The response of parental time investments to the child's abilities and health

Cheti Nicoletti

DERS, University of York and ISER, University of Essex

Valentina Tonei

DERS, University of York

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Abstract

Recent empirical research in family economics has shown the importance of parental investments on human capital development during childhood, but it is still not clear what drives parental investments and, in particular, how they respond to changes in the child's abilities and health. Using the Longitudinal Study of Australian Children we study the behavioural response of parents' time investments to changes in their child's cognitive, socio-emotional abilities and health across time. We find that mothers tend to compensate for differences in non-cognitive abilities and especially so if they have a low education or if they are not working. On the contrary, mothers with a university degree compensate mainly for differences in cognitive abilities. While mothers invest equally in daughters and sons, fathers seem to have a stronger compensating behaviour for sons than for daughters.

Keywords: Time-use, family investment, quality time, abilities, child development.

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Contact: Cheti Nicoletti: cheti.nicoletti@york.ac.uk; Valentina Tonei: vt563@york.ac.uk

1 Introduction

The behavioural response of parental investments to child's endowments has attracted a lot of researchers' attention, but there is not yet consensus on whether parents compensate or reinforce for differences in child's human capital (see Currie and Almond, 2011; and Almond and Mazumder, 2013). Most of the empirical literature has focused on the reaction of parental investments to siblings' or twins' differences in endowments at birth or in early childhood (e.g. Behrman et al. 1994; Royer 2009; Rosenzweig et al. 2009; Datar et al. 2010; Currie and Almond 2011; Hsin 2012; Aizer and Cunha 2012; Del Bono et al. 2012; Restrepo 2012; Rosales-Rueda 2014; Yi et al. 2013) or to exogenous shocks that affect child's endowments (e.g. Kelly 2011, Adhvaryu and Nyshadham 2012; Venkataramani 2012; Parman 2012). On the contrary, in our paper we focus on the response of parental time investments in their children when they are between 6-7 and 8-9 years old and we consider health, cognitive as well as socio-emotional abilities observed for the same child at different points in time.

As in Borghans et al. (2008), Cunha et al. (2010) and Almlund et al. (2011) we account for the multidimensionality of child's human capital and allow for a heterogenous response of parental investments by type of human capital, namely cognitive and socio-emotional abilities and health (see Rosales-Rueda 2014; Yi et al. 2014; and Attanasio et al. 2015). In addition, following Behrman et al. (1986) we allow the parental investments response to differ between sons and daughters as well as between mothers and fathers.

Using the first three waves of the Longitudinal Study of Australian Children (LSAC), we take advantage of the availability of time-use diaries to measure the time that parents spend with their child doing activities that can help the child's development. Unlike proxy measures of time investment, such as parents' employment status and number of working hours, time-use diaries allow us to distinguish between formative and non-formative activities that children do together with their parents and to derive a more accurate measure of time investment. While most of the measures of parental investments considered in the empirical literature (e.g. family income and parental employment status) cannot respond instantaneously to changes in child's abilities and health, parental time investment is likely to be more reactive and therefore represents a better way to model the potential response of parents to shocks and changes in their child's health, cognitive and socio-emotional abilities.

Similar concepts of parental investments based on time diaries have been used by Stafford and Yeung (2004), Price (2008), Hsin (2007, 2009), Carneiro and Rodriguez (2009), Del Boca et al. (2012), Fiorini and Keane (2013) and Del Boca et al. (2014).

We estimate a parental investment model by regressing the time parents spend with their child when 8-9 years old on child's cognitive and socio-emotional abilities and health measured when the child is 6-7 year old. We also control for other types of investments in children, in particular for child care, school inputs and family income. To take account of unobserved heterogeneity and more in particular of unobserved family and environment characteristics that are time invariant and potentially relevant to explain both child's human capital and parental investments, we use a panel data approach and express our equation in first differences, therefore controlling for child (family) fixed effects. The reverse causality issue, i.e. the fact that time parents spend with their child may improve child's human capital, is tackled by instrumenting the first differences in child's abilities and health with the corresponding measures lagged twice. To summarize, our identification strategy is based on a fixed effect estimator that evaluates the reaction of parental investment when children are between 6-7 and 8-9 years old and uses child's human capital endowments measured at age 4-5 to instrument endogenous changes in human capital endowments between age 4-5 and 6-7.

We also carry out an extensive set of sensitivity analysis which includes (i) accounting for the heterogeneity of the investment response by mother's labour status, level of education and health, (ii) taking into consideration the reaction of parental investments to potential shocks experienced by the household, (iii) assessing the effect of a potential measurement error in the time investment by restricting our sample to the cases where the information on the daily time-use has been collected in ordinary days.

Our estimation results show that parental time investments respond differently to changes in different types of child's endowment. Both mothers and fathers seem to adopt a compensating strategy for socio-emotional ability and to be little reactive to cognitive ability and health. In particular we find that for one standard deviation decrease in child's socio-emotional ability mothers (fathers) increase the time invested in their child by about one hour and a half (one hour) per week. While mothers seem to invest equally in sons and daughters, fathers invest more in sons. We also find a difference in the investment response

by level of education, labour status and health of the mother. In particular, mothers with a university degree compensate for cognitive abilities but not for socio-emotional abilities; whereas mothers without a paid job and those with poor health seem to compensate more extensively for socio-emotional abilities.

