Child Cognitive and Non-Cognitive Development: Does Money Matter?

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Abstract

This paper investigates the routes through which family income may affect children's cognitive and non-cognitive development by exploiting comprehensive information from the Longitudinal Study of Australian Children (LSAC). Our paper takes a new approach to combine economists' and psychologists' views in modelling the relationship between household income and child development outcomes. Using a dynamic panel data framework, this research contributes to the literature by examining the impact of contextual factors in child health and development. Our results reveal that when a basic set of covariates is used family income is strongly associated with child cognitive and behavioural outcomes. However, when indicators of parental investment, parental stress, parenting practice and neighbourhood characteristics are controlled for, the income coefficients are no longer significant for most children's outcomes. We also find that income has higher effects on children cognitive development than upon their non-cognitive development. Our results suggest that the effect of income can be mediated by the family's ability to invest in materials, services and a home environment, parenting practice and neighbourhood characteristics. We find that parental mental health and parenting practice are particularly important for childrens' behavioural and emotional development. When unobserved heterogeneity is controlled for using a random and fixed effect estimators, we did not find any significant association between family income and cognitive and emotional and behavioural development of children. We also find evidence of the dynamic nature of children's human capital investment that current cognitive and non-cognitive outcomes of a child are significantly related to previous outcomes.

Key words: Family income, Behavioural development, Health inequalities, Panel data, Australia
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1 Introduction

Understanding the origin of health and development deficits of low-income children is not only important for the scholarship of knowledge, but it is also vital for informing cost efficient policies to improve outcomes for these children. There is a clear policy debate whether we should target direct income transfers to the family or whether we should instead target the factors that may mediate the relationship between income and child outcome. Such policy debates can only be resolved by constructing a proper conceptual framework that can be backed by empirical evidence, which is the focus of this paper.

Child poverty rates are higher in Australia than many OECD countries. According to a UNICEF study Australia ranked 13^{th} out of 24 OECD nations for children's material well being [1], finding that about11.6% of Australian children are living in poverty(Bradshaw et al., 2007). The Luxembourg Income study reported that Australia's child poverty rate is 15% and that Australia ranks 21 out of 30 upper income nations in terms of 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, behavioural and health outcomes than their wealthier counterparts (Case et al. (2002); Currie et al. (2007); Dooley and Stewart (2007); Khanam et al. (2009); Violato et al. (2010)). The poorer outcomes of less wealthy children can be attributed to low incomes if there are causal relationships between children's outcomes and family income. This has implications for the inter-generational transmission of poverty. Children who have worse cognitive, behavioural and health outcomes may be more likely to have less education and to have lower earnings as adults, and are more likely to raise their children in poor environments. This line of understanding suggests that policies and programs that improve the outcomes of low income children, and thus, break the links between poverty across generations, are desirable.

This paper investigates the routes through which family income may affect children's cognitive and non-cognitive development by exploiting comprehensive information from the Longitudinal Study of Australian Children (LSAC). It contributes to the literature in the following ways. First, compared to the conventional theoretical framework that is dominated by 'investment theory' (Becker, 1981; Becker and Tomes, 1986) and 'family stress theory' (Yeung et al., 2002;Smith and Brooks-Gunn, 1997), this study incorporates neighbourhood effects in the model of child development. Second, this paper investigates the dynamic nature of children's human capital investment, which has rarely been investigated empirically in children's cognitive and behavioural development literature in particular. To the best of our knowledge, only Heckman and colleagues (e.g., Cunha and Heckman, 2007) examine the dynamic nature of children's skill formation theoretically. The paper fills this gap in the empirical literature of children's cognitive and non-cognitive development. It focuses on modelling the evolution process of child health and development from childhood to adolescence, taking advantage of longitudinal data. Third, this paper takes a new approach to combine economists' and psychologists' views to model income and child outcomes. Economics literature has not extensively investigated the factors that are outside of economics such as parental stress, parenting style, family functioning and neighbourhood

[1] It combines relative child income poverty, parents' joblessness and child deprivation.

effects. By incorporating these factors into a dynamic panel data framework, this research contributes by examining the impact of contextual factors in child health and development.

2 Literature review

A growing body of literature, mainly from North America, reports that children in low income families produce worse cognitive, non-cognitive and health outcomes than children in high income families Brooks-Gunn and Duncan (1997); Blau (1999a); Case et al. (2002); Currie and Stabile (2003); Dooley and Stewart (2007); Currie et al. (2007); Khanam et al. (2009); Violato et al. (2010). Recent research concerned with whether and why income is associated with child cognitive and non-cognitive development (Brooks-Gunn and Duncan, 1997; Duncan et al., 1998; Mayer, 1997). There is disagreement among scholars about the causality and magnitude of family income on child outcome. It is not always clear whether the differences between poor and non poor children is because of income itself or other correlates of income such as parental education, health and single parenthood. Economic literature mainly focuses on investigating appropriate models to take into account the potential endogeneity of income. For example, higher motivation in parents may lead to higher income and also encourage their children to do well in school, and also to put efforts to child's non-cognitive achievement as well. Failure to take these factors into account may lead to biased estimates.

Among economics studies, Blau (1999b) and Mayer (1997) were the first to focus on the endogeneity of income. Using a fixed effect estimator to control for within generation and multigenerational differences in families, Blau (1999b) found only small effect of current income on child outcomes. Using an instrumental variable (IV) approach, and controlling for a variety of factors that might confound income estimates, Mayer (1997) found that the effect of income on child outcome was largely spurious in ordinary least square (OLS) estimation. Adopting a variety of approaches (e.g, fixed effects model, instrumental variable approach) some recent studies also found smaller effects of income on child outcome (Shea, 2000; Aughinbaugh and Gittleman, 2003; Khanam et al., 2009). On the contrary, Maurin (2002) and Dahl and Lochner (2005) found larger effects of income using data from the US and French respectively. Using a fixed effect IV strategy, Dahl and Lochner (2005) found that an increase in annual income of $1,000 has increased math and reading test scores by 2% and 3.6% of a standard deviation of the population. More importantly, improvement in test scores were higher for children from disadvantaged families.

The literature from developmental psychology focused on examining the extent and depth of poverty on child development and found that the effect of income is much higher for a child's cognitive development compared to non-cognitive development (e.g. Duncan et al., 1998). Also, effects of income is largest on early childhood development (e.g., Brooks-Gunn and Duncan, 1997; Morris et al., 2004). There is also evidence that the effect of income on children's outcomes has a steep slope at lower levels of income distribution (Dearing et al., 2006; Alderson et al., 2008). The evidence on how income is translated into better childhood outcomes is rather scarce, particularly in economics literature. The little evidence that is available is mostly from developmental psychology (e.g. Guo and Harris, 2000; Yeung et al., 2002). These two studies focus only on the investment and family process perspectives, whereas this study will focus on a far richer array of child outcomes than previous research to give a

more comprehensive picture of these contrasting pathways.

