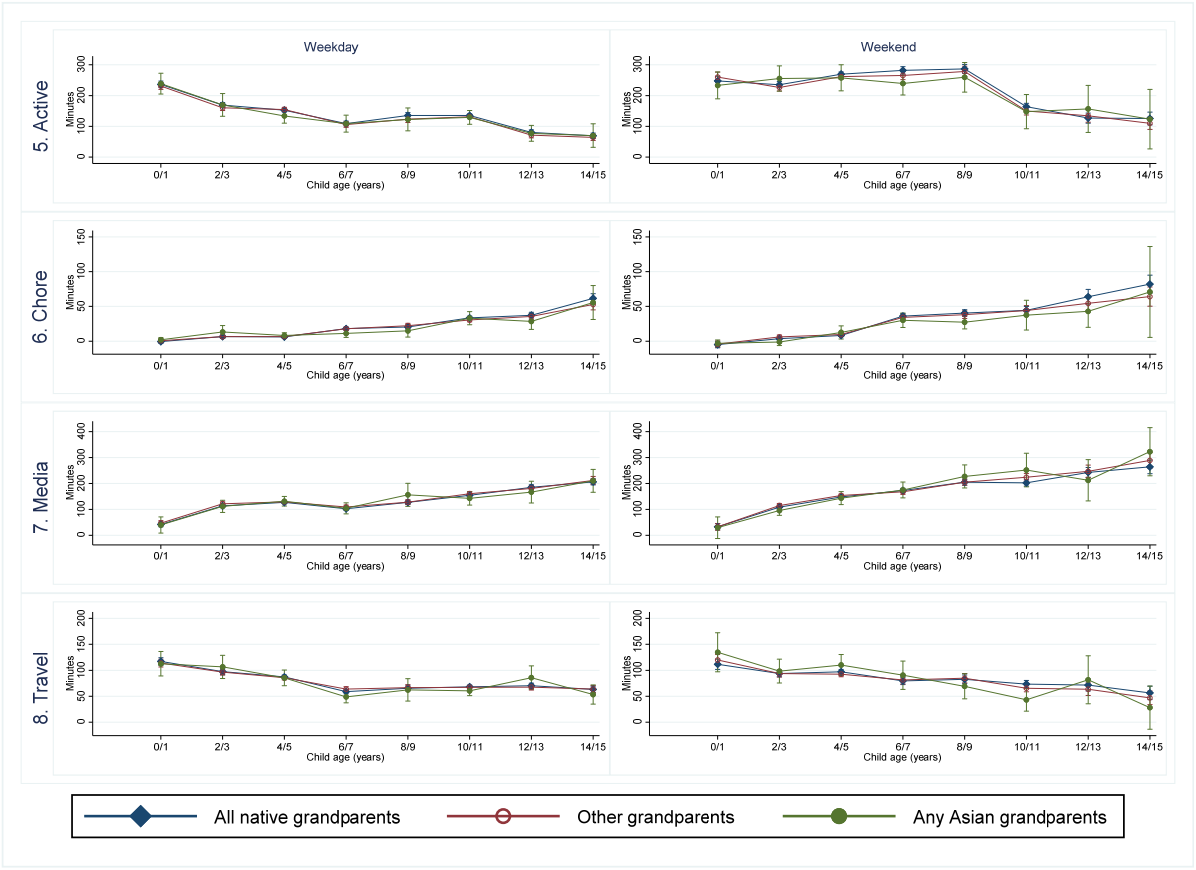
Notes: Children of both Australian-born parents are the base group. Estimates for each subject-level are obtained from a separate OLS regression of test score on parent country of birth grouping dummies only. Robust standard errors are in square brackets. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Figure B1: Robustness checks – The evolution of children's time investment by third-generation immigrant children



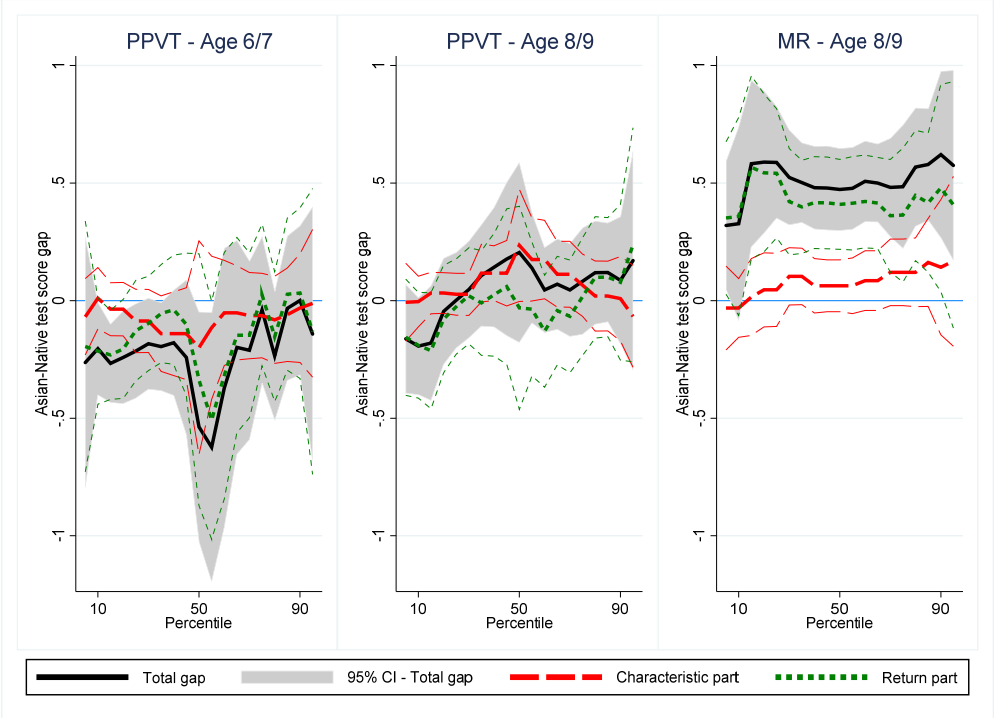
Notes: This figure reports estimated time use by children's ages and nativity background of third-generation immigrant children. Results are from model (2) for a sample of all Australian-born parent children with valid information of birthplaces of all grandparents. Other explanatory variables: see Appendix Table A2.

