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# Family Income and Child Cognitive and Noncognitive Development in Australia: Does Money Matter?

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**Abstract** This article investigates whether family income affects children's cognitive and noncognitive development by exploiting comprehensive information from the Longitudinal Study of Australian Children. We include variables that represent parental investment, parental stress, and neighborhood characteristics to examine if these factors mediate the effects of income. Using dynamic panel data, we find that family income is significantly associated with children's cognitive skills but not with noncognitive skills. Mother's education, parent's physical and mental health, parenting styles, child's own health, and presence of both biological parents are the most important factors for children's noncognitive development. For cognitive development, income as well as parents' education, child's birth weight, and number of books that children have at home are highly significant factors. We also find strong evidence to support the skill formation theory that children's previous cognitive and noncognitive outcomes are significantly related to their current outcomes.

**Keywords** Family income · Child cognitive and noncognitive development · Health inequalities · Panel data · Australia

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## Introduction

Child poverty rates[1] are higher in Australia than in many OECD countries. According to a UNICEF study, Australia ranked 13 of 24 OECD nations for children's material well-being, with about 11.6 % of Australian children living in poverty (Bradshaw et al. 2007). The Luxembourg Income Study also reported that Australia's child poverty rate is 15 % and that Australia ranks 21 of 30 upper-income nations in child poverty (Gornick and Jäntti 2010). The literature indicates that children born into families with limited financial resources are at greater risk of having poor cognitive, behavioral, and health outcomes than their wealthier counterparts (Brooks-Gunn and Duncan 1997; Case et al. 2002; Currie et al. 2007; Currie and Stabile 2003; Dooley and Stewart 2007; Duncan et al. 2014; Khanam et al. 2009; Violato et al. 2010). The poorer outcomes of less wealthy children may cause an intergenerational transmission of poverty: because children who have worse cognitive and noncognitive outcomes may be more likely to have less education and to have lower earnings as adults, they are more likely to raise their children in poor environments. Thus, policies and programs should aim to improve the outcomes of low-income children and break the poverty cycle between generations.

However, it is not always clear whether the observed differences in outcomes between poor and nonpoor children result from income itself or from correlates of income, such as parental education, health, and single parenthood. Duncan et al. (2014), for example, found that an increase in family income can improve children's school performance. On the other hand, Heckman and Mosso (2014) argued that the role of income and credit constraints has been exaggerated in the literature. They found more support for the positive roles of mentoring, parenting, and human interaction in shaping child outcomes. They reported that targeted cash transfer policies to families are unlikely to improve child outcomes. Washbrook et al. (2014) used ecological models of child development to examine the income gradient in children's cognitive, noncognitive, and health outcomes. Using a decomposition approach, they found that the income gradient is highest for cognitive development, followed by noncognitive and health outcomes. In a recent Australian study, Nghiem et al. (2015) used LSAC data to examine the effects of school type on child's cognitive and noncognitive development. They found that enrolment in private or Catholic schools did not have significant effects on children's cognitive outcomes.

Among economics studies on this issue, Mayer (1997) and Blau (1999) were the first to focus on the endogeneity of income. Using an instrumental variable (IV) approach and ordinary least squares (OLS) analysis, Mayer (1997) found that the effects of income on child outcome were largely spurious. Blau (1999) applied a fixed-effects estimator and found only minor effects of current income on child outcomes. Some recent studies (Aughinbaugh and Gittleman 2003; Khanam et al. 2009, 2013; Shea 2000) also found smaller effects of income on child outcomes by using fixed-effects and IV estimators. By applying a fixed-effects IV estimator, Dahl and Lochner (2012) found that a $1,000 increase in household income was associated

[1] Child poverty rate is defined as the rate of children living in households with an income lower than 50 % of the country's household size–adjusted median.

with a rise in mathematics and reading test scores by 2 % and 3.6 % of a standard deviation (SD), respectively.

The developmental psychology literature focusing on the extent and depth of poverty on child development has found that effects of income are much higher for a child's cognitive development than for noncognitive development (e.g., Duncan et al. 1998; Brooks-Gunn and Duncan 1997; Morris et al. 2004). The evidence on how income is translated into better child outcomes is rather sparse, particularly in the economics literature. The available evidence comes mostly from developmental psychology (e.g., Guo and Harris 2000; Yeung et al. 2002), but these studies have focused on the investment and family process perspectives.

In this article, we aim to investigate the routes through which family income may affect children's cognitive and noncognitive development by exploiting comprehensive information from the Longitudinal Study of Australian Children (LSAC). This study contributes to the literature in the following ways. First, we incorporate neighborhood effects in the model of child development based on empirical evidence that the social environment, including neighborhood characteristics, has a strong influence on child development (Aaronson 1998; Case and Katz 1991; Ginther et al. 2000; Goetz 2010; Oliver and Hayes 2005; Owens 2010; Sampson et al. 2002; Solon et al. 2000). Second, we investigate the *dynamic nature* of children's human capital development—that is, how current cognitive and noncognitive outcomes are determined by lagged outcomes. The concept of interdependence between lagged and current outcomes has rarely been investigated empirically, particularly in the literature on children's cognitive and behavioral development. To the best of our knowledge, only Heckman and colleagues (e.g., Cunha and Heckman 2007) have examined this dynamic nature of children's skill formation. This article fills this gap in the empirical literature on children's cognitive and noncognitive development. Third, we combine economists' and psychologists' views to model income and child outcomes. For example, the economics literature on child development has not extensively investigated factors such as parental stress, family functioning, and neighborhood effects. We include father's physical and mental health and father's parenting style in modeling income and child development, which have been ignored even in the developmental psychology literature. Finally, we address endogeneity and unobserved heterogeneity by using a comprehensive set of covariates and applying a generalized method of moments (GMM) approach. Thus, using appropriate econometric techniques and taking advantage of longitudinal data, we can model the evolution of child health and development from childhood to adolescence, which represents an important methodological refinement to the existing literature.

## Theoretical Framework

Previous research on the effects of income on child outcomes is dominated by two complementary theories: the investment theory (Becker 1981; Becker and Tomes 1986) and the family stress theory (Smith and Brooks-Gunn 1997; Yeung et al. 2002). The

investment theory postulates that out of concern for their children's future well-being, parents invest material and time input in their children's human capital in a way that will maximize parents' utility. Family stress theory posits that income affects parenting ability because economic hardships adversely affect parents' psychological well-being. Psychologically stressed parents are less able to promote family functioning and to adopt a parenting style that is conducive to child development (Smith and Brooks-Gunn 1997; Yamauchi 2010; Yeung et al. 2002).