3 Methodology

3.1 Conceptual framework

The existing theoretical framework on the effects of income on child outcome is dominated by two complementary theories: Investment theory and Family stress theory. The investment theory (Becker, 1981; Becker and Tomes, 1986) postulates that parents' are concerned about the future well-being of their children, so they invest material and time input in their children's human capital in a way that will maximise their utility. In this process parental biological/genetic traits are also transmitted to their children. Any altruistic parent wants to invest maximum amount of resources for the well being of their children. However, income can affect the resources that parents can provide for their children. Parents from high socio-economic status (SES) are able to buy more materials resources such as better housing, good food, childcare, after school care and more books, which in turn provide a cognitively stimulating environment for the children.

Family stress theory posits that income affects parents' ability to be a good parent, because economic hardships affect parents' psychological well-being adversely. Psychological stressed parents are less able to lead a better family functioning and practice an effective parenting style that are conducive to child development (Yeung et al., 2002; Yamauchi, 2010). Evidence demonstrates that economic hardship diminishes parental abilities to provide warm and disciplined parenting and contributes to harsh parenting (Smith and Brooks-Gunn, 1997).

We develop a model of child outcome that combines investment perspective (ability to invest in materials, services and a home environment); family stress theory (highlighting the role of stress, mental health and parenting practice) and neighbourhood effect perspective. The reason for including neighbourhood effects in our model is that evidence suggests that neighbourhood has a strong effect on child development (see, for example, Pebley and Sastry, 2004; Contoyannis and Li, 2011).

Our theoretical model for the analysis of child outcome derives from household production theory, which originated in the work of Becker (1965) and Becker and Lewis (1973). We consider a model, where a child is a passive participant in the production of its own human capital. We assume that parents get utility from the human capital of their child and can use total time available for market and non-market activities. Therefore, parents use inputs of market goods and their own time and resources to produce child outcome.

Following the above arguments and in the vein of Becker (1981), Rosenzweig and Schultz (1982; 1983), Becker and Tomes (1986), Rosenzweig and Wolpin (1988) and Currie (2009) we suppose that the utility function (U_t) for a family at time t can be written as[2]

$$U_t = U_t(Q_t, C_t, Y_t, T_t^L, \delta_t^u, \varepsilon_t^u) \tag{1}$$

where Q_t is a measure of child development outcomes such as cognitive and non-cognitive development, C_t is a set of factors that affect child development (e.g., books, toys, child care, school, home envi-

[2]The following section is heavily drawn from Khanam et al (2009)

ronment and neighbourhood), Y_t represents other commodities consumed by the household, $T_t^L$is the leisure time, δ_t^u and $\varepsilon_t^u$are exogenous observable and unobservable factors respectively that influence the household's utility.

Child development outcome is produced according to the following production function

$$Q_t = Q_t(Q_{t-1}, C_t, T_t^Q, \delta_t^Q, \varepsilon_t^Q) \tag{2}$$

where $T_t^Q$is the amount of time used in the production of child quality, $\delta_t^Q$and $\varepsilon_t^Q$are respectively exogenous observable and unobservable variables such as household and neighbourhood characteristics. In our study, since the LSAC data set consists of data for only one child per family, may also pick up unobservable fixed family characteristics. In line with the proposal of Heckman (2007) that the stock of quality depends on the stock of child's outcome in a preceding period, we include a lagged value of Q.

The budget constraint of the household is

$$I_t = w_t T_t^w = P_t^C C_t + P_t^Y Y_t \tag{3}$$

where I_t is family income, T_t^w is the time spend to earn wage income w, P_t^C, and P_t^Y are respectively the wage rate, prices of C_t and Y_t.

The household also faces a time constraint

$$T^t = T_t^L + T_t^Q + T_t^w \tag{4}$$

where T^t is the total fixed amount of time available (e.g., 24 hours per day).

Substituting the solutions for C and T^Q into (2) yields Frisch demand function for Q_t that depends on Q_{t-1}

$$Q_t = Q(Q_{t-1}, w_t, P_t^C, P_t^Y, \delta_t^u, \delta_t^Q, \varepsilon_t^u, \varepsilon_t^Q) \tag{5}$$

A household maximises its intertemporal utility with the discount rate ρ, i.e.,

$$\underset{Q_t, C_t, T_t^l, T_t^w, T_t^Q}{Max} \sum (1+\rho)^{-t} U_t \tag{6}$$

subject to the budget and time constraints above, plus the condition of positive initial stock of child quality ($Q_0 > 0$).

Taking the first derivatives of the Lagrangian function with respect to child quality, and taking its lag repeatedly until the initial condition is met, produces the Marshallian demand function for child health:

$$Q_t = Q(Q_0, X_k, w, P_t^C, P_t^Y, \delta_t^u, \delta_t^Q, \varepsilon_t^u, \varepsilon_t^Q) \tag{7}$$

where $X = \delta^u, \delta^Q, w, P^C, P^Y, \varepsilon^u, \varepsilon^Q$ and $k = 1, 2 \ldots\ldots\ldots\ldots t-1$.[3]

Alternatively, we could also start with (5)

$$Q_t = Q(Q_{t-1}, X_k, w_t, P_t^C, P_t^Y, \delta_t^u, \delta_t^Q, \varepsilon_t^u, \varepsilon_t^Q) \tag{8}$$

The above model is consistent with the existing 'investment theory' and 'family stress theory' presented above. In addition, we added other determinants of the household income and child outcome relationship, which can be referred to as 'neighbourhood effect theory'. This model provides us with some insights into why parental income, education and neighbourhood conditions might affect child development. Neighbourhood effect theory posits that children living in poor neighbourhood perform worse in school, and have lower skills, and more behavioural and health problems even after controlling for household characteristics (Pebley and Sastry, 2004; Contoyannis and Li, 2011). Our model assumes that richer families can afford to live in better neighbourhoods (i.e. , less incidence of crime, better public facilities, and higher ratio of educated residents).

In a model of life cycle skill formation, Heckman (2007) stressed on the dynamic nature of skill formation, particularly on the way Q_t depends on Q_{t-1}. In many of his writings he argued that skill begets skill and motivation begets motivation through a multiplier process. Cunha et al. (2010) developed a model of cognitive skills, auguring that human capital investment exhibits both 'dynamic complementaries' and 'self productivity'. For example, dynamic complementaries state that investments in period t is more productive, if there is high level of capacity in period $t-1$. Self productivity implies that skill attainment in one period raises skill attainment in the next period. In our model we accommodate these ideas including past capacity, Q_{t-1} as a function Q in the current capacity.