Appendix Figure B1: Robustness checks – The evolution of children's time investment by third-generation immigrant children (cont.)



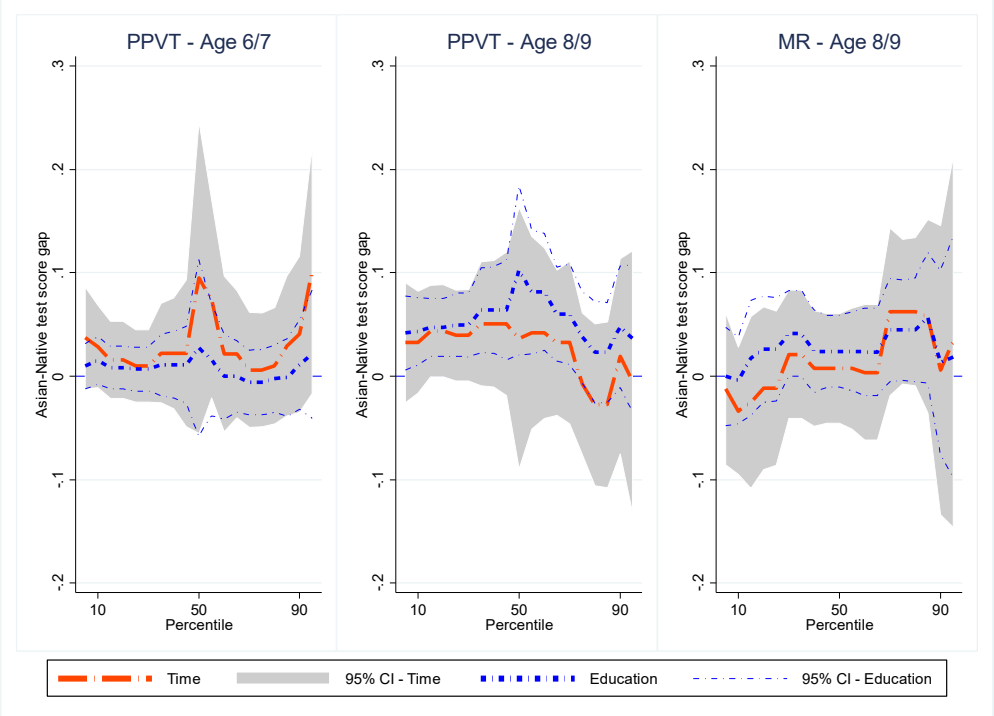
Appendix Figure B2: Robustness checks – Model without lags of test score and time allocation

Panel A1: Aggregated decomposition of Asian–Native test score gap - PPVT and MR



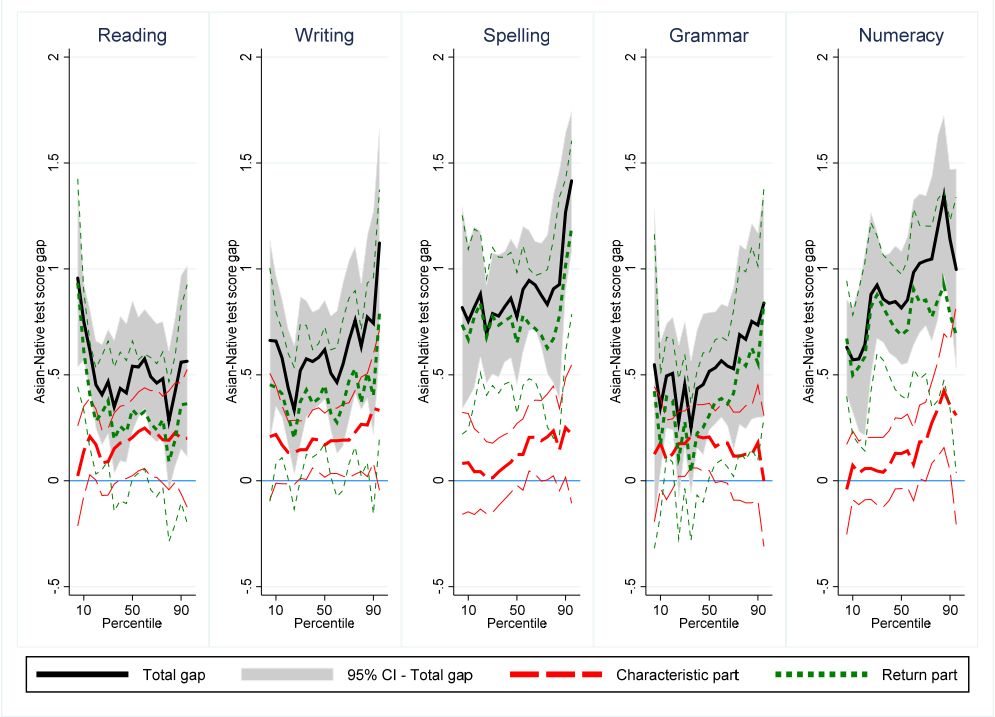
Notes: See Figure 4 – Panel A.