We propose a model of child outcomes that combines the investment perspective (focusing on the ability to invest in materials, services, and a home environment), family stress theory (highlighting the role of parental stress and mental health, as well as parenting style), and a neighborhood perspective (focusing on neighborhood with more educated and employed residents and with better facilities). This model provides us with some insights into why parental income, education, and stress, as well as neighborhood conditions might affect child development. Investment theory posits that child outcome is a result of parental investments of material resources and time. Parents with high socioeconomic status (SES) can buy higher-quality resources, such as better housing, nutritious food, better-quality schools, reputable childcare, and good books, which can stimulate their children's cognitive development. The framework also implies that parents with different wage rates, which depend on parental education and health, have different time preferences. For example, a higher wage rate might reduce parental interaction with child because the parent has higher opportunity costs. However, this substitution effect (i.e., using time to work or to play with children) might be offset by the income effects (i.e., if parents with high wage rates do not need to work long hours to earn extra money and hence have more time to play with their children). The net effect will depend on the relative size of income and substitution effects. In addition, parents in wealthier families are likely to be less stressed than parents with budget constraints, and lower stress levels help them to practice parenting that is conducive for child development. The importance of neighborhoods for child development can be explained by stress theory (exposure to pollution and community violence), social organization theory (the importance of role models and social values in the neighborhood), institutional factors (better schools, parks, health facilities, and police protection), and epidemic theories (power of peer influence) (Coulton 1996; Earls and Buka 2000; Ginther et al. 2000; Jencks and Mayer 1990; Shonkoff 2003). Our model assumes that wealthier families can afford to live in neighborhoods with less violence, better facilities (i.e., library, park, museum), and more residents who are educated and employed. Empirical evidence has shown that children living in poor neighborhoods perform worse at school, have lower skills, and have more behavioral and health problems, even after household characteristics are controlled for (Contoyannis and Li 2011; Pebley and Sastry 2004).

We also include children's development outcome in the previous period ($Q_{i,t-1}$, lagged outcomes) in our model, which is consistent with Heckman and colleagues' (e.g., Cunha et al. 2010; Cunha and Heckman 2008; Heckman 2007) self-productivity and dynamic complementarity theories of skill formations. Heckman and colleagues stressed the dynamic nature of skill formation,

particularly in the way current outcome ($Q_t$) depends on the previous outcome ($Q_{t-1}$). For example, the dynamic complementarity and self-productivity theories state that investment in one period (e.g., $t$) is more productive if there is high capacity in the previous period ($t-1$).

## Econometric Specification

To integrate the main contributions of this study, the empirical specification to estimate the relationship between child development and family income in this study is as follows:

$$Q_{it} = \alpha + \beta_1 Q_{i,t-1} + \beta_2 Y_{it} + \beta_3 PI_{it} + \beta_4 FS_{it} + \beta_5 NF_{it} + \beta_6 \mathbf{Z}_{it} + (\mu_i + \varepsilon_{it}); \quad t = 1, 2, \ldots T, \tag{1}$$

where $Q_{it}$ and $Q_{i,t-1}$ are the outcomes of child $i$ in period $t$ and $t-1$ respectively; $PI$, $FS$, and $NF$ are the indicators for parental investment, family stress, and neighborhood factors, respectively; $Y_{it}$ is the inflation-adjusted family income; $\varepsilon_{it}$ is the random error; and the $\beta$s are parameters to be estimated. Other remaining factors that affect child development are represented by $\mathbf{Z}_{it}$. The component $\mu_i$ captures a set of time-invariant individual unobserved characteristics (i.e., fixed effects) that affect both household income and child development outcomes. Thus, income is endogenous, and applying standard regressions can produce biased results. In this study, we address endogeneity by using a comprehensive set of covariates (Gregg et al. 2005) and applying the GMM approach of Blundell and Bond (1998).

We minimize the effects of unobserved individual heterogeneity by controlling for a comprehensive set of observable characteristics that are available in LSAC data. The implicit assumption under this approach is that observable and unobservable characteristics are highly correlated. However, we acknowledge that this approach cannot eliminate all sources of unobserved heterogeneity.

The parameter $\mu_i$ in Eq. (1) can also be eliminated by applying the first difference, but the difference of the lagged dependent variable still correlates with the difference of the error term. Arellano and Bond (1991) proposed using a second or higher lag as an IV; one can estimate the first-differenced transformation consistently using a GMM framework (i.e., "difference GMM"). However, the time-invariant observable covariates will be eliminated, and lags of level dependent variables are weak instruments. Blundell and Bond (1998) proposed a system GMM estimator that uses both level and lags of additional covariate IVs for differenced endogenous variables ("system GMM"). Results of a Monte Carlo experiment by Blundell and Bond (1998: table 2) showed that the system GMM estimator provides a substantial improvement over results by the difference GMM estimator. A potential issue with this estimator is that too many IVs are available, which can lead to overidentification problems (Roodman 2009). A Sargan test can be applied to identify the desirable number of IVs (Bond 2002). Another issue with this estimator is that standard errors of the estimates can be biased downward; hence, we apply the finite sample correction proposed by Windmeijer (2005) in the analysis.

## Data and Variables

### Data Sources

This study uses data from the first five waves of the nationally representative Longitudinal Study of Australian Children (LSAC) survey. The LSAC has comprehensive information about children's cognitive and noncognitive development, health outcomes, demographics, parental health, parenting practices, financial status, lifestyle, housing, and neighborhood attributes. The LSAC sampling frame consists of all children born between March 2003 and February 2004 (B cohort, infants aged 0–1 years in 2004), and between March 1999 and February 2000 (K cohort, children aged 4–5 years in 2004). The LSAC sample consists of ten thousand children, approximately 5,000 children from each cohort. It involves biennial follow-up of the enrolled households and will continue until at least 2018. In this study, we focus on presenting the results for children of the K cohort because measures of child cognitive outcomes are more widely available for this cohort in all five waves of the survey. Although the survey included around 10,000 children in Wave 1, the number of children surveyed in subsequent waves was smaller: 9,070 in Wave 2 (2006), 8,717 in Wave 3 (2008), 8,411 in Wave 4 (2010), and 8,041 in Wave 5 (2012). The attrition rates are therefore 10.1 %, 3.9 %, 3.5 %, and 4.4 % for Waves 2 through 5, respectively.

### Outcome Variables

*Noncognitive Skills*

We use data from the Strengths and Difficulties Questionnaire (SDQ) to measure a child's behavioral development. The SDQ includes five subscales: (1) Prosocial Scale, (2) Hyperactivity Scale, (3) Emotional Symptoms Scale, (4) Conduct Problems Scale, and (5) Peer Problems Scale. These measures were calculated as the sum of responses to five questions assessing children's feelings and behavior (see, e.g., Muris et al. (2003) for more details), with responses rated on a 3-point scale (1 = not true, 2 = somewhat true, 3 = certainly true). Higher SDQ scores indicate a negative outcome for all subscales but the Prosocial Scale.

Although the SDQ measures have been widely used in the literature, one may argue that SDQ measures reflect more behavior outcomes than noncognitive outcomes. Therefore, we select five indicators: self-efficacy,[2] being a bullying perpetrator,[3] and

[2] Measured as the mean of responses on a 5-point Likert scale (1 = false, 2 = mostly false, 3 = sometimes false, 4 = mostly true, 5 = true). The assessment starts with a statement: "I now have some sentences to read out to you. Please listen to each one carefully and then pick the answer that best describes you." The statement is then followed by specific descriptions: "I do lots of important things," "Overall, I have a lot to be proud of," "I can do things as well as most other people," and "A lot of things about me are good."

[3] Measured as the mean response on a 4-point Likert scale (1 = never, 2 = once or twice, 3 = about once a week, 4 = several times a week) to items such as "I hit or kicked someone," "I grabbed or shoved someone," "I threatened someone," and "I said mean things to someone."

being a bullying victim[4] to provide additional measures of noncognitive skills.[5] Unfortunately, these variables are available only for Wave 5 (when the B cohort was 8–9 years old and the K cohort was 12–13 years old); thus, we cannot apply panel data analysis for these three noncognitive skills.