3.2 Empirical specification

The following models that represent child health and development production functions will be estimated in this study. It is assumed that child outcome is produced by combining parental material and time inputs. Child health and development outcomes are also functions of family stress and broader community characteristics.

$$Q_{it} = \alpha_0 + \alpha_1 I_{it} + \alpha_2 Z_{it} + \alpha_3 PI_{it} + \alpha_4 FS_{it} + \alpha_5 NF_{it} + \mu_{it} \tag{9}$$

$$Q_{it} = \alpha_0 + \alpha_1 I_i t + \alpha_2 Q_{it-1} + \alpha_3 Z_{it} + \alpha_4 PI_{it} + \alpha_5 FS_{it} + \alpha_6 NF_{it} + \mu_{it} \quad (i = 1, \ldots\ldots N; t-2 \ldots\ldots T) \tag{10}$$

Equations (9) and (10) are the static and dynamic specification of the child outcome functions respectively, where, Q_{it} is the latent variable of child outcome at time t, and Q_{it-1} is an indicator of a child's outcome in the previous period. Z_{it} is a set of standard controls that include parental input and characteristics other than income, together with child characteristics at time t. The term μ_{it} is a time

[3] See, for example, J.Currie (2009) for a similar derivation of both the Frisch and Marshallian demand functions for child health

and individual-specific error term which is assumed to be normally distributed and uncorrelated across individuals and over time. PI_{it}, FS_{it} and NF_{it} represent a set of variables for parental investment, family stress and neighbourhood effects respectively. The estimation of (9) and (10) might provide us with inconsistent estimates because of endogeneity of income and lagged dependent variable, when I and Q_{it-1} are correlated with μ_{it}. In the first stage, in cross sectional setting, we apply the 'mopping-up' approach by (Gregg et al., 2005), which exploit a variety of variables to minimise residual heterogeneity so that the error term in (9) and (10) are orthogonal to income, and hence reduce estimation bias. This approach is relevant to our study due to the comprehensive information from the LSAC. However, we acknowledge that this approach might not be sufficient to control for individual unobserved heterogeneity.

To address this issue, one can choose a random effect or a fixed effect estimator. While random- and fixed-effects estimators in with continuous dependent variables are well established, estimators for ordered dependent variable were introduced later and are still under refinement. Thus, we focus on discussing the choice of estimators for ordered dependent variables. Due to the presence of a time-invariant individual unobserved characteristic, the error term in (9) and (10) has two components:

$$\mu_{it} = u_i + e_{it} \tag{11}$$

where u_i is a child-specific and time-invariant unobserved effect, and e_{it} is a random error term. A random effect estimator, proposed by Mundlak (1978), assumed that the unobserved individual effect is correlated with the between-wave average of exogenous covariates

$$\mu_i = \rho_0 + \rho_1 \bar{Z}_i + e_i \tag{12}$$

where $\bar{Z}_i = \frac{1}{w_i} \sum_{j=1}^{w_i} Z_{it}$ ($w_i = 1, 2, 3, 4$ is the number of waves household i participated in the survey) and $r_i | \bar{X}_i \sim N(0, \sigma_r^2)$. Contoyannis et al. (2004) suggested that the individual effect may, in fact, be associated with the initial condition of the dependent variable. In this study, we choose the cognitive/non-cognitive outcomes in Wave 1 as a proxy for the initial health stock, and hence the individual effect is now specified as

$$\mu_i = \rho_0 + \rho_1 \bar{Z}_i + \rho_2 Q_{i1} + e_i \tag{13}$$

where Q_{i1} is the set of dummy variables for the initial condition (proxied by the child development outcome in Wave 1).

One advantage of the random effect estimator is that the between-wave average of income becomes a convenient proxy for permanent income in the interpretation of its relationship on child health. The main disadvantage of this random effect estimator is that it demands an assumption about the relationship between individual effects and other covariates, as well as initial conditions.

One can also control for unobserved individual heterogeneity using fixed effect estimators such as conditional fixed effect ordered logit estimators by Das and van Soest (1999), Ferrer-i Carbonell and Frijters (2004) and Baetschmann et al. (2011). Essentially, all these three fixed effect estimators involve the dichotomisation of the ordered limited dependent variable and implement the conditional fixed effect logit estimators by Chamberlain (1980). In particular, Das and van Soest (1999) dichotomised the original K ordered category into $K-1$ binary variable and then combined the coefficients weighted

by their variances; Ferrer-i-Carbonell and Frijters (2004) chose to estimate an optimal cut-off point and recoded the original K-ordered into one binary dependent variable; and Baetschmann et al. (2011) estimated jointly the $K-1$ dichotomised variable by creating a new data set where each individual is repeated $K-1$ times. Unfortunately, in a dynamic setting like Equation (10), the Chamberlain (1980)'s conditional logit fixed-effect estimator and its variations could produce biased estimates unless it is adjusted by an approach proposed by Carro (2007). Essentially, this approach involves the estimation of an estimation of two fixed effects: the individual unobserved fixed effects and the fixed-effect for individualised cut-off points. The application of this method to the current study is not identified because the numbers of data point are less than the numbers of paramaters to be estimated.[4]

In summary, there are two main approach to control for unobserved individual effect: fixed effect and random effect. The random effect requires an assumption on initial condition and the correlation between the unobserved effects and means of exogenous variables whilst the fixed effect estimator does not require these assumptions because the unobserved individual effect will be conditioned out in the likelihood function as demonstrated by Chamberlain (1980). Estimators for ordered dependent variables generally dichotomise the original categorical variable and apply the Chamberlain's approach. In this study, we will focus on applying the random effect estimator due to our inability to apply the adjusted fixed effect estimators for dynamic specification.

4 Data and Variable Selection

4.1 Data and descriptive statistics

This study utilises data from the four waves of the nationally representative Longitudinal Study of Australian Children (LSAC) survey. The LSAC has comprehensive information about childrens cognitive and non-cognitive development, health outcomes, demographics, education, the relationship history of parents, parental health, parenting practices, financial factors, lifestyle, housing and neighbourhood attributes. The LSAC sampling frame consists of all children born in the selected primary sampling units 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 has so far involved with four waves of data collection for more than ten thousand children, approximately 5000 children from each cohort. The LSAC involves biennial follow-up of the enrolled households and will continue until at least 2018. In this study we focus on children of K-cohort because measures on child cognitive outcomes are more widely available for this cohort in all four waves of the survey.

4.2 Outcome variables

4.2.1 Measures of non-cognitive skills

We use Strengths and Difficulties Questionnaire (SDQ) to measure a child's behavioural develop-

[4] we have only four waves, thus only 3 data points per individual due to the use of lag dependent variable while most ordered child development outcomes of interest require from 4 cut-off points (e.g., 5-point Likert scale literacy and mathematical skills) to 9 cut-off points (e.g., SDQ social skills) plus an individual fixed effect.