Panel A2: Detailed decomposition of Asian–Native test score gap - PPVT and MR



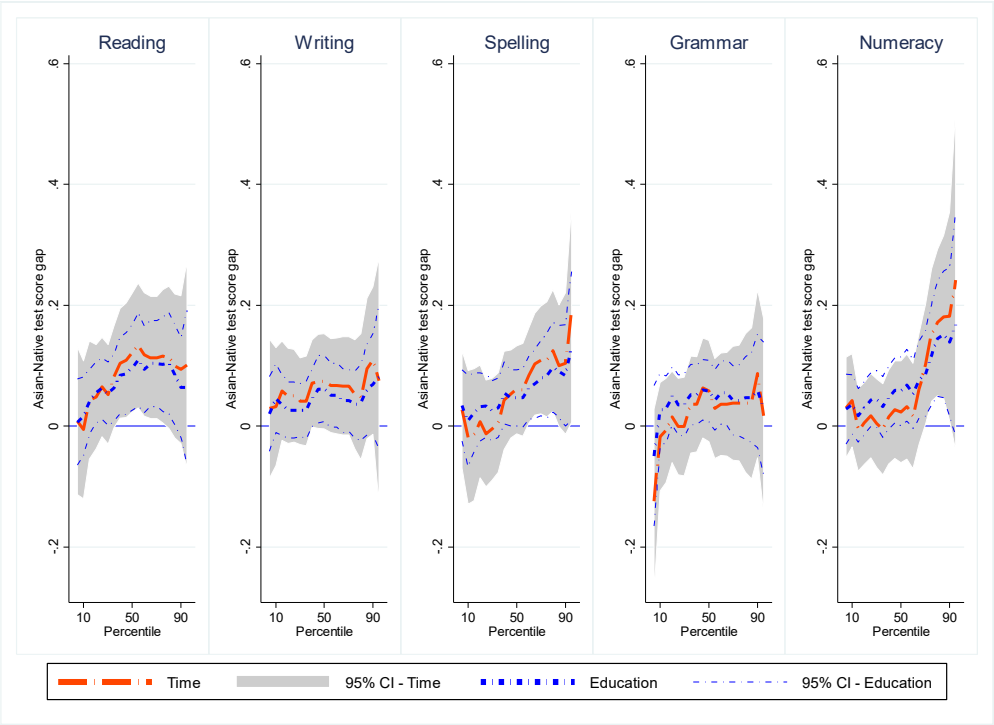
Notes: See Figure 4 – Panel B.

Panel B1: Aggregate decomposition of Asian–Native test score – Grade 5 NAPLAN



Notes: See Figure 4 – Panel A.

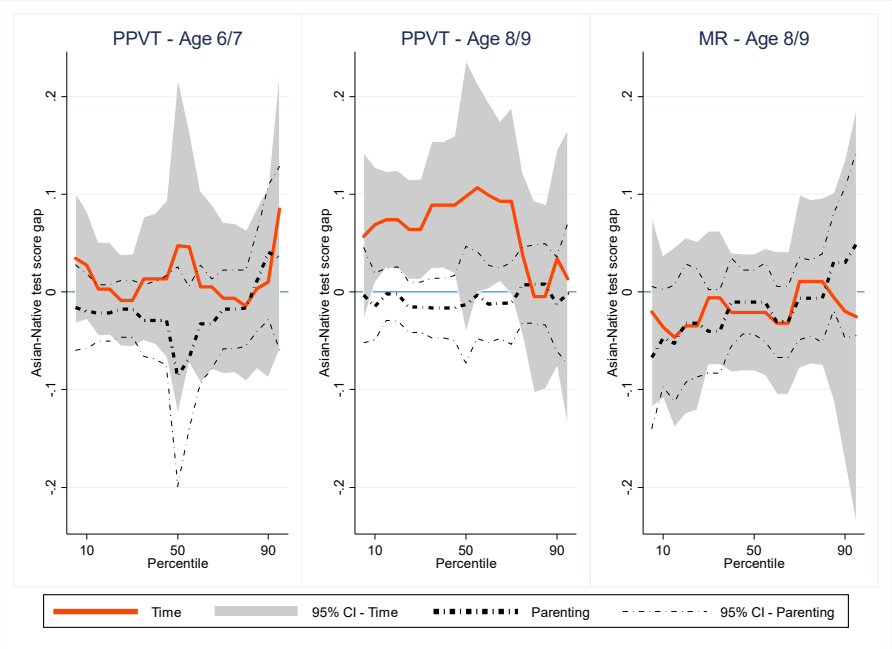
Panel B2: Detailed decomposition of Asian–Native test score – Grade 5 NAPLAN