*Cognitive Skills*

Based on available data, we select the following measures of children's cognitive development.

**Matrix Reasoning (MR) test:** Children from Waves 2 through 5 completed the MR test from the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV). MR tests assessed a child's nonverbal intelligence by presenting them with an incomplete set of pictures, which they needed to complete by selecting a picture from five options. The raw matrix reasoning score is presented as the number of correct answers. This indicator has been used widely to measure child development (see, e.g., Fiorini 2010; Fuchs et al. 2008, 2010; Jaeggi et al. 2010; Mazzocco et al. 2011).

**Peabody Picture Vocabulary Test (PPVT):** The PPVT, which is available only in the first three waves of LSAC, is an interviewer-administered test designed to assess a child's listening comprehension ability for spoken words in Standard English. The PPVT test requires a child to show the picture that best represents the meaning of a stimuli word spoken by the examiner (Dunn and Dunn 1997).

**Literacy and Mathematical Skills:** Both parents and teachers assessed these skills. We use the teacher assessments because we assume that teachers had more detailed knowledge of the child's academic performance. The literacy variable measures the average of responses on a 5-point Likert scale to questions concerning the child's contribution to classroom discussions, understanding and interpreting stories, and reading and writing comprehension. Similarly, the mathematical skills variable captures the average of a series of 5-point Likert scale responses to questions assessing children's understanding of place values, organizing data in graph, estimating of quantities, and using strategies to solve mathematical problems. Literacy and mathematical scores have been widely used to measure child development (see, e.g., Fiorini 2010; Harrison et al. 2009; Murray and Harrison 2011; Pasnak et al. 2009).

To make relevant comparisons among outcomes, we standardize all indicators of cognitive and noncognitive skills for B and K cohorts. Figure 1 shows that the distribution of PPVT and MR scores are symmetrical, while the distribution of mathematical and literacy scores are more skewed to the left (panel a). Panel a of the figure also reveals that no data were available for the literacy and mathematical scores in the B cohort. The distribution of noncognitive outcomes shows that data are left-skewed for prosocial skills and right-skewed for hyperactivity, emotional symptoms, conduct problems, and peer problems,

[4] Measured as mean responses on a 4-point Likert scale (1 = never, 2 = once or twice, 3 = about once a week, 4 = several times a week) to items such as "Kids hit or kicked me," "Kids grabbed or shoved me," "Kids threatened me," and "Kids said mean things to me."

[5] We acknowledge an anonymous referee for suggesting that we include these measures.

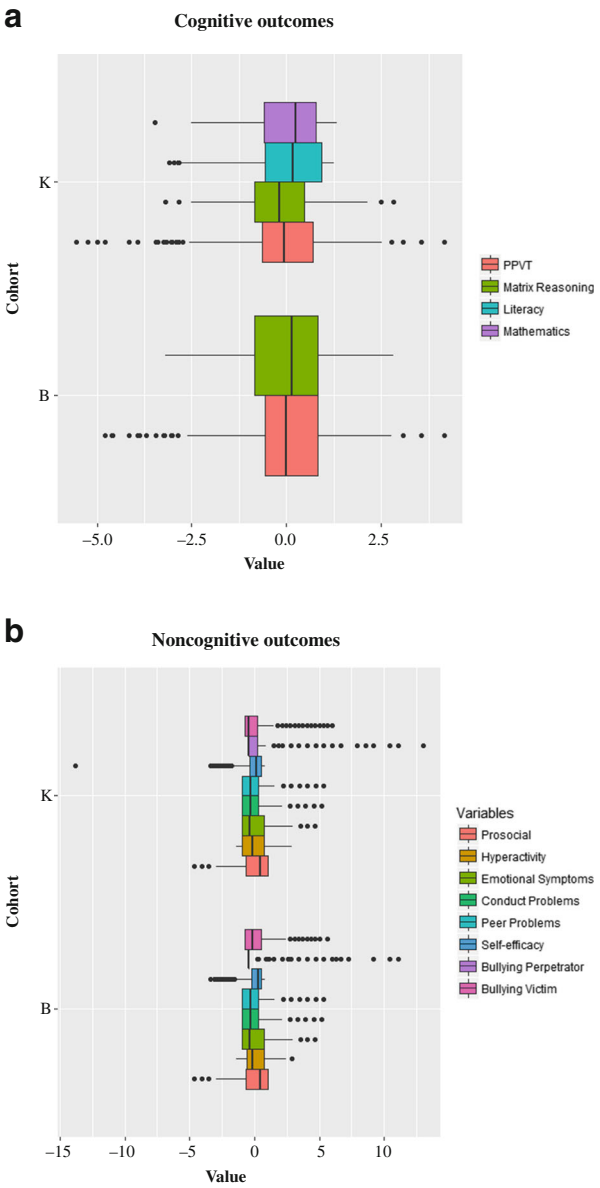


**Fig. 1** Distribution of standardized cognitive and noncognitive outcomes

suggesting that most children have good behavior, according to their SDQ responses. Also, the distribution of other noncognitive indicators shows that most children were neither perpetrators nor victims of bullying (panel b). The distributions of self-efficacy for both the B cohort and the K cohort show a neutral tendency but skew to the left, indicating that some children express the feeling of having a low self-esteem.

## Independent Variables

Our main variable of interest is the log of household income. The household income variable is constructed as the sum of the mother's and father's reported weekly income from all sources,[6] which is multiplied by 52 weeks to obtain the annual household income. We control for the effect of inflation using the consumer price index, with the price index of Wave 1 (2004) arbitrarily selected as the base. We take the logarithm of the inflation-adjusted household income because income is known to be highly skewed (see, e.g., Calvo and Wellisz 1979; Petrou et al. 2007). The main advantage of making income symmetrical by taking the logarithm is that the mean is similar to the median. Therefore, parameters of regressions represent the relationship at median income, which is convenient for predicting outcomes of interests (cognitive and noncognitive skills) for children living in poverty, which is a measure of relative poverty (i.e., households with incomes 50 % lower than the median income). We focus on relative income in this study because Australia is a high-income country with a generous system of welfare and safety nets. Thus, absolute poverty measured by the international poverty line of $1.25 per person per day is not relevant in Australia. Taking the logarithm also makes the relationship between income and the outcomes of interest in this study nonlinear and has relevant properties of a production function. For example, the relationship between continuous measures (PPVT, mathematics, and literature scores) and income is log-linear, which also conveniently reflects some useful properties, such as monotonicity (i.e., knowledge is cumulatively acquired) and diminishing returns (e.g., more parental investments lead to a smaller incremental increase in child outcomes).

We also include a basic set of control variables used in previous studies (see, e.g., Currie and Stabile 2003; Khanam et al. 2009, 2013; Murasko 2008; Nghiem et al. 2015) on child development: parents' age, education, and employment status; child characteristics (dummy variables for gender, birth order, birth weight, and physical health status); and household characteristics (household size, presence of both biological parents at home, Aboriginal and Torres Strait Islander status, and whether English is spoken at home).

In addition, drawing on human capital theory (Becker 1981; Becker and Tomes 1986), we include two types of indicators for parental investment: materials and time. Measures of material investments include housing tenure (defined as a dummy variable equal to 1 for owning outright, and 0 otherwise), the number of children's books at home, and access to a home computer. The time that parents spend with their children in stimulating activities that improve child outcomes is measured as an index of family bonding activities (e.g., frequency of someone engaging in activities such as going to cinema or sporting events).