Table 1: Descriptive statistics of outcome variables

Variables	Mean	Std.	Min	Max
SDQ pro-social scale	8.15	1.76	0.00	10.00
SDQ hyperactivity scale	3.30	2.32	0.00	10.00
SDQ emotional problems scale	1.70	1.77	0.00	10.00
SDQ conduct problem scale	1.70	1.72	0.00	10.00
SDQ peer problem scale	1.55	1.62	0.00	10.00
Matrix reasoning	10.58	3.00	1.00	19.00
PPVT	72.04	8.03	28.20	105.65
Language and literacy	3.46	1.40	1.00	5.00
Mathematical thinking	3.51	1.31	1.00	5.00

ment. We use five SDQ measures available in LSAC: 1) SDQ pro-social scale, (2) SDQ hyperactivity scale, (3) SDQ emotional problems scale, (4) SDQ conduct problems scale, and (5) SDQ peer problems. The SDQ pro-social scale was the sum of responses to five 3-point questions (1=not true, 2=somewhat true, 3=certainly true) questions: 'considerate of other's feelings', 'readily share with children', 'helpful if someone is hurt', 'kind to younger children', and 'often volunteer to help'. Higher score for SDQ pro-social scale indicates a positive attitude. Similarly, SDQ hyper activity scale is the sum of responses to five 3-point questions: not been able to stay still, constantly fidgeting, easily distracted, stopped to think before acting, and has a good attention span. Higher score for SDQ hyperactivity scale refers that the child is hyperactive. SDQ emotional problem scale was the sum of responses to 5 questions: 'complained of headache', 'often seemed worried', 'often been unhappy or tearful', 'nervous or easily lose confidence', and 'had many fears'. Higher score of SDQ emotional problem scale indicates a emotional problem. In contrast, SDQ conduct problem scale was calculated as the mean of responses to five 3-point Likert scale questions whether the child: 'has hot temper', 'not obedient, often fights', 'argumentative with adults', and 'been spiteful to others'. The mean score was then rescaled to make an integer from 0 to 10. Similarly, the SDQ peer problem scale was calculated as the rescaled mean of responses to five 3-point Likert scale questions: the child has been solitary, has no good friend, not liked by other children, bullied by children, and gets on better with adult. Higher score indicates a negative symptom except for SDQ pro-social scale, for which higher score indicates a positive outcome. Table 1 shows that children surveyed in LSAC achieved relatively good SDQ scores (i.e., high on pro-social scale and low on other SDQ scales).

All outcome variables examined in this study are collected from the responses of Parent 1, who is often the biological mother of the child. Children's behavioural outcome functions will be estimated by OLS in the first stage, then random effects model will be used to account for unobserved heterogeneity.

4.2.2 Measures of Cognitive Outcomes

We will use the following measures of a child's cognitive development.

Matrix reasoning test (MR): Children from wave 2 to 4 completed the Matrix Reasoning (MR) test from the Wechsler Intelligence Scale for Children, 4^{th} edition (WISC-IV). MR test assessed a child's non-verbal intelligence by presenting them with an incomplete set of pictures, which they needed to complete by selecting a picture from 5 different options.

The Peabody Picture Vocabulary Test (PPVT): The PPVT, which is only available in the first three waves, was an interviewer-administered test that assessed a child's listening comprehension ability for spoken words in standard English. The PPVT test required a child to show the picture that best represented the meaning of a stimuli word spoken by the examiner (Dunn and Dunn, 1997). The sample of words were: sawing, wrapping, cage, exercising, fountain, nest, claw, delivering, frame and envelope.

Literacy and **Mathematical** skills were answered by both parents and teachers. We selected the results by teachers, assuming they had more detailed knowledge of the child's academic performance. For literacy skills, in Wave 1 this variable was the sum of "yes" answers to various "yes/no" questions about the child's experiment with writing tool, awareness of writing directionality, interest in copying, ability to write their names, simple words and simple sentences. From Wave 2 onwards, this variables consisted of the average of answers to a 5-point Likert scale questions, such as the child's contribution to classroom discussions, understanding and interpreting stories, reading and writing comprehension. Similarly, mathematical skills in Wave 1 was measured as the number of "yes" answers to questions such as ability to sort and count, recognition of numbers and do simple addition. From Wave 2 onwards, this variable captured the average of a series of 5-point Likert scale questions on issues such as understanding of place and value, organise data in graph, estimation of quantities, and use of various strategies to solve mathematical problems. We group the variables into five point categorical order where higher values represent higher skills for mathematics and literacy. Table 1 shows that children covered in this survey achieved relatively high literacy, language skills and PPVT, on average.

4.3 Independent variables

The conceptual framework dictates us to use three sets of covariates such as the indicators of parental investment, family stress and neighbourhood, in addition to basic set of control variables. The basic set of controls include household income, age, education, health and employment status of parents' and characteristics of the child (dummies for gender, birth weight, and breastfeeding status); and characteristics of the households (i.e., household size, Aboriginal and Torres Strait Island (ATSI) status, and whether English is spoken at home). The investment theory of Becker (1981); Becker and Tomes (1986) are conceptualised using two types of indicators for parental investment: material (service) and parental time inputs. The material inputs include housing condition, housing tenure, number of children's books at home, home computer use and use of child care. The time inputs reflects the time that parents spend (invest) with their children in stimulating activities that improve child outcome. Parental time input includes home activities index (frequency of someone engaging in activities such as reading, drawing, and singing with the child), and out of home activities index (frequency of someone engaging activities such as going to cinema or sporting events) and use of a child care centre. The family stress hypothesis (Guo and Harris, 2000; Yeung et al., 2002) is conceptualised using indicators of parenting style, couple relationship (degree of happiness), parental emotional well being (mental health, difficulty of life) and parents' consumption of alcohol. The indicators of neighbourhood characteristics include: Socio-Economic Index for Areas (SEIFA), Neighbourhood belonging (civic engagement and positive feeling about neighbourhood), neighbourhood social capital scale physical characteristics of

the neighbourhood (parks, museum, traffic safety), and stability and demographics (including the percentage of persons with high education and income) of neighbourhood.

The descriptive statistics presented in Table 2 show that 60 percent of mothers have completed year 12, and 23 percent have a graduate degree, while the figure for fathers is 45 and 18 percent. However, the numbers of hours work per week of fathers (44.15) is more than double than that of mother (17.81) respectively. The set of controls for parental investment show a generally positive sign (i.e., on average, there's are good investment for children). One exception is that only 7 percent of children go to a child care centre, on average. However,we want to remind readers that these results for K-cohort, of whom many have already started school, would use child care centre. The richness of the LSAC data set enable us to select a wide range of independent variables in an attempt to minimise the chance of unobserved individual heterogeneity, apart from econometric treatment of using a random effect estimator.