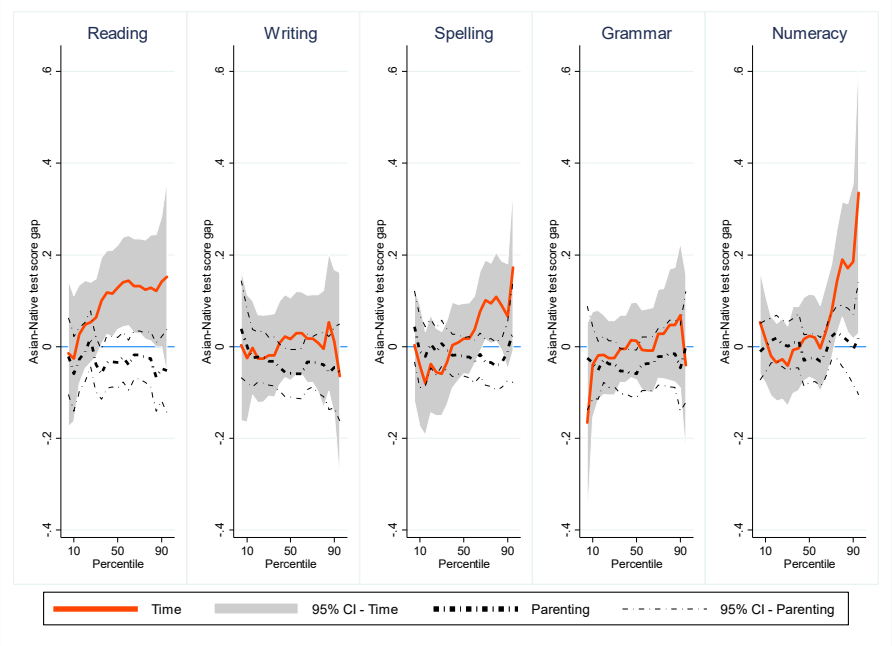
Notes: See Figure 4 – Panel B.

Appendix Figure B3: Robustness checks – The role of parenting styles

Panel A: Detailed decomposition of the characteristic part of PPVT and MR



Panel B: Detailed decomposition of the characteristic part of Grade 5 NAPLAN



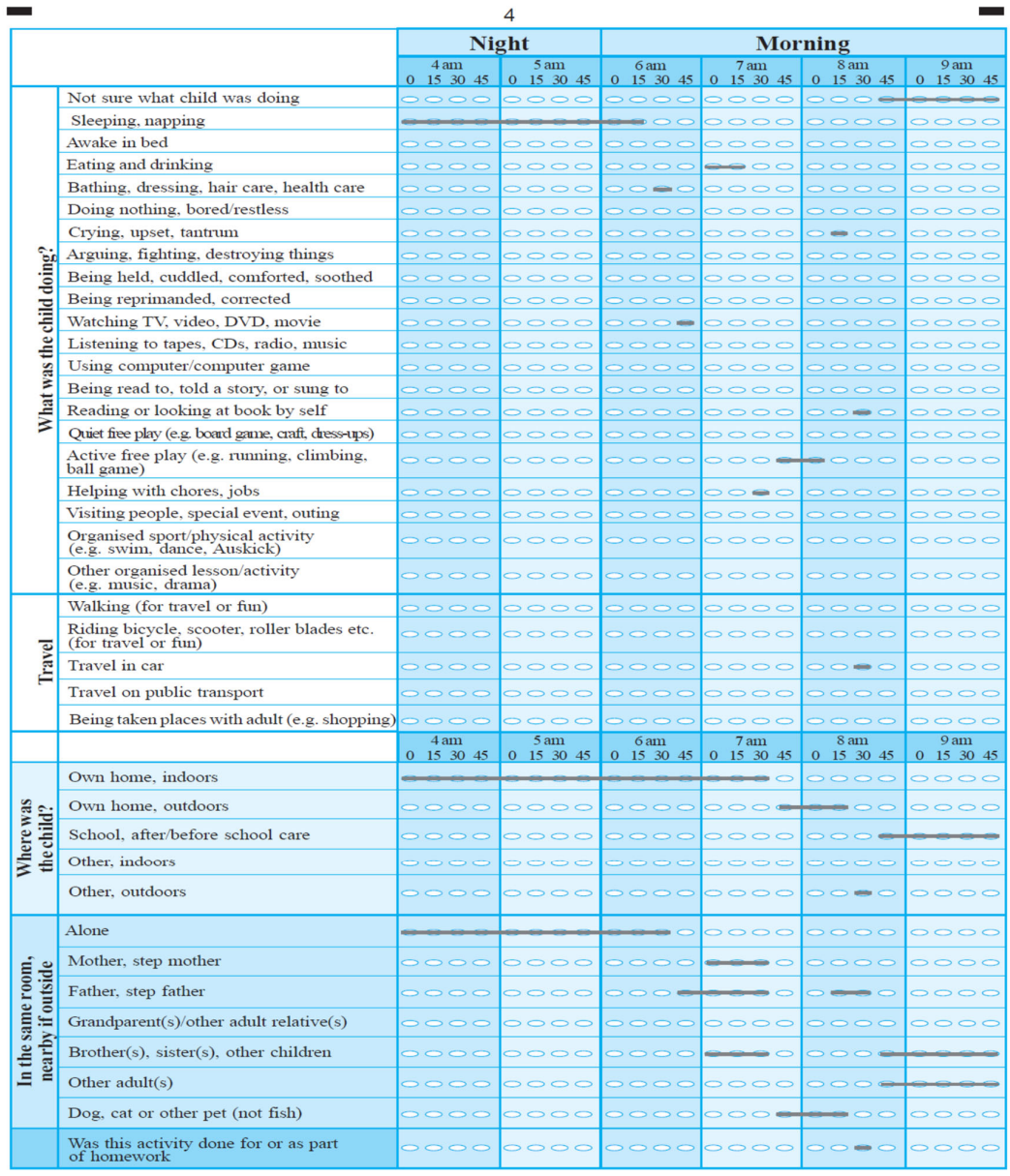
Notes: Nativity test score gap: Asian–Native, standardized scores. Thick long dash orange line (grey shaded area) indicates characteristic effect due to time allocation (95% CIs). Thick (thin) black short dash dot line shows the characteristic effect due to maternal parenting styles (95% CIs).