The family stress hypothesis (Guo and Harris 2000; Yeung et al. 2002) is conceptualized using indicators of parenting style and parental physical and mental health. Another innovation of this study is the inclusion of father's physical and mental health as well as father's parenting style among the explanatory variables; these variables for fathers have been ignored in most previous studies.

[6] The weekly income data are derived from responses to the question, "Before income tax is taken out, how much does…usually receive from all sources in total?"

Finally, variables representing neighborhood effects include a neighborhood facility index (a proxy for availability, accessibility, and quality of infrastructure), the percentage of residents with high school education, and the percentage of residents who speak English.

The inclusion of these variables is partly influenced by the data availability and our attempt to make the model parsimonious. For example, because the data do not have information on parents' expenditures on toys, childcare, or extracurricular activities, we cannot include these variables as measures of parental investment. By contrast, the data set has a wide range of variables representing characteristics of the neighborhood: percentage of residents who are Aboriginal and Torres Strait Islanders, percentage of households earning less than $1,000 per month, and a remoteness index. However, these variables were highly correlated with the percentage of residents who speak English, the percentage of residents who are high school graduates, and the infrastructure index, respectively; thus, in the interest of parsimony, we opted to include only the latter variables to avoid possible multicollinearity.

Table 1 shows that 79 % of children are firstborns. Educational attainment differs across parents: 65 % of mothers but only 49 % of fathers have completed Year 12, which is the last year at high school in the Australian education system. The number of hours worked per week by fathers (47 hours) is almost double that of mothers (26 hours). The controls for parental investment show that only 12 % of families own their house outright (i.e., the rest still pays mortgage or renting), 89 % of households have a computer at home and, on average, households have more than 30 children's books at home. The variables for parental stress reveal that mothers show a warmer style of parenting compared with fathers. Among neighborhood characteristics, 45.6 % of residents have 12 years of education, and 85.6 % speak English. The neighborhood facility index shows that, on average, respondents are happy with the infrastructure of their neighborhoods.

## Results and Discussion

To investigate the effects of family income on child outcomes, we first use log of family income and a basic set of control variables in Specification 1. We then develop three specifications to investigate the three mechanisms proposed in the theoretical section: we include parental investment, family stress, and neighborhood characteristics in Specifications 2, 3, and 4, respectively, in addition to the variables included in Specification 1. Finally, we estimate the most comprehensive model (Specification 5), which includes all variables from Specifications 1 through 4.

### Dynamic Framework of Cognitive and Noncognitive Skill Formation

The results of OLS, fixed-effects, and GMM analyses show that outcomes in the previous wave are the most significant determinant of children's cognitive and non-cognitive skills (see Table 2). This result is consistent with the self-productivity and dynamic complementarity theories of skill formation and with previous empirical evidence (Cunha and Heckman 2008; Cunha et al. 2010; Heckman 2007; Nghiem et al. 2015). The results also confirm Bond's (2002) argument that the parameter of the

**Table 1** Descriptive statistics for selected independent variables

| Variables | Mean | SD | Min. | Max. |
|---|---|---|---|---|
| Log of Household Income | 11.03 | 0.75 | 2.13 | 14.55 |
| Basic Control Variables | | | | |
| Mother's age | 36.89 | 6.37 | 14.00 | 82.00 |
| Mother completed Year 12 education (1 = yes) | 0.65 | 0.48 | 0.00 | 1.00 |
| Father completed Year 12 education (1 = yes) | 0.49 | 0.50 | 0.00 | 1.00 |
| Mother's weekly work hours | 25.55 | 14.10 | 0.00 | 120.00 |
| Father's weekly work hours | 46.53 | 12.95 | 0.00 | 168.00 |
| Child's age (months) | 78.97 | 42.36 | 3.00 | 166.00 |
| Child's gender (1 = male) | 0.51 | 0.52 | 0.00 | 32.00 |
| Child was firstborn (1 = yes) | 0.79 | 0.40 | 0.00 | 1.00 |
| Aboriginal and Torres Straits Islander (1 = yes) | 0.21 | 0.41 | 0.00 | 1.00 |
| English spoken at home (1 = yes) | 0.90 | 0.30 | 0.00 | 1.00 |
| Household size | 4.48 | 1.22 | 2.00 | 32.00 |
| Both biological parents at home (1 = yes) | 0.85 | 1.37 | 0.00 | 81.00 |
| Low birth weight (<2,500g) | 0.06 | 0.23 | 0.00 | 1.00 |
| Parental Investment | | | | |
| Housing tenure (1 = owned outright) | 0.12 | 0.33 | 0.00 | 1.00 |
| Out-of-home activities index[a] | 2.61 | 1.20 | 0.00 | 5.00 |
| Number of children's books in home[b] | 3.61 | 0.81 | 0.00 | 4.00 |
| Has computer at home (1 = yes) | 0.89 | 0.31 | 0.00 | 1.00 |
| Family Stress | | | | |
| Mother is in excellent health (1 = yes) | 0.19 | 0.39 | 0.00 | 1.00 |
| Father is in excellent health (1 = yes) | 0.18 | 0.39 | 0.00 | 1.00 |
| Mother's parenting style[c] | 4.44 | 0.52 | 1.00 | 5.00 |
| Father's parenting style | 4.10 | 0.61 | 1.00 | 5.00 |
| Depression scale of mother[d] | 4.45 | 0.59 | 0.00 | 5.00 |
| Depression scale of father[d] | 4.51 | 0.53 | 0.00 | 5.00 |
| Neighborhood Effects[e] | | | | |
| Neighborhood facilities[f] | 1.95 | 0.70 | 1.00 | 4.00 |
| Percentage of residents completed Year 12 | 45.64 | 13.80 | 6.00 | 90.00 |
| Percentage of residents speak English | 85.66 | 14.01 | 8.00 | 100.00 |

[a] Number of "yes" answers to questions about activities that the family does together, such as going to cinema and sporting events.

[b] Categorical variables: 1 = 1–10 books; 2 = 11–20 books; 3 = 21–30 books; 4 = more than 30 books (recode to 4 = 1, 0 otherwise).

[c] Mean of responses to questions on a 5-point Likert scale (1 = never, 5 = always) about the frequency of showing affection (e.g., hug) to children and expressing happiness to children.

[d] Parental depression scale (mental health) is measured using six questions about the frequency of feeling nervous, hopeless, restless, lacking energy, sad, and worthless. In particular, the questions are "In the past 4 weeks about how often did you feel…: (1) nervous?; (2) hopeless?; (3) restless or fidgety?; (4) that everything was an effort?; (5) so sad that nothing could cheer you up?; (6) worthless?" The responses were recoded on 5-point Likert scale: 1 = all the time, 5 = not at all. The final variable was constructed from the mean of responses to these six questions, with values ranging from 1 (highly depressed) to 5 (no depression).

[e] "Neighborhood" in this study refers to the neighborhood of residence, even though the primary sampling unit is the postcode, which is also the primary sampling unit of the LSAC. Robust standard errors (Rogers 1994), taking into account correlation of residuals within postcode, are used in the analyses where appropriate.