Table 2: Descriptive statistics: Independent variables

Variables	Mean	Std.	Min	Max
Basic Control Variables				
Log of household income (permanent)	11.01	0.63	3.26	13.34
Mother's age at child birth (years)	32.81	5.24	17.00	64.00
Mother has year 12 education	0.60	0.49	0.00	1.00
Mother has a graduate degree	0.23	0.42	0.00	1.00
Mother has a postgraduate degree	0.07	0.25	0.00	1.00
Father has year 12 education	0.45	0.50	0.00	1.00
Father has a graduate degree	0.18	0.39	0.00	1.00
Father has a postgraduate degree	0.08	0.26	0.00	1.00
Mother's work hours per week	17.81	16.89	0.00	120.00
Father's work hours per week	44.15	16.95	0.00	168.00
Child age (months)	91.82	27.46	51.00	140.00
Sex (1=male)	0.51	0.50	0.00	1.00
Aboriginal and Torres Straits Islander (1=yes)	0.03	0.18	0.00	1.00
English spoken at home (1=yes)	0.89	0.32	0.00	1.00
Household size (log)	1.48	0.26	0.69	2.64
Both biological parents present at home (1=yes)	0.80	0.40	0.00	1.00
Low birth weight<2500gm	0.06	0.24	0.00	1.00
Breastfed (1=Yes)	0.72	0.45	0.00	1.00
Controls for parental investment				
Housing condition (1=clean)	0.93	0.25	0.00	1.00
Housing tenure (1=owned out right)	0.13	0.34	0.00	1.00
Home activities index[1]	1.55	0.53	0.00	3.00
Out of home activities index[2]	2.74	1.21	0.00	5.00
Number of children's book at home[3]	3.66	0.75	0.00	4.00
Has computer access at home (1=yes)	0.88	0.33	0.00	1.00
If the child go to child care centre (1=yes)	0.07	0.25	0.00	1.00
Controls for Parental Stress				
Mother is in good health (1=yes)	0.63	0.48	0.00	1.00
Father is in good health (1=yes)	0.59	0.49	0.00	1.00
Mother has warm parenting style (1=warm: often or always)	0.83	0.38	0.00	1.00
Father has warm parenting style (1=warm: often or always)	0.62	0.49	0.00	1.00
Relationship quality between parents	4.18	0.89	1.00	5.00
Depression scale (parent1)[4]	4.41	0.61	1.00	5.00
Stressful life events index[5]	1.65	1.92	0.00	22.00
Mother is problematic drinker (1=yes)	0.12	0.33	0.00	1.00
Father is problematic drinker (1=yes)	0.26	0.44	0.00	1.00

Table 2. Continued

Variables	Mean	Std.	Min	Max
Controls for Neighbourhood Effects				
Neighbourhood belonging scale [6]	2.14	0.58	1.00	5.00
Neibourhood social capital[7]	1.99	0.59	1.00	4.00
Neighbourhood facilities[8]	1.97	0.70	1.00	5.00
Percentage of people completed year 12 the neighbourhood	44.55	13.58	6.00	90.00
Percentage of people who is employed in the neighbourhood	61.67	7.53	19.00	94.00

Note:

Data are for K cohort only.

[1] *average of 3-point Likert scale (0=none, 3=every day) questions about the frequency of activities that parents and child do together at home such as read books, tell stories, draw pictures, play toys & games;*

[2] *Number of "yes" answers to questions about activities that the family do together such as go to cinema and sporting events;*

[3] *Categorical variables: 1=1-10 books; 2=11-20 books; 3=21-30 books; 4=more than 30 books (recode to 4=1, zero otherwise);*

[4] *means of 5-point Likert scale (1=all the time, 5=none) questions about the frequency of feeling: nervousness, hopeless, restless, sadness, worthless and lack of energy;*

[5] *Number of "yes" responses to questions such as suffered a serious illness, injury or assault, job lost, sought work unsuccessfully, had a major financial crisis, legal problems, valuable lost or stolen, relationship separation.;*

[6] *Average of 5-point Likert scale (1=strongly agree, 5=strongly disagree) questions about: ability to find information about local services, level of being informed about local affairs, level of feeling a strong sense of identity about the neighbourhood;*

[7] *Average of 4-point Likert scale (1=strongly agree, 4=strongly disagree) questions about the level of safety for children to play outside during the day, and the willingness of neighbours to help each other;*

[8] *Average of 4-point Likert scale (1=strongly agree, 4=strongly disagree) questions about the ability to access to: close, affordable, regular public transport; basic shopping facilities; and services such as banks, medical clinics, etc. in the neighbourhood*

5 Results and discussions

To investigate the effects of family income on child outcomes, we first use a basic set of controls (Specification 1). We then gradually include constructs for parental investments (Specification 2), family stress (Specification 3) and neighbourhood characteristics (Specification 4) in all regressions. Finally, we estimate a complete model (Specification 5) of child cognitive and non-cognitive development by including all controls from Specification 1 to Specification 5.

5.1 Cross-sectional estimates

In this section we estimate Equation 9 to examine the relationship between parents' income and children's cognitive and behavioural development using a cross-sectional analysis (i.e., data are analysed by waves) and standard regressions (ordered probit for categorical measures and OLS for continuous measures). The results from Table 3 show that the income parameter receives expected signs and reveals that parental income significantly affects children's behavioural development with the exception of the SDQ pro-social scale where significant results only appear in two instances. Also, the relationship between income and a child's behaviour did not change considerably across waves. However, it is clear that when a richer set of controls are used, there is less statistical confidence about the association between income and children's non-cognitive development. For example, when using Specification 5 which controls for basic household characteristics plus parental investment, family stress level and neighbourhood characteristics, the parameter of income is insignificant across all waves with the exception of

the SDQ conduct scale and the SDQ peer problem scale. This finding suggests that omitting variable bias may contribute to the findings that income significantly affects children's behavioural development. This finding further indicates that there are factors in 'investment construct', 'family stress' and 'neighbourhood characteristics' that combine to mediate the effects of income on child outcome. Table 3 shows that the role of 'family stress' is higher compared to parental investment and neighbourhood characteristics in reducing the significance and magnitude of income. However, the results do not show clear trend from which we can conclude that the influence of income vary by children's development stages.

Table 3: Cross-sectional regressions: The effect of income on child non-cognitive development

	SDQ pro-social scale	SDQ hyperactive scale	SDQ emotional scale	SDQ conduct scale	SDQ peer problem scale
Specification 1					
Wave 1 (4-5 Yrs)	0.01	***-0.084	***-0.100	***-0.136	***-0.104
Wave 2 (6-7 Yrs)	-0.073	-0.063	-0.048	-0.06	***-0.111
Wave 3 (8-9 Yrs)	0.006	-0.062	-0.053	-0.06	***-0.159
Wave 4 (10-11 Yrs)	**0.086	***-0.134	***-0.120	***-0.149	***-0.207
Specification 2					
Wave 1 (4-5 Yrs)	-0.027	-0.045	***-0.145	***-0.133	***-0.193
Wave 2 (6-7 Yrs)	-0.045	*-0.087	-0.031	**-0.105	***-0.141
Wave 3 (8-9 Yrs)	0.075	*-0.110	**-0.108	***-0.156	***-0.177
Wave 4 (10-11 Yrs)	0.031	-0.015	-0.039	*-0.079	0.007
Specification 3					
Wave 1 (4-5 Yrs)	0.013	***-0.133	***-0.125	***-0.150	***-0.202
Wave 2 (6-7 Yrs)	0.045	**-0.103	**-0.101	***-0.121	***-0.205
Wave 3 (8-9 Yrs)	0.042	*-0.070	**-0.095	***-0.154	*-0.078
Wave 4 (10-11 Yrs)	-0.084	-0.013	0.015	-0.02	-0.057
Specification 4					
Wave 1 (4-5 Yrs)	**0.087	***-0.132	***-0.125	***-0.171	***-0.227
Wave 2 (6-7 Yrs)	0.01	-0.038	*-0.075	***-0.086	-0.04
Wave 3 (8-9 Yrs)	-0.026	**-0.083	***-0.116	***-0.130	***-0.144
Wave 4 (10-11 Yrs)	-0.055	-0.043	0.015	-0.032	*-0.100
Specification 5					
Wave 1 (4-5 Yrs)	0.008	-0.054	-0.051	***-0.132	-0.06
Wave 2 (6-7 Yrs)	-0.051	-0.022	-0.062	*-0.080	***-0.123
Wave 3 (8-9 Yrs)	0.003	***-0.140	***-0.116	***-0.138	***-0.193
Wave 4 (10-11 Yrs)	0.006	-0.062	-0.095	-0.061	-0.098