Appendix Figure C1: Sample of Time-use Diary and activity codes – Wave 2

EXAMPLE

Below is an example of how the diary would be filled in for a child's morning.

Joshua woke at 6.30am and dressed himself. He then watched the morning news with his father. At 7.00am he had breakfast with his parents and baby brother. After breakfast he helped his mother clear the breakfast dishes from the table and at 7:45am went outside to play with the family dog. At 8.15am his father went outside to tell Joshua it was time to leave for school. Joshua became upset because he didn't want to stop playing with the dog His father calmed him down and they left home at 8.30am to drive to school. During the drive to school Joshua read out loud to his father from a book he had brought home from school the previous day. His father dropped him off at school ten minutes later and gave him a hug goodbye before going on to work.



Source: Corey *et al.* (2014).

Appendix Figure C2: Sample of Time-use Diary - Wave 5

Source: Corey *et al.* (2014).

Appendix Figure C3: Sample of activity codes – Time-use Diary Wave 5

Work	**Non-Active Activities**
00. Retailing (including fast food)	50. Filling out the diary
01. Pamphlet delivering	51. Private music lessons/practice, academic tutoring
02. Umpiring/refereeing	52. Listening to music, Playing musical instruments or singing for leisure
03. Car washing	53. Reading or being read to for leisure
04. Gardening / lawn mowing	54. Unstructured non-active play
05. Babysitting	55. Non-active club activities
06. Animal care	56. Doing nothing
07. Working in a family business or farm	57. Sleeping/napping (not end of the day bed-time)
08. Work nec.	58. Doing homework (not via electronic devices)
09. Volunteering	59. Non-active activities nec.
Eating/Drinking	**Electronic Device Use**
10. Eating/drinking	60. Doing homework
	61. Playing games
Personal Care/ Medical/Health Care	62. Watching TV programs or movies/videos
20. Cleaning teeth	63. Spending time on social networking sites
21. Showering/bathing	64. Downloading/posting media (e.g. music, videos, applications)
22. Getting dressed / getting ready	65. Internet shopping
23. Personal care nec.	66. General Internet browsing (excluding homework)
24. Doctor	67. Creating/maintaining websites (excluding social networking profile)
25. Dentist	68. General application use (e.g. Microsoft Office; excluding homework)
26. Physiotherapist / Chiropractor	69. Electronic device use nec.
27. Medical/Health care nec.	
Chores	**School Lessons**
30. Cleaning/tidying	70. School lessons
31. Laundry/clothes care	
32. Food/drink preparation	**Communication**
33. Food/drink clean up	80. Talking face-to-face (in person not via electronic devices)
34. Gardening / lawn mowing	81. Talking on a landline phone (not video chat)
35. Animal care (excluding active play)	82. Talking on a mobile phone (not video chat)
36. Home maintenance	83. Video chatting (e.g. Skype)
37. Taking care of siblings	84. Texting/emailing
38. Chores nec.	85. Online chatting / Instant messaging
	86. Non-verbal interaction (e.g. cuddles)
Active Activities	87. Communication nec.
40. Organised team sports and training	
41. Organised individual sport and training	**Travel**
42. Unstructured active play	90. By foot
43. Walking pets / playing with pets	91. By bike, scooter, skateboard etc.
44. Active club activities	92. By private motor vehicle/bike
45. Shopping	93. By public/chartered transport such as bus, taxi or aeroplane
46. Going out to a concert, play, museum, art gallery, community or school event , an amusement park etc.	94. Travel nec.
47. Religious activities / ritual ceremonies	
48. Attending live sporting events	**Others**
49. Active activities nec.	99. Others

Source: Corey *et al.* (2014).

Appendix Table C1: Coding rules for activities by B cohort children

Grouping	Wave 1	Wave 2	Wave 3	Wave 6
Sleep	Sleeping, napping	Sleeping, napping	Sleeping, napping	Sleeping/napping (not end of the day bed-time); Time between sleep (from response to the question "what time did you go to sleep?") and wake-up (next day, from response to the question "What time did you wake up?")
Personal care	Awake in bed / cot; Looking around, doing nothing; Bathe / nappy change, dress / hair care; Breastfeeding; Other eating, drinking, being fed; Crying, upset; Destroy things, create mess; Held, cuddled, comforted, soothed; Not sure what child was doing	Awake in bed; Eating, drinking, being fed; Bathing, dressing, hair care, health care; Doing nothing, bored/restless; Crying, upset, tantrum; Arguing, fighting; Destroy things, create mess; Being reprimanded; Being held, cuddled, comforted, soothed; Quiet free play; Not sure what child was doing	Awake in bed; Eating, drinking, being fed; Bathing, dressing, hair care, health care; Doing nothing, bored/restless; Crying, upset, tantrum; Arguing, fighting; destroying things, creating mess; Being reprimanded; Being held, comforted, soothed; Quiet free play; Not sure what child was doing	Eating/drinking; Cleaning teeth; Showering/bathing; Getting dressed / getting ready; Personal care nec.; Doctor; Dentist/Orthodontist; Physiotherapist / Chiropractor; Medical/Health care; Personal care/Medical/Health Care nec.; Listening to music; Playing musical instruments or singing for leisure; Chess, card, paper and board games / crosswords; Games of chance / gambling; Hobbies, collections; Handwork crafts (excl. clothes making); Arts; Unstructured non-active play nec; Clubs; Religious groups; Doing nothing; Non-active activities nec.; Talking face-to-face; Talking on a landline phone; Non-verbal interaction; Negative face-to-face communication; Communication nec.; Illegal activities; Filling out the diary; Other; Uncodeable activity
School	Responses "Day care centre / playgroup" to the question "where was the child?"	Responses "Day care centre / playgroup" to the question "where was the child?"	Responses "Day care centre / playgroup" to the question "where was the child?"	School lessons, excluding Recess and Lunch