[f] Average of responses to questions on a 4-point Likert scale (1 = strongly agree, 4 = strongly disagree) about the ability to access affordable, regular public transportation, basic shopping facilities, and services such as banks and medical clinics in the neighborhood.

lag outcome (i.e., outcome in the previous period) is overestimated by the OLS estimator but underestimated by the fixed-effects estimator, suggesting that the GMM results are reliable. In addition, not only do the lag outcome parameters remain highly significant, but their magnitudes are also stable across specifications. Thus, we suspect that significant effects of income on child development found in the literature could be overestimated as a result of specification bias (i.e., omitting the lag outcome). Because the results from OLS models are biased upward and the results of the fixed-effects estimator are biased downward, we focus on presenting the results of the GMM estimator hereafter. Table 2 reports the results of the K cohort only; results for the B cohort are similar.

### Family Income and Child Outcomes

Table 3 shows that household income has expected effects on child development outcomes, but the results are not consistent across outcomes and specifications. When only a basic set of covariates is controlled for (Specification 1), children of wealthier households are less likely to have emotional and conduct problems. However, when the most comprehensive set of covariates is used (Specification 5), family income has no effect on noncognitive outcomes except hyperactivity, which is significant at only the 10 % level. Family income is mainly associated with better cognitive outcomes. In particular, an increase of log family income by 1 SD is associated with an improvement on the PPVT, MR, literacy, and mathematical scores of children by about 0.29, 0.26, 0.23, and 0.24 SD, respectively. However, for noncognitive skills, inclusion of the three mechanisms (investment, parental stress, and neighborhood characteristics) makes most of the income coefficients insignificant. An explanation for the different effect of income on cognitive and noncognitive skills could be that cognitive outcomes are more directly affected by purchasable inputs, such as private schooling, tutors, and extracurricular activities; noncognitive outcomes are more likely to be affected by nonpurchasable inputs, such as personal traits (e.g., introversion vs. extroversion), family environment (parenting skills and family functioning), neighborhoods (peer effects and infrastructure), and social trends (the dominance of mobile devices over human interaction).

### Parental Investment, Parental Stress, and Neighborhood

The effects of investment, parental stress, and neighborhood mechanisms can be investigated by comparing income parameters across the five specifications. As shown in Table 3, parental investment (Specification 2) improves the level of significance and magnitude of income effects on most outcomes. The income effect becoming stronger and significant suggests that parental investment (i.e., material and time) is not a substitute for parental income. One explanation is that material inputs, which are often complimentary of income, play an important role in parental investment and hence strengthen the income effect.

However, when parenting style and parental physical and mental health are controlled for in Specification 3, the effect of income on most outcomes is no longer significant, and the magnitude of the income coefficients is also reduced. This result

**Table 2** Dynamic framework of skills formation (parameters of lagged outcomes)

| | Noncognitive Outcomes | | | | | Cognitive Outcomes | | | |
|---|---|---|---|---|---|---|---|---|---|
| Specification/Estimator | Prosocial | Hyperactivity | Emotional Symptoms | Conduct Problems | Peer Problems | PPVT | Matrix Reasoning | Literacy Score | Math Score |
| Specification 1 | | | | | | | | | |
| FE | –.10** | –.05** | –.08** | –.05** | –.09** | –.32** | .04† | –.16** | .03* |
| GMM | .18** | .36** | .30** | .19** | .31** | .06* | .43** | .04† | .26** |
| OLS | .51** | .68** | .53** | .49** | .53** | .39** | .63** | .37** | .56** |
| Specification 2 | | | | | | | | | |
| FE | –.10** | –.05** | –.08** | –.05** | –.09** | –.32** | .04 | –.16** | .04* |
| GMM | .19** | .37** | .30** | .19** | .32** | .08** | .46** | .05* | .29** |
| OLS | .51** | .67** | .53** | .49** | .52** | .37** | .63** | .36** | .55** |
| Specification 3 | | | | | | | | | |
| FE | –.11** | –.07** | –.10** | –.05** | –.10** | –.30** | .07* | –.14** | .03 |
| GMM | .20** | .34** | .31** | .18** | .30** | .06* | .41** | .05* | .30** |
| OLS | .48** | .66** | .50** | .45** | .51** | .38** | .64** | .35** | .54** |
| Specification 4 | | | | | | | | | |
| FE | –.11** | –.07** | –.10** | –.05** | –.10** | –.32** | –.01 | –.16** | .03† |
| GMM | .18** | .36** | .30** | .20** | .31** | .06† | .37** | .05* | .29** |
| OLS | .52** | .68** | .53** | .50** | .53** | .38** | .60** | .39** | .57** |
| Specification 5 | | | | | | | | | |
| FE | –.11** | –.07** | –.10** | –.05** | –.11** | –.30** | .07* | –.14** | .03† |

**Table 2** (continued)

| | Noncognitive Outcomes | | | | | Cognitive Outcomes | | | |
|---|---|---|---|---|---|---|---|---|---|
| Specification/Estimator | Prosocial | Hyperactivity | Emotional Symptoms | Conduct Problems | Peer Problems | PPVT | Matrix Reasoning | Literacy Score | Math Score |
| GMM | .20** | .34** | .31** | .18** | .30** | .08* | .44** | .07** | .33** |
| OLS | .48** | .65** | .50** | .44** | .51** | .37** | .63** | .35** | .54** |

*Notes:* Specification 1 includes the log of household income, lagged outcomes, and a basic set of covariates: child's age, gender, birth weight, education, and parents' work hours, mother's age at child birth, household size, English-speaking household, and Aboriginal and Torres Strait Islander. Specification 2 includes Specification 1 plus indicators of parental investments: housing tenure; index of activities that the family does together, such as going to cinema and sporting events; number of children's books at home; and availability of a computer at home. Specification 3 includes Specification 1 plus indicators of family stress: parenting style, and parental mental and physical health. Specification 4 includes covariates in Specification 1 plus neighborhood characteristics: neighborhood facilities, percentage of residents who completed Year 12, and percentage of residents who speak English. Specification 5 includes all covariates from Specifications 1–4. Other covariates are omitted from this table for brevity.

$^{\dagger}p \leq .10$; $*p \leq .05$; $**p \leq .01$

**Table 3** Effects of household income on child outcomes (GMM estimator)

| | Specification 1 | Specification 2 | Specification 3 | Specification 4 | Specification 5 |
|---|---|---|---|---|---|
| Noncognitive Outcomes | | | | | |
| Prosocial | 0.06 | 0.12 | –0.12 | 0.12 | –0.04 |
| Hyperactivity | 0.02 | –0.03 | 0.15* | 0.08 | 0.12† |
| Emotional Symptoms | –0.19* | –0.18* | –0.16† | –0.14 | –0.09 |
| Conduct Problems | –0.18* | –0.22** | –0.07 | –0.10 | –0.05 |
| Peer Problems | –0.11 | –0.11 | 0.03 | –0.04 | 0.08 |
| Cognitive Outcomes | | | | | |
| PPVT | –0.002 | 0.11** | –0.02 | –0.05 | 0.29** |
| Matrix Reasoning | 0.19† | 0.22* | 0.19† | 0.23* | 0.26** |
| Literacy score | 0.06 | 0.13 | 0.05 | 0.28** | 0.23** |
| Mathematical score | 0.003 | 0.19** | 0.04 | 0.10 | 0.24** |

*Notes:* The covariates in Specification 1 to Specification 5 are the same as those described in Table 2. Other covariates are skipped in this table for brevity.