*Note: Specification **1** includes basic set of covariates: log of household income, child's age, gender, birth weight, status of breastfeeding, education and hours of work of parents, age of mother at child birth and household size,English speaking household, and Aboriginal and Torres strait Islander.*

***Specification 2** includes Specification 1 plus indicators of parental investments: housing condition, housing tenure home activities index (frequency of someone engaging in activities (reading, drawing, and singing with the child), out of home activities index (activities that the family do together such as go to cinema and sporting events), number of children's books at home,home computer use, and use of child care*

***Specification 3** Specification 1 plus indicators of family stress: parenting style, relationship between parents, frequency of stressful event, parental mental and physical health and whether parents are problematic drinkers.*

***Specification 4** includes covariates in Specification 1 plus neighbourhood characteristics:), Neighbourhood belonging scale, Neighourhood social capital scale, Neighbourhood facilities,Percentage of people completed year 12 in the neighbourhood,Percentage of families earn <$1k/week in the neighbourhood, Percentage of people who is employed in the neighbourhood*

***Specification 5** includes all covariates from Specifications 1-4 .*

*Other covariates are skipped for brevity. Significant levels are: ***=1%, **=5% and *=10%*

The results in Table 4 reveal that income is positively and significantly associated with child cognitive development. Family income has a very significant positive effect on a child's cognitive development. The inclusion of a richer set of covariates (Specification 5) did not result in a less significant association between income and cognitive measures except for Wave 4. Comparing Table 3 and 4, we see that the magnitude of the income parameter is higher for a child's cognitive development than it is for non-cognitive outcomes.

Table 4: Cross-sectional regressions:The effect of income on child cognitive development

	Literacy score	Mathematical score	Matrix reasoning[1]	PPVT[2]
Specification 1				
Wave 1 (4-5 Yrs)	***0.137	***0.151		***0.755
Wave 2 (6-7 Yrs)	**0.112	*0.082	***0.325	***0.685
Wave 3 (8-9 Yrs)	***0.166	***0.203	***0.466	***0.526
Wave 4 (10-11 Yrs)	***0.129	***0.126	0.185	
Specification 2				
Wave 1 (4-5 Yrs)	***0.167	***0.127		***0.623
Wave 2 (6-7 Yrs)	***0.176	***0.211	***0.414	**0.390
Wave 3 (8-9 Yrs)	0.07	**0.121	*0.263	0.188
Wave 4 (10-11 Yrs)	0.055	0.07	**0.277	
Specification 3				
Wave 1 (4-5 Yrs)	***0.143	***0.178		***0.608
Wave 2 (6-7 Yrs)	**0.105	***0.141	*0.209	*0.371
Wave 3 (8-9 Yrs)	*0.088	**0.119	**0.287	***0.781
Wave 4 (10-11 Yrs)	**0.119	*0.093	0.245	
Specification 4				
Wave 1 (4-5 Yrs)	***0.128	***0.158		***0.552
Wave 2 (6-7 Yrs)	**0.109	***0.135	*0.211	***0.564
Wave 3 (8-9 Yrs)	***0.165	***0.121	**0.249	***0.633
Wave 4 (10-11 Yrs)	0.18	0.213	***0.533	
Specification 5				
Wave 1 (4-5 Yrs)	*0.087	**0.122		***0.657
Wave 2 (6-7 Yrs)	***0.165	**0.104	*0.221	***0.641
Wave 3 (8-9 Yrs)	***0.148	***0.172	**0.246	***0.541
Wave 4 (10-11 Yrs)	0.098	0.103	0.103	

*Note: Covariates of all specifications are the same as in Table 2. Other covariates are skipped for brevity. Significant levels are: ***=1%, **=5% and *=10%. [1]Data is not available for Wave 1; [2]Data is not available for Wave 4*

5.2 Panel data estimates

In this section we first estimate Equation 9 by pooling data from Wave 1 to Wave 4. These results (Table 5) are consistent with those from the cross-sectional analysis in that household income significantly

Table 5: Pooled regressions (static): The effect of income on child non-cognitive and cognitive development

	Spec 1	Spec 2	Spec 3	Spec 4	Spec 5
Non-Cognitive Development					
SDQ pro-social scale	0.018	-0.012	0.01	0.024	-0.021
SDQ hyperactive scale	***-0.076	***-0.055	-0.035	***-0.088	-0.017
SDQ emotional problem	***-0.116	***-0.075	***-0.075	***-0.105	*-0.051
SDQ conduct problem	***-0.133	***-0.098	***-0.073	***-0.115	-0.029
SDQ peer problem	***-0.154	***-0.110	***-0.095	***-0.132	*-0.052
Cognitive Development					
Literacy score	***0.117	***0.099	***0.101	***0.105	**0.076
Mathematical score	***0.121	***0.115	***0.117	***0.116	***0.117
Matrix reasoning	***0.197	***0.253	***0.245	***0.186	***0.260
PPVT	***0.607	***0.463	***0.335	***0.330	0.107

*Note: Covariates of all specifications are the same as in Table 2. Other covariates are skipped for brevity. Significant levels are: ***=1%, **=5% and *=10%*

affects cognitive and non-cognitive outcomes of children with the exception of the SDQ pro-social scale. In addition, the inclusion of additional covariates such as "household's investment", "family stress" and "neighbourhood characteristics" separately to the basic set of controls (Specification 2, 3 and 4) did not affect the significance level of the income parameter. However, when all these additional covariates are used (i.e, Specification 5), the fewer non-cognitive outcomes are significantly associated with household income. This suggests that when we consider the effects of income on child development in a broader context there are some specific variables in these four Specifications which are responsible for mediating the effects of income on child non-cognitive development. Surprisingly the effects of family income on child cognitive development remained consistently significant even in Specification 5, with the exception of PPVT.