Grouping	Wave 1	Wave 2	Wave 3	Wave 6
Education	Read a story, talked / sung to, sing / talk; Colour / draw, look at book, puzzles; Organised activities / playgroup	Read a story, told a story, sung to; Colour/draw, look at book, educational game; Organised lessons/activities	Read a story, talk/sing, talked/sung to; drawing/colouring, looking at book, etc.; organised lessons/activity	Private music lessons/practice, academic tutoring; Reading or being read to for leisure; Doing homework (not via electronic devices); Doing homework (electronic device); Attend courses (excluding school /university)
Active	Crawl, climb, swing arms or legs; Other play, other activities; Visiting people, special event, party	Active free play; Visiting people, special event, party; Walking; Ride bicycle/trike	Active free play; visiting people, special event, outing; walking; travel in pusher/bicycle seat; ride bicycle, trike, etc.	Archery / Shooting sports; Athletics / Gymnastics; Fitness / Gym / Exercise; Ball Sports; Martial arts / Dancing; Motor Sports / Roller Sports / Cycling; Water/Ice/Snow Sports; Organised team sports and training other; Archery / Shooting sports (individual); Athletics / Gymnastics (individual); Fitness / Gym / Exercise (individual); Martial arts / Dancing (individual); Motor Sports / Roller Sports / Cycling (individual); Ball Sports (individual); Water/Ice/Snow Sports (individual); Organised individual sport and training other; Archery / Shooting sports (unstructured); Athletics / Gymnastics (unstructured); Fitness / Gym / Exercise (unstructured); Ball Sports (unstructured); Martial arts / Dancing (unstructured); Motor Sports / Roller Sports / Cycling (unstructured); Water/Ice/Snow Sports (unstructured); Unstructured active play Other; Walking pets/playing with pets; Active club activities; Shopping; Shopping; Purchasing consumer goods; Purchasing durable goods; Window shopping; Purchasing repair services; Purchasing administrative services; Purchasing personal care services; Purchasing other services; Attendance at movies / cinema; Attendance at concert/theatre; Attendance at museum / exhibition / art gallery; Attendance at zoo / animal park / botanic garden; Attendance at other mass events; Going out nec; Religious practice; Weddings, funerals, rites of passage; Religious activities / ritual ceremonies nec; Attending live sporting events; Active activities nec
Chore		Being taught to do chores	Being taught to do chores	Retailing; Hospitality (including fast food); Clerical/office; Labourers and related workers; Gardening / lawn mowing; Babysitting; Apprenticeships/trades persons; Working in a family business or farm; Work Other; Umpiring (work); Car washing (work); Animal care (work); Volunteering (work); Cleaning/tidying; Laundry/clothes care; Clothes making; Food/drink preparation; Food/drink clean up; Gardening (maintenance chores); Cleaning grounds/garage/shed/outside of house (chores); Pool care (chores); Animal care; Home maintenance; Design/Home Improvement; Heat/water/power upkeep; Car/boat/bike care; Selling/disposing of household assets; Rubbish/Recycling; Packing; Household management Other; Taking care of siblings (chores); Chores nec

Grouping	Wave 1	Wave 2	Wave 3	Wave 6
Media	Watching TV, video or DVD; Listening to tapes, CD's, radio, music	Watching TV, video, DVD, movie; Listening to tapes, CDs, radio, music; Using computer, computer game	Watching TV, video, DVD, movie; listening to tapes, CDs, radio, music; using computer, computer game	Playing games (electronic device); Playing games (Electronic device) nfd; Watching TV programs or movies/videos; Spending time on social networking sites; Downloading/posting media; Internet shopping; General Internet browsing; Creating/maintaining websites; General application use; Electronic device use nec.; Talking on a mobile phone; Video chatting; Texting/emailing; Online chatting / Instant messaging
Travel	Taken places with adult (e.g. shopping); Taken out in pram or bicycle seat; Travel in car / other household vehicle; Travel on public transport, ferry, plane	Travel in car; Travel in a pusher/bicycle seat; Travel on public transport; Taken places with adult (e.g. Shopping)	Travel in car; travel on public transport; taken places with adult	Travel by foot; by bike, scooter, skateboard etc.; by private motor vehicle/bike; by public/chartered transport; Travel nec.