†$p \leq .10$; *$p \leq .05$; **$p \leq .01$

suggests that parental stress plays a significant role in mediating the effect of income on a child's outcomes.

Similarly, when neighborhood characteristics are added in Specification 4, family income has no significant effect on noncognitive outcomes but a highly significant effect on cognitive outcomes except for mathematical and PPVT scores.

## Determinants of Child Noncognitive and Cognitive Development

### *Noncognitive Outcomes*

Table 4 shows that household income has no significant effect on children's noncognitive outcomes. One exception is that children from high-income households may be more hyperactive, but this result is significant only at the 10 % level. Table 4 also reveals that child's gender, age, and health status are the most significant determinants of noncognitive outcomes. Boys have lower prosocial skills scores (by 0.3 SD) and face fewer emotional problems (by 0.09 SD) than girls; but they are more likely to be hyperactive (by 0.3 SD) and to have conduct and peer problems (by 0.12 SD and 0.07 SD, respectively) than girls. Prosocial skills improve and hyperactivity declines with age, but older children are also more likely to face emotional problems. Children with excellent health status are significantly more likely to exhibit good behavior, but the magnitude of the effect is small: they are more likely to be prosocial (by 0.08 SD), less likely to be hyperactive and have conduct problems (by 0.1 SD for both), and less likely to have peer and emotional problems (by 0.2 SD for both). Children from a family with both biological parents present and children from large households are also less likely to be hyperactive (by 0.13 SD) and to have peer problems (by 0.09 SD). Also, children from highly educated parents are less likely to be hyperactive (lowered by 0.13 SD if mother completed Year 12 and by 0.1 SD if father completed Year 12).

**Table 4** Results of the GMM estimator for noncognitive outcomes, Specification 5

| | Prosocial | | Hyperactivity | | Emotional Symptoms | | Conduct Problems | | Peer Problems | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variables | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE |
| Lagged Outcome | .20** | .02 | .35** | .02 | .31** | .02 | .18** | .02 | .31** | .02 |
| Log of Family Income | –.04 | .07 | .12† | .07 | –.09 | .08 | –.05 | .06 | .08 | .08 |
| Child's Gender (male = 1) | –.30** | .02 | .28** | .02 | –.09** | .02 | .12** | .02 | .07** | .02 |
| Low Birth Weight | .01 | .06 | –.00 | .05 | .02 | .05 | –.03 | .05 | –.003 | .05 |
| Aboriginal and Torres Straits Islander | –.10** | .03 | –.05* | .03 | .01 | .03 | –.15** | .02 | .01 | .03 |
| English Spoken at Home | –.01 | .05 | .08* | .04 | .05 | .04 | .05 | .04 | –.03 | .04 |
| Mother Completed Year 12 | –.01 | .03 | –.13** | .03 | –.01 | .03 | –.05† | .03 | –.05† | .03 |
| Father Completed Year 12 | .03 | .03 | –.10** | .03 | –.01 | .03 | –.04 | .03 | –.06* | .03 |
| Child Was Firstborn | –.01 | .03 | –.06† | .03 | .11** | .03 | .04 | .03 | .01 | .03 |
| Mother's Age | .02 | .02 | –.04* | .02 | –.01 | .02 | –.04* | .02 | –.06** | .02 |
| Mother's Weekly Work Hours | .03* | .01 | –.001 | .01 | –.02† | .01 | .01 | .01 | .01 | .01 |
| Father's Weekly Work Hours | .01 | .01 | –.03** | .01 | .001 | .01 | –.01 | .01 | –.002 | .01 |
| Child's Age (months) | .14** | .02 | –.07** | .02 | .07** | .02 | –.02 | .02 | –.02 | .02 |
| Child Has Excellent Health | .08** | .02 | –.10** | .02 | –.22** | .02 | –.09** | .02 | –.18** | .02 |
| Household Size | .01 | .02 | –.08** | .01 | –.07** | .01 | .01 | .01 | –.06** | .01 |
| Both Biological Parents at Home | .08 | .06 | –.13* | .05 | –.001 | .05 | .001 | .05 | –.09† | .06 |
| Parental Investment | | | | | | | | | | |
| Housing tenure | –.05† | .03 | –.01 | .03 | –.05† | .03 | –.01 | .02 | –.01 | .03 |
| Out-of-home activities index | .03** | .01 | –.02* | .01 | –.02 | .01 | –.02† | .01 | –.02† | .01 |
| Has computer at home | .01 | .06 | .04 | .05 | –.02 | .06 | –.08† | .04 | –.11† | .06 |

**Table 4** (continued)

| | Prosocial | | Hyperactivity | | Emotional Symptoms | | Conduct Problems | | Peer Problems | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variables | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE |
| Number of children's books in home | .02† | .01 | –.02* | .01 | –.001 | .01 | .001 | .01 | –.003 | .01 |
| Parental Stress | | | | | | | | | | |
| Mother has excellent health | .02 | .02 | –.02 | .02 | .01 | .03 | .002 | .02 | –.05* | .02 |
| Father has excellent health | .05* | .02 | –.06** | .02 | –.01 | .02 | –.03† | .02 | –.05* | .02 |
| Mother's parenting style | .17** | .01 | –.07** | .01 | –.01 | .01 | –.09** | .01 | –.03* | .01 |
| Father's parenting style | .03** | .01 | –.04** | .01 | –.02† | .01 | –.04** | .01 | –.04** | .01 |
| Mother's depression scale | .08** | .01 | –.11** | .01 | –.14** | .02 | –.11** | .01 | –.09** | .01 |
| Father's depression scale | .01 | .01 | –.02* | .01 | –.04** | .01 | –.02* | .01 | –.04** | .01 |
| Neighborhood | | | | | | | | | | |
| Neighborhood facilities | –.03** | .01 | .02* | .01 | .01 | .01 | .01 | .01 | .03** | .01 |
| % completed Year 12 | –.03 | .02 | –.04† | .02 | .001 | .02 | –.01 | .02 | –.02 | .02 |
| % English-speaking | .01 | .02 | –.04** | .01 | –.03* | .01 | –.03† | .01 | –.02 | .01 |
| Constant | .12 | .10 | .001 | .08 | .09 | .09 | –.09 | .08 | .28** | .09 |
| Number of Observations | 7,380 | | 7,380 | | 7,380 | | 7,380 | | 7,378 | |
| Sargan Test $p$ Value | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| Number of Instruments | 121 | | 121 | | 121 | | 121 | | 121 | |

†$p \leq .10$; *$p \leq .05$; **$p \leq .01$

Most of the variables representing parental investment are either insignificant or significant at 5 % or 10 % with a modest effect. Among the variables representing parental stress and neighborhood characteristics, most of the variables significantly affect noncognitive outcomes of children. For example, children whose parents have better physical and mental health are less likely to have behavior problems and more likely to have good prosocial skills. In particular, a 1 SD reduction in mother's depression scale is associated with an improvement of about 0.1 SD in prosocial skills and a reduction of about 0.1 SD in hyperactivity and conduct, emotional, and peer problems. The effects of father's depression have a similar sign but smaller magnitude. For example, a 1 SD reduction in the depression scale of father is associated with an increase in hyperactivity, emotional symptoms, conduct problems, and peer problems (by 0.02 to 0.04 SD, or 2.5 to 5 times smaller than effects of mother's depression scale). Also, father's depression scale has no significant effect on children's prosocial skills.