Heckman (2007) and Cunha et al. (2010) revealed that skill formation has two properties: self-productivity and dynamic complementary. Self-productivity embodies the idea that ability produced in one stage augments ability in later stages. Dynamic complimentary arguments state that capacity produced in one period increases the productivity of investments in the other period. These hypotheses can be tested by estimating Equation 10, where current skills (children's cognitive and non-cognitive development) are a function of previous skills. In our regressions, children's previous outcomes are used to account for the investment made in child development in the past period, which in turn makes current investment more productive in terms of better outcomes. This is also consistent with the idea of cumulative effects of child development i.e. that a child with better cognitive and non-cognitive skills in the previous period is more likely to have better cognitive and non-cognitive skills in the current period as well. It is expected that the current development outcomes of a child are positively associated with her past performance. In particular, we estimate Equation 10 using a random-effect estimator, where the time-invariant individual unobserved effect was assumed to be correlated with the between-wave average of exogenous covariates. The results from the random effects estimate show that the past outcome is the most significant determinant of the current outcome. Previous outcomes

are consistently statistically significant across all regressions. Household income does not significantly determine the child's SDQ pro-social skill, which is consistent with the findings from cross-sectional and pooled regressions. The income parameter still has the expected negative sign for the remaining non-cognitive measures but the statistical significance is no longer achieved for the SDQ emotional problem scale and the SDQ peer problem scale. In addition, the magnitude of the income parameter reduces considerably compared to the cross-sectional estimates. However, these results reveal a causual relationship between family income and child's SDQ hyperactivity scale in that children from low income family are more likely to be hyperactive.

Table 6: Dynamic panel data model: The effect of income on child non-cognitive behaviour (Random effects model)

	SDQ pro-social scale	SDQ hyperactive scale	SDQ emotional problem	SDQ conduct problem	SDQ peer problem
Specification 1					
Child's baseline outcome	***0.386	***0.406	***0.346	***0.373	***0.382
Household Income	-0.01	***-0.116	-0.047	**-0.095	-0.062
Specification 2					
Child's baseline outcome	***0.382	***0.406	***0.335	***0.381	***0.380
Household Income	-0.049	**-0.096	-0.031	-0.056	-0.051
Specification 3					
Child's baseline outcome	***0.383	***0.404	***0.327	***0.359	***0.380
Household Income	-0.017	**-0.114	0.007	-0.031	-0.006
Specification 4					
Child's baseline outcome	***0.392	***0.412	***0.354	***0.386	***0.380
Household Income	-0.017	***-0.157	-0.055	*-0.085	-0.031
Specification 5					
Child's baseline outcome	***0.384	***0.403	***0.327	***0.375	***0.379
Household Income	-0.043	**-0.105	0.006	0.001	-0.002

*Note: Specifications are the same as in Table 2. Other covariates are skipped for brevity. Significant levels are: ***=1%, **=5% and *=10%*

The random effect results also suggest that household income has no significant association with the cognitive development of children except for the PPVT score, where this outcome is positively associated with income. However, the level of significance is only 10 percent under some specifications. It is revealed from all regressions that the association between parental income and the PPVT score is quite robust.

Table 7: Dynamic panel data model: The effect of income on child cognitive behaviour(Random effects model

	Literacy score	Mathematical score	Matrix reasoning	PPVT
Specification 1				
Child's baseline outcome	***0.322	***0.332	***0.334	***0.459
Household income	0.013	0.029	0.129	***0.387
Specification 2				
Child's baseline outcome	***0.321	***0.340	***0.323	***0.464
Household income	-0.017	0.031	0.015	**0.303
Specification 3				
Child's baseline outcome	***0.315	***0.336	***0.313	***0.432
Household income	0.02	0.03	0.246	*0.343
Specification 4				
Child's baseline outcome	***0.343	***0.351	***0.320	***0.465
Household income	0.016	0.012	0.064	**0.345
Specification 5				
Child's baseline outcome	***0.322	***0.343	***0.296	***0.414
Household income	-0.009	0.025	0.109	*0.318

*Note: Covariates of all specifications are the same as in Table 2. Other covariates are skipped for brevity. Significant levels are: ***=1%, **=5% and *=10%*

6 Factors mediating the effects of income

In this section we will look closely at the factors that determine cognitive and non-cognitive outcomes of children, and hence are responsible for reducing the effects of income. We estimate Equation (10) for child cognitive and non-cognitive outcomes using random effects model and report the results in Table 8 and Table 9. The results reported in Table 8 and Table 9 are quite robust, because in these specifications we use wide range of variables (mopping up approach) and random effects estimate to control for unobserved individual heterogeneity. It appears (from Table 8 and Table 9) that while family stress (e.g., parenting styles, mother's mental health) is important for child emotional and behavioural development, parental investment capacity and neighbourhood characteristics are important for child cognitive development. Moreover, different mediating factors work for different outcomes. For example, a warm parenting style from the mother and parents' mental health are the most important factors for child behavioural development across all regressions including random effects and pooled regression. In particular, children of mothers with warm parenting styles and good mental health are associated with higher pro-social outcomes and fewer SDQ problems (e.g., hyperactivity, emotional, conduct and peer problems). The results also report that children of highly educated mother are less likely to have conduct problems. Moreover, children from households where both biological parents are living together

are less likly to have behavioural problems.

There are only a few factors that are significantly associated with cognitive outcomes of children, apart from their baseline outcomes. Also, the effects of these factors are not consistent across all measures. For example, children of depressed parents are more likely to have poorer mathematical scores, poorer matrix reasoning scores and poorer PPVT scores. Also, children of fathers with warm parenting styles are significantly more likely to have higher matrix reasoning scores and significantly higher PPVT scores.

Table 8: Determinants of children's non-cognitive outcomes: dynamic and random effects estimates