Appendix Table C2: Coding rules for activities by K cohort children

Grouping	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6
Sleep	Sleeping, napping	Sleeping, napping	Same as Wave 2	Sleeping/napping; Time between sleep (from response to the question "what time did you go to sleep?") and wake-up (next day, from response to the question "What time did you wake up?")	Sleeping/napping (not end of the day bed-time); Time between sleep (from response to the question "what time did you go to sleep?") and wake-up (next day, from response to the question "What time did you wake up?")	Sleeping/napping (not end of the day bed-time); Time between sleep (from response to the question "what time did you go to sleep?") and wake-up (next day, from response to the question "What time did you wake up?")
Personal care	Awake in bed; Eating and drinking; Bathe, dress, hair care, health care; Do nothing, bored/restless; Crying, upset, tantrum; Arguing, fighting, destroy things; Held, cuddled, comforted, soothed; Being reprimanded, corrected; Not sure what child was doing	Awake in bed; Eating and drinking; Bathe, dress, hair care, health care; Do nothing, bored/restless; Crying, upset, tantrum; Arguing, fighting, destroy things; Held, cuddled, comforted, soothed; Being reprimanded, corrected; Quiet free play; Not sure what child was doing	Same as Wave 2	Eating/drinking; Bathing, dressing, toileting, teeth brushing, hair care; Dentist, Doctor, Chiropractor, Physio, Optometrist; Listening to music, CDs, playing music; Board or card games, puzzles, toys, art; Non-Active Club Activities i.e. Chess C; Doing nothing; Talking face to face; Other	Eating/drinking; Cleaning teeth; Showering/bathing; Getting dressed / getting ready; Personal care nec.; Doctor; Dentist; Physiotherapist / Chiropractor; Medical/Health care nec.; Listening to music, playing musical instruments or singing for leisure; Unstructured non-active play; Non-active club activities; Doing nothing; Non-active activities nec.; Talking face-to-face (in person not via electronic devices); Non-verbal interaction (e.g. cuddles); Negative face-to-face communication; Communication nec.; Filling out the diary; Other	Eating/drinking; Cleaning teeth; Showering/bathing; Getting dressed / getting ready; Personal care nec; Doctor; Dentist/Orthodontist; Physiotherapist / Chiropractor; Medical/Health care; Personal care/Medical/Health Care nec.; Listening to music; Playing musical instruments or singing for leisure; Chess, card, paper and board games / crosswords; Games of chance / gambling; Hobbies, collections; Handwork crafts (excl. clothes making); Arts; Unstructured non-active play nec; Clubs; Religious groups; Doing nothing; Non-active activities nec; Talking face-to-face; Talking on a landline phone; Non-verbal interaction; Negative face-to-face communication; Communication nec; Illegal activities; Filling out the diary; Other; Uncodeable activity
School	Responses "Day care centre / playgroup" to the question "where was the child?"	Responses "School, after/; before school; care" to the question "where was the child?"	Same as Wave 2	School Lessons, excluding Recess and Lunch	School Lessons, excluding Recess and Lunch	School Lessons, excluding Recess and Lunch

Grouping	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6
Education	Read a story, talk/sing, talked/sung to; colour, look at book, educational game; being taught to do chores, read, etc.; organised lessons / activities	Use computer/computer games (if this activity done for or as part of homework); Read a story, talk/sing, talked/sung to; Reading looking at book by self; Other organised lessons / activities	Same as Wave 2	Private music, language, religion lessons, tutoring; Reading or being read to for leisure; Homework (not on computer) including music practice; Computer for homework - internet; Computer for homework - not internet	Private music lessons/practice, academic tutoring; Reading or being read to for leisure; Doing homework (not via electronic devices); Doing homework	Private music lessons/practice, academic tutoring; Reading or being read to for leisure; Doing homework (not via electronic devices); Doing homework (electronic device); Attend courses (excluding school /university)
Active	Walk for travel or for fun; ride bicycle, trike etc. (travel or fun); other exercise - swim / dance/ run about; visiting people, special event, party; other play, other activities	Walk for travel or for fun; Ride bicycle, trike etc. (travel for fun); Visiting people, special event, party; Organised sport/physical activity; Other organised lessons / activities	Same as Wave 2	Organised team sports and training i.e.; Organised individual sport i.e. swimming; Ball games, riding a bike, scooter, ska; Taking Pet for a walk; Scouts, girl guides, etc.; Shopping; Going out to museums, cultural events,; Cinema; Live Sporting Events	Organised team sports and training; Organised individual sport and training; Unstructured active play; Walking pets / playing with pets; Active club activities; Shopping; Going out to a concert, play, museum, art gallery, community or school event , an amusement park etc.; Religious activities / ritual ceremonies; Attending live sporting events; Active activities nec.	Archery / Shooting sports; Athletics / Gymnastics; Fitness / Gym / Exercise; Ball Sports; Martial arts / Dancing; Motor Sports / Roller Sports / Cycling; Water/Ice/Snow Sports; Organised team sports and training other; Archery / Shooting sports (individual); Athletics / Gymnastics (individual); Fitness / Gym / Exercise (individual); Martial arts / Dancing (individual); Motor Sports / Roller Sports / Cycling (individual); Ball Sports (individual); Water/Ice/Snow Sports (individual); Organised individual sport and training other; Archery / Shooting sports (unstructured); Athletics / Gymnastics (unstructured); Fitness / Gym / Exercise (unstructured); Ball Sports (unstructured); Martial arts / Dancing (unstructured); Motor Sports / Roller Sports / Cycling (unstructured); Water/Ice/Snow Sports (unstructured); Unstructured active play Other; Walking pets/playing with pets; Active club activities; Shopping; Shopping; Purchasing consumer goods; Purchasing durable goods; Window shopping; Purchasing repair services; Purchasing administrative services; Purchasing personal care services; Purchasing other services; Attendance at