Positive parenting significantly reduces the probability of hyperactivity and conduct problems. Mother's parenting style has more positive effects than father's parenting style.

Good neighborhood characteristics (i.e., more facilities and a higher percentage of neighborhood residents who speak English) are also associated with fewer behavior problems, but the effects of these characteristics have small magnitudes and modest significance levels. For example, a 1 SD increase in the percentage of residents who speak English is associated with reduction in hyperactivity (by 0.04 SD), emotional problems (by 0.03 SD), and conduct problems (by 0.03 SD). Also, children in neighborhoods with poor infrastructure have lower prosocial skills and a higher chance of having behavior problems: a 1 SD decrease in infrastructure (with lower scores indicating better infrastructure) is associated with a 0.03 SD reduction in prosocial skills. In particular, parental stress and neighborhood characteristics along with other factors (such as child's age, gender, and health; parental education; and presence of both biological parents at home) play a significant role in mediating the effect of income on children's noncognitive development.

For children in the B cohort, child's physical health is the most significant determinant of child behavior and noncognitive skills. For example, children with excellent health have higher prosocial skills (by 0.06 SD) and lower scores for behavior problems (0.08 SD lower for hyperactivity and 0.12 SD lower for being a bullying perpetrator). Mother's depression and parenting style have similar effects: a reduction in mother's depression scale score and an increase in warm parenting style activities (e.g., frequency of kissing or hugging children) are associated with better noncognitive outcomes for their children. However, we did not find significant effects of father's depression scale score and parenting style.

We also examine the effects of income on other noncognitive outcomes—self-efficacy, bullying perpetrator, and bullying victim—using an OLS estimator, given that these outcomes are available for only one wave. Table 5 shows that income has a positive effect on self-efficacy (significant only at 10 %) but no effect on bullying. Gender and age are the most significant factors contributing to these noncognitive measures. In particular, girls have lower overall self-efficacy scores (by 0.22 SD). Boys have higher scores for both bullying perpetrator (by 0.27 SD) and bullying victim (by

**Table 5** Results of the OLS estimator for additional noncognitive outcomes

| | Self-Efficacy | | Bullying Perpetrator | | Bullying Victim | |
|---|---|---|---|---|---|---|
| Variables | Coef. | SE | Coef. | SE | Coef. | SE |
| Log of Family Income | 0.03† | 0.02 | –0.004 | 0.02 | –0.01 | 0.02 |
| Child's Gender (male = 1) | –0.22** | 0.02 | 0.27** | 0.03 | 0.19** | 0.03 |
| Low Birth Weight | 0.03 | 0.06 | –0.03 | 0.06 | –0.06 | 0.06 |
| English Spoken at Home | –0.03 | 0.03 | 0.01 | 0.06 | 0.16** | 0.06 |
| Mother Completed Year 12 | 0.11** | 0.03 | –0.01 | 0.04 | –0.11** | 0.04 |
| Father Completed Year 12 | 0.06* | 0.03 | –0.04 | 0.03 | –0.06† | 0.03 |
| Child Was Firstborn | 0.05 | 0.04 | –0.03 | 0.04 | 0.05 | 0.05 |
| Mother's Age | –0.06** | 0.02 | 0.02 | 0.02 | –0.02 | 0.02 |
| Mother's Weekly Work Hours | –0.01 | 0.01 | –0.001 | 0.02 | 0.02 | 0.02 |
| Father's Weekly Work Hours | –0.02 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 |
| Child's Age (months) | –0.34** | 0.05 | 0.05* | 0.03 | –0.23** | 0.03 |
| Child Has Excellent Health | 0.10** | 0.03 | –0.03 | 0.03 | –0.07* | 0.03 |
| Household Size | –0.01 | 0.02 | –0.00 | 0.02 | –0.02 | 0.02 |
| Both Biological Parents at Home | 0.19** | 0.06 | –0.14† | 0.08 | –0.12 | 0.07 |
| Parental Investment | | | | | | |
| Housing tenure | –0.01 | 0.03 | –0.06 | 0.04 | –0.12** | 0.04 |
| Out-of-home activities index | 0.03* | 0.01 | –0.01 | 0.01 | –0.02 | 0.02 |
| Has computer at home | –0.06 | 0.07 | –0.09 | 0.10 | –0.18† | 0.10 |
| Number of children's books in home | –0.02 | 0.02 | 0.01 | 0.02 | 0.03† | 0.02 |
| Parental Stress | | | | | | |
| Mother has excellent health | 0.002 | 0.03 | –0.004 | 0.03 | 0.02 | 0.04 |
| Father has excellent health | –0.01 | 0.03 | 0.07† | 0.04 | 0.02 | 0.04 |
| Mother's parenting style | 0.07** | 0.01 | –0.01 | 0.01 | –0.02 | 0.02 |
| Father's parenting style | 0.07** | 0.01 | –0.03* | 0.01 | –0.02 | 0.02 |
| Mother's depression scale | 0.04* | 0.02 | –0.03† | 0.02 | –0.06** | 0.02 |
| Father's depression scale | 0.02 | 0.01 | –0.01 | 0.02 | –0.02 | 0.02 |
| Neighborhood | | | | | | |
| Neighborhood facilities | 0.01 | 0.01 | 0.005 | 0.01 | 0.01 | 0.02 |
| % completed Year 12 | 0.001 | 0.02 | –0.03† | 0.02 | –0.03 | 0.02 |
| % English-speaking | 0.04* | 0.02 | –0.04* | 0.02 | –0.01 | 0.02 |
| Constant | 0.25* | 0.11 | –0.06 | 0.13 | 0.45** | 0.14 |

†$p \leq .10$; *$p \leq .05$; **$p \leq .01$

0.19 SD). Age has mixed effects: older children have lower scores on self-efficacy and being a bullying victim, but they have higher scores on being a bullying perpetrator. Children whose mothers had 12 years of education have a higher self-efficacy score (by 0.11 SD) and a lower score for being a bullying victim (also by 0.11 SD). The results for children whose fathers had 12 years of education are the same, but the magnitude is only 0.06 SD for both higher self-efficacy and lower bullying victim scores.

*Cognitive Outcomes*

Table 6 shows that income significantly affects children's cognitive development. On average, a 1 SD increase in log of household income is associated with a 0.29, 0.26, 0.23, and 0.24 SD increase in PPVT, MR, literacy, and mathematical scores, respectively. This result is consistent with a recent study (Washbrook et al. 2014) that found that income has the greatest effect on child cognitive development compared with other indicators of child development, such as noncognitive development and health. Child and household characteristics are also significant determinants of children's cognitive development. It is surprising that gender still plays a significant role in determining cognitive outcomes: boys achieve higher PPVT and mathematical scores than girls (by 0.05 SD), but their MR and literacy scores are lower than those of girls (by 0.07 and 0.19 SD, respectively). Low stock of initial health status seems to create long-lasting effects on child development: children with low birth weight achieve significantly lower cognitive scores (by about 0.1 SD) for all four measures of cognitive outcomes. Children from Aboriginal and Torres Strait Islander families are more likely to have lower MR (by 0.13 SD), literacy (by 0.3 SD), and mathematical (by 0.1 SD) scores; but their PPVT scores do not significantly differ from those of other children. Another surprising result is that children from English-speaking households have considerably worse MR, literacy, and mathematics scores (lower by 0.2 SD). One possible explanation is that migrant families from some cultural groups (e.g., Asian "tiger moms") pay more attention to their children's scholarly development. Parental education also strongly affects children's cognitive outcomes. Children whose father or mother completed Year 12 have higher cognitive scores (by about 0.1 SD).