Variables	SDQ pro-social scale	SDQ hyperactive scale	SDQ emotional problem	SDQ Conduct problem	SDQ peer problem scale
Child's baseline outcome	***0.384	***0.403	***0.327	***0.375	***0.379
Household Income	-0.043	**-0.105	0.006	0.001	-0.002
Mother's age	-0.007	-0.042	0.018	-0.047	0.045
Mother completed Year 12	-0.681	0.437	0.838	**0.932	0.425
Mother has graduate degree	-0.003	-0.214	*-0.32	***-0.502	-0.114
Mother has postgraduate degree	0.063	-0.196	-0.258	*-0.493	**-0.507
Father completed Year 12	-0.138	0.035	0.293	0.338	0.031
Father has graduate degree	0.267	-0.158	-0.098	0.027	0.113
Father has postgraduate degree	0.102	0.101	-0.027	-0.384	0.265
Hours of work for mother	0.001	0.001	-0.001	*0.004	0.001
Hours of work for father	0.0004	**-0.003	0.001	-0.002	-0.001
Child age	-0.00002	0.0002	**0.002	***0.005	-0.001
Household size	**-0.428	0.236	-0.124	*0.459	0.205
Both parents are available	**0.368	**-0.355	-0.25	**-0.495	-0.275
House condition (1=clean)	0.004	0.043	0.056	0.148	0.014
House tenure (1=own outright)	-0.058	0.044	-0.038	-0.034	**0.156
Home activities index	0.073	-0.031	0.0002	-0.039	0.099
Out of home activities index	0.011	-0.01	-0.011	-0.014	0.029
Number of children's books at home	-0.022	0.003	-0.042	0.018	-0.053
Has computer access at home (1=yes)	0.002	0.027	*-0.151	-0.12	-0.056
Relationship quality (1=excellent)	0.033	-0.033	0.029	-0.049	0.003
Mother's health (1=excellent, 5=poor)	-0.003	0.008	0.001	-0.041	0.023
Father's health (1=excellent, 5=poor)	-0.005	0.009	-0.02	0.005	-0.033
Mother's warm parenting (1=yes)	***0.235	*-0.096	**-0.122	***-0.173	***-0.187
Father's warm parenting (1=yes)	0.006	0.00002	0.017	-0.018	0.003
Depression scale of parent (1=all the time, 5=none of the time)	***0.148	***-0.202	***-0.241	***-0.199	*-0.085
Stressful life index (number "yes" answers to stressful events)	*0.021	0.001	*0.024	-0.014	0.019
Mother abuse of alcohol (1=yes)	-0.046	-0.031	0.048	0.068	-0.049
Father abuse of alcohol (1=yes)	-0.035	0.015	-0.021	0.015	0.063
Neibourhood belonging scale	-0.045	0.032	0.068	-0.011	-0.039
Neibourhood social capital	-0.035	-0.026	-0.045	0.061	0.035
Neibourhood infrastructure	-0.052	**0.067	0.002	0.051	0.029
% of people completed Year 12 in the neibourhood	-0.002	*-0.008	-0.004	0.002	-0.001
% of people employed in the neibourhood	-0.003	0.007	-0.004	-0.006	0.003
$\mu 1$	-0.426	*-1.061	***-2.986	***-1.989	***-1.924
$\mu 2$	0.631	-0.249	***-2.137	-0.957	*-1.151
$\mu 3$	0.93	0.387	**-1.528	-0.072	-0.514
$\mu 4$	**1.447	1.018	-1.012	0.603	0.018
$\mu 5$	***2.018	**1.553	-0.5	*1.239	0.524
$\mu 6$	***2.819	***2.134	-0.021	**1.826	1.045
$\mu 7$	***3.387	***2.56	0.406	***2.34	**1.564
$\mu 8$	***3.903	***2.955	0.919	***2.699	***2.049
$\mu 9$	***4.48	***3.401	*1.305	***3.14	***2.377
$\mu 10$	***5.187	***3.937	**1.664	**1.664	***3.017
N	5980	5980	5978	5980	5979

Table 9: Determinants of children's cognitive outcomes: dynamic and random effects estimates

Variables	Literacy score	Mathematical score	Matrix reasoning	PPVT
Child's baseline outcome	***0.322	***0.343	***0.296	***0.414
Household Income	-0.009	0.025	0.109	*0.318
Mother's age	0.028	0.076	**0.448	0.208
Mother completed Year 12	-0.021	-0.184	-1.762	0.706
Mother has graduate degree	-0.051	0.081	-0.127	-0.529
Mother has postgraduate degree	-0.222	-0.076	-0.504	-0.074
Father completed Year 12	*0.475	0.062	0.512	-0.078
Father has graduate degree	-0.013	0.036	-0.038	0.639
Father has postgraduate degree	0.436	0.399	-0.32	-0.855
Hours of work for mother	-0.0003	0.001	-0.005	0.004
Hours of work for father	-0.00006	-0.003	-0.003	0.003
Child age	-0.0003	***0.005	0.005	***-0.023
Household size	-0.037	0.092	0.391	**1.696
Both parents are available	0.335	0.292	-0.559	0.447
House condition (1=clean)	-0.102	-0.082	-0.327	*-0.536
House tenure (1=own outright)	-0.018	0.129	-0.13	0.118
Home activities index	***-0.326	***-0.366	***-0.546	***1.438
Out of home activities index	0.002	0.028	*-0.095	-0.079
Number of children's book at home	0.065	0.095	***0.405	0.115
Has computer access at home (1=yes)	-0.037	-0.063	**0.599	***-0.789
Relationship quality (1=excellent)	0.015	0.031	-0.074	**-0.218
Mother's health (1=excellent)	0.023	0.05	-0.013	0.071
Father's health (1=excellent)	-0.036	-0.024	0.006	-0.108
Mother's warm parenting (1=yes)	0.084	0.07	0.118	0.048
Father's warm parenting (1=yes)	0.007	-0.093	**0.259	**0.371
Depression scale of parents (1=all the time, 5=none of the time)	0.045	-0.021	-0.203	***-0.421
Stressful life index (number of "yes" answer to stressful events)	-0.011	*-0.027	***-0.079	***-0.173
Mother abuse alcohol (1=yes)	-0.109	-0.064	-0.018	0.025
Father abuse alcohol (1=yes)	**0.177	0.079	0.211	0.135
Neibourhood belonging scale	-0.023	-0.025	-0.15	***-0.386
Neibourhood social capital	0.007	0.022	0.113	*0.216
Neibourhood infrastructure	-0.043	-0.012	0.074	0.19
% of people completed Year 12 in the neighbourhood	-0.003	0.001	-0.023	0.015
% of people employed in the neibourhood	-0.007	-0.002	0.02	*0.035
Constant			***8.504	***39.017
$\mu 1$	*1.502	***2.784		
$\mu 2$	***2.298	***3.833		
$\mu 3$	***3.528	***5.226		
N	4398	4159	3869	5845

7 Conclusions

This paper advances our knowledge in the following ways. First, using longitudinal data, it presents a comprehensive analysis of the relationship between income and a wide range of child cognitive and non-

cognitive outcomes that have rarely been explored in the Australian context. Second, it examines the association between household income and child outcomes both in cross section using a 'mopping-up' approach and in the longitudinal dimension using random effects approaches to account the potential endogeneity of income and unobserved individual heterogeneity. Third, it investigates whether the relationship between child outcomes and income can be mediated by 'parental investment', 'parental stress' and 'neighbourhood characteristics'.

Our results show that, when individual unobserved effect is not controlled for, income has significant effects on behavioural outcomes of children with the exception of the SDQ pro-social scale. However, when unobserved heterogeneity is controlled using a richer set of covariates and random effects model, the effect of income on children's non-cognitive outcomes becomes insignificant, except for SDQ hyper-activity scale. For cognitive outcomes, when a rich set of controls is used, income remains significantly associated with child outcomes. However, when individual unobserved effect is controlled for using a random effects estimator, income is no longer a significant determinant of children's cognitive outcome (except for PPVT scores, which is significant at only 10%). Our results provide some causal relationship between parental socio-economic status and child behavioural development. We find that children from low income households are more likely to be hyperactive and children of highly educated mother are less likely to have conduct problems. Children from a household, where both biological parents live together, are less likely to have behavioural problems. This paper, however, reveals a rather moderate relationship between child development and family income, and a strong effect on child outcomes of parental characteristics such as parenting style and parental mental health.

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