Grouping	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6
						movies / cinema; Attendance at concert/theatre; Attendance at museum / exhibition / art gallery; Attendance at zoo / animal park / botanic garden; Attendance at other mass events; Going out nec; Religious practice; Weddings, funerals, rites of passage; Religious activities / ritual ceremonies nec; Attending live sporting events; Active activities nec.
Chore		Helping with chores/jobs	Same as Wave 2	Making own bed, tidying own room; Making, preparing own food; Getting self ready, packing own school; Cleaning, tidying other rooms; Cooking, meal preparation, making lunch; Washing dishes, stacking and emptying d; Gardening, putting out the bin; Taking care of siblings, other children; Taking care of pets (excluding Walking pets)	Retailing (including fast food); Pamphlet delivering; Umpiring/refereeing; Car washing; Gardening / lawn mowing; Babysitting; Animal care; Working in a family business or farm; Work nec.; Volunteering; Cleaning/tidying; Laundry/clothes care; Food/drink preparation; Food/drink clean up; Gardening / lawn mowing; Animal care (excluding active play); Home maintenance; Taking care of siblings; Chores nec.	Retailing; Hospitality (including fast food); Clerical/office; Labourers and related workers; Gardening / lawn mowing; Babysitting; Apprenticeships/trades persons; Working in a family business or farm; Work Other; Umpiring (work); Car washing (work); Animal care (work); Volunteering (work); Cleaning/tidying; Laundry/clothes care; Clothes making; Food/drink preparation; Food/drink clean up; Gardening (maintenance chores); Cleaning grounds/garage/shed/outside of house (chores); Pool care (chores); Animal care; Home maintenance; Design/Home Improvement; Heat/water/power upkeep; Car/boat/bike care; Selling/disposing of household assets; Rubbish/Recycling; Packing; Household management Other; Taking care of siblings (chores); Chores nec
Media	Watching TV, video, DVD, movie; Listening to tapes, CD's, radio, music; Use computer/computer games	Watching TV, video, DVD, movie; Listening to tapes, CD's, radio, music; Use computer/computer games (if this activity done NOT for or NOT as part of homework)	Same as Wave 2	Electronic media, games, computer use; Computer games - internet; Computer games - not internet; Xbox, Playstation, Nintendo, WII etc.; Internet not covered elsewhere; TV/DVD; Talking on a landline phone; Talking on a mobile phone; Texting,	Playing games; Watching TV programs or movies/videos; Spending time on social networking sites; Downloading/posting media (e.g. music, videos, applications); Internet shopping (excluding downloading/posting media); General Internet browsing (excluding homework); Creating/maintaining websites (excluding social networking profile); General application use	Playing games (electronic device); Playing games (Electronic device) nfd.; Watching TV programs or movies/videos; Spending time on social networking sites; Downloading/posting media; Internet shopping; General Internet browsing; Creating/maintaining websites; General application use; Electronic device use nec; Talking on a mobile phone; Video chatting; Texting/emailing; Online chatting / Instant messaging

Grouping	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6
				email, social networking - facebook/twitter; Skype or Webcam	(e.g. Microsoft Office; excluding homework); Electronic device use nec.; Talking on a landline phone (not video chat); Talking on a mobile phone (not video chat); Video chatting (e.g. Skype); Texting/emailing; Online chatting / Instant messaging	
Travel	Travel in pusher or on bicycle seat; travel in car / other household vehicle; travel on public transport, ferry, plane; taken places with adult (e.g. shopping)	Travel in car; Travel on public transport; Taken places with adult (e.g. Shopping)	Same as Wave 2	Travel by foot; by bike, scooter, skateboard etc.; by private car; Travel by public transport such as bus	Travel by foot; by bike, scooter, skateboard etc.; by private motor vehicle/bike; by public/chartered transport such as bus, taxi or aeroplane; Travel nec.	Travel by foot; by bike, scooter, skateboard etc.; by private motor vehicle/bike; by public/chartered transport; Travel nec.

Appendix Table C3: Loading factors of maternal parenting styles

	Wave 2		Wave 3	
Variable	Factor 1	Factor 2	Factor 1	Factor 2
Display physical affection	***0.711***	***0.302***	***0.730***	***0.306***
Hug study child	***0.662***	***0.290***	***0.671***	***0.300***
Express happiness to study child	***0.721***	0.221	***0.736***	***0.270***
Warm encounters with study child	***0.754***	***0.277***	***0.769***	***0.292***
Enjoy doing things with study child	***0.713***	0.198	***0.756***	0.197
Close when happy or upset	***0.734***	0.212	***0.751***	0.199
Explains correction	***0.504***	0.140	***0.463***	0.197
Reasons when misbehaves	***0.534***	0.186	***0.498***	0.193
Make sure completes requests	***0.314***	-0.169	***0.296***	-0.191
Punish study child	0.182	***-0.308***	0.192	***-0.347***
Study child gets away unpunished	***-0.316***	***0.692***	***-0.355***	***0.662***
Study child gets out of punishment	***-0.279***	***0.684***	***-0.318***	***0.667***
Study child ignores punishment	***-0.333***	***0.694***	***-0.398***	***0.662***
Praise behavior	***0.532***	0.049	***0.590***	-0.023
Disapprove of behavior	***-0.397***	***0.416***	***-0.495***	***0.287***
Angry when punishing	***-0.340***	***0.369***	***-0.339***	***0.332***
Have problems managing	***-0.408***	***0.558***	***-0.454***	***0.513***

Notes: Factor 1 represents index of warmth parenting style while factor 2 corresponds to index of effective discipline parenting style. Factor loadings with an absolute value greater than 0.25 are in bold italic.