Variables in parental investment become more influential for cognitive outcomes compared to noncognitive outcomes. Among the variables proxied for parental investment, computers and books play the most significant role in improving cognitive outcomes of children, but the magnitude of computer is larger: students with a computer at home achieve higher MR and mathematics scores (by 0.15 and 0.13 SD, respectively). Housing tenure, proxied by a dummy variable for whether the family owns a house outright, is also associated with higher literacy and mathematical scores (by 0.07 SD for both). The indicators of parental stress provide either unexpected or insignificant results for cognitive skills. Among the neighborhood characteristics, only the percentage of residents who speak English is significantly associated with an increased probability of having better PPVT, with a marginal effect of 0.05 SD.

In summary, our results indicate that parental stress and neighborhood characteristics are important for children's noncognitive development, whereas parental investment is important for children's cognitive development. Child's age and gender, mother's education, parents' physical and mental health, positive parenting, child's own health, and presence of both biological parents in the home are the most important factors for children's noncognitive development. For cognitive development, in addition to family income, parents' education, and having a computer and children's books in the home (which are proxies for a cognitively stimulating environment) are important factors.

**Table 6** Results of the GMM estimator for cognitive outcomes, Specification 5

| | PPVT | | Matrix Reasoning | | Literacy Score | | Mathematical Score | |
|---|---|---|---|---|---|---|---|---|
| Variables | Coef. | SE | Coef. | SE | Coef. | SE | Coef. | SE |
| Lagged Outcome | .08* | .03 | .45** | .03 | .25** | .02 | .28** | .02 |
| Log of Family Income | .29** | .08 | .26** | .09 | .29** | .03 | .24** | .07 |
| Child's Gender (male = 1) | .05* | .02 | –.07** | .02 | –.24** | .03 | .05* | .02 |
| Low Birth Weight | –.14** | .04 | –.13** | .05 | –.10† | .06 | –.09† | .05 |
| Aboriginal and Torres Strait Islanders | .01 | .07 | –.13† | .08 | –.30** | .11 | –.10** | .02 |
| English Spoken at Home | .06 | .05 | –.18** | .05 | –.15** | .05 | –.23** | .04 |
| Mother Completed Year 12 | .04 | .03 | .05 | .03 | .10** | .04 | .11** | .03 |
| Father Completed Year 12 | .04† | .03 | .06* | .03 | .13** | .03 | .08** | .03 |
| Child Was Firstborn | .05 | .03 | –.02 | .04 | .07† | .04 | .05 | .03 |
| Mother's Age | .02 | .02 | .01 | .02 | .02 | .02 | .02 | .02 |
| Mother's Weekly Work Hours | –.04** | .01 | –.04** | .02 | –.03* | .01 | –.03* | .01 |
| Father's Weekly Work Hours | –.02 | .01 | –.02 | .01 | –.03* | .01 | –.01 | .01 |
| Child's Age (months) | .84** | .07 | .03 | .02 | .26** | .02 | .11** | .03 |
| Child Has Excellent Health | .01 | .02 | .01 | .02 | .04† | .02 | .05* | .02 |
| Household Size | –.04** | .01 | .003 | .02 | .002 | .02 | .03† | .01 |
| Both Biological Parents at Home | .03 | .05 | –.06 | .06 | –.02 | .07 | .01 | .06 |
| Parental Investment | | | | | | | | |
| Housing tenure | .03 | .03 | .02 | .03 | .07* | .03 | .07* | .03 |
| Out-of-home activities index | .003 | .01 | –.0004 | .01 | .02* | .01 | –.01 | .01 |
| Has computer at home | –.01 | .05 | .15* | .06 | .11† | .06 | .13† | .08 |
| Number of children's books in home | .07** | .02 | .02 | .02 | .05** | .02 | .01† | .01 |
| Parental Stress | | | | | | | | |
| Mother has excellent health | –.04† | .02 | –.003 | .03 | –.02 | .03 | .02 | .03 |
| Father has excellent health | –.003 | .02 | –.02 | .03 | –.05† | .03 | –.05† | .03 |
| Mother has warm parenting style | –.01 | .01 | –.02 | .01 | .02† | .01 | .004 | .01 |
| Father has warm parenting style | –.001 | .01 | –.01 | .01 | –.003 | .01 | –.01 | .01 |
| Mother's depression scale | –.02† | .01 | –.07** | .02 | .01 | .01 | –.01 | .01 |
| Father's depression scale | –.02† | .01 | –.01 | .01 | .004 | .01 | –.01 | .01 |
| Neighborhood | | | | | | | | |
| Neighborhood facilities | .004 | .01 | .01 | .01 | –.01 | .01 | –.01 | .01 |
| % completed Year 12 | .01 | .02 | –.01 | .03 | –.05† | .03 | –.04† | .02 |
| % English-speaking | .05** | .02 | –.0005 | .02 | –.02 | .02 | –.01 | .02 |
| Constant | –.002 | .10 | –.002 | .10 | –.06 | .11 | –.14 | .10 |
| Number of Observations | 3,545 | | 5,687 | | 5,171 | | 5,368 | |
| Sargan Test $p$ Value | 0.00 | | 0.00 | | 0.00 | | 0.00 | |
| Number of Instruments | 81 | | 110 | | 121 | | 121 | |

†$p \leq .10$; *$p \leq .05$; **$p \leq .01$

## Conclusions

This article examines the association between household income and child outcomes using a system GMM method to account for the potential endogeneity of income and unobserved individual heterogeneity. It investigates whether the relationship between child outcomes and parents' income is mediated by parental investment, parental stress, and neighborhood characteristics. One of the unique contributions of this study is our inclusion of previous outcomes in the model of child development, which have been largely ignored in previous empirical studies of children's cognitive and noncognitive development. Because of this dynamic specification (i.e., inclusion of a lagged outcome among the covariates), our results are less likely to suffer from upward bias, which could be the case for most of the previous studies that used a static specification. We find that the parameters of previous outcomes are highly significant, providing strong support for the skill formation theory proposed by Heckman (2007) and Cunha et al. (2010).

Results from the preferred model (GMM estimator, Specification 5) confirm that family income has a significant positive effect on most cognitive outcomes for children, but income effects on noncognitive or behavioral development are mostly nonsignificant. We find that parental stress plays a significant role in mediating the effect of income on noncognitive development. Also, parental physical and mental health, parenting style, child characteristics (age, gender, and health), and household characteristics (presence of both biological parents at home, parents' education) are the important determinants of children's noncognitive development. Other factors, such as child's gender, age, birth weight, parental education, a computer in the home, and number of children's books at home, are the most important factors for child cognitive development. Overall, we found moderate support for the parental investment theory and great support for the parental stress and neighborhood theories for noncognitive outcomes; we found the opposite for cognitive outcomes, for which the results support the parental investment theory to a greater extent.

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