The remainder of the paper is organized as follow. Section 2 presents a literature review on the response of parental investments to child's human capital. Section 3 discusses the conceptual framework and the identication strategy used to produce our empirical evidence on parental time investment. Section 4 describes data and descriptive statistics, while in Section 5 we report our main results and robustness checks. Section 6 concludes.

2 Related literature

Most of the empirical papers that analyze the response of parental investments to changes in child's human capital are based on the effect of siblings or twins differences in endowments at birth on postnatal parental investments (see Currie and Almond, 2011; and Almond and Mazumder, 2013). Examples of empirical papers using family fixed effect estimation to assess the response of postnatal parental investments to child's birth weight include: Royer (2009), who finds no effect of differences in birth weight between twins on mother's breastfeeding decisions and on neonatal medical care; Datar et al. (2010), whose empirical evidence suggests that postnatal investments (e.g. breastfeeding initiation and immunization) are higher for the sibling with birth weight larger than 2,500 grammes; Hsin (2012), who looks at the difference in mother's time investment[1] between siblings and provides evidence of a compensating behavior for highly-educated mothers and a reinforcing one (but not statistically significant) for lowly-educated mothers; Restrepo (2012), who considers differences in parental investment between siblings by using the Home Observation for Measurement of the Environment (HOME) score and finds again that parental investments are reinforcing for lowly-educated parents and compensating for highly-educated parents; Currie and Almond (2011), who conclude that there is generally no difference in parental investments between twins except perhaps for a higher concern about kindergarten readiness for the twin with lower birth weight.

[1]Time investment is measured in two different ways considering the total time mothers spend with their child and the time that they spend in human capital enhancing activities.

Evaluating the effect of endowments at birth on postnatal parental investments by considering a family fixed effect estimation may lead to biased results because differences in birth endowments between siblings may be not random. Differences in endowments at birth can depend on unobserved differences in inputs during pregnancy that may be correlated with differences in postnatal parental investments. An approach to correct for the endogeneity of the endowment at birth, which was first proposed by Rosenzweig and Wolpin (1988), is to estimate child's endowment at birth net of the effect of prenatal investments and of sibling-invariant endowment and family characteristics, which we call child-specific endowment (see also Pitt et al. 1990; Rosenzweig and Wolpin 1995; Del Bono et al. 2012; Aizer and Cunha 2012). This approach consists of two stages: in the first stage a human capital production model is estimated by regressing child's endowment at birth on prenatal parental investments using family fixed effects and instrumental variables to correct for the endogeneity, while in the second stage a family fixed effect estimation is applied to the regression of postnatal parental investment on child-specific endowment (which is estimated using the child idiosyncratic error in the first stage) and on other control variables.

Using a similar approach Del Bono et al. (2012) find that breastfeeding initiation and duration are negatively related to child-specific endowment, therefore suggesting that mothers compensate for differences between siblings. On the contrary, Aizer and Cunha (2012), who extend the approach of Rosenzweig and Wolpin (1988) to correct for measurement errors in the estimated child-specific endowment and in the mother's investment,[2] find that mother's investment tends to reinforce for differences in endowments between siblings.

The assumptions imposed by the estimation procedure suggested by Rosenzweig and Wolpin (1988) are generally less credible when the focus is on the the response of parental investments to child's endowments measured during childhood or later in life rather than at birth. Alternative methods have been used to correct for the endogeneity of child's endowments measured later in life. They usually consider family fixed effects and correct for the residual endogeneity of child's endowment by either controlling thoroughly for prenatal investments and child's characteristics (e.g. Rosales-Rueda 2014), or by exploiting exogenous variation in child's endowment caused by instrumental variables (e.g. Frijters et al. 2013),

[2] By exploiting the availability of multiple measures of birth endowments (birth weight, gestation, head circumference and body length) they use a factor analysis to extract the latent common endowment. Similarly they measure mother's investment by extracting the common latent factor of 7 different measures of mother's parenting behavior.

randomized programs in early childhood (e.g. Attanasio et al. 2015), or natural exogenous shocks (e.g. Yi et al. 2014).

Rosales-Rueda (2014) looks at how the HOME score responds to health conditions during childhood and corrects for the bias caused by the potential endogeneity of health conditions by using family fixed effect and controlling for child's characteristics and prenatal parental investments. His empirical evidence suggests that there is a reinforcing parental behavior in the case of mental illness; but there is no statistically significant response of parental investment to physical health conditions. Frijters et al. (2013) examine the responsiveness of HOME score to cognitive test scores and correct for the potential endogeneity bias by adopting a family fixed effect estimation and instrumenting the cognitive test scores using the child handedness. They find that parents reinforce for differences in cognitive abilities between siblings. Yi et al. (2014) study the effect of twin differences in health shocks in early childhood on twin differences in parental investments. Health shocks are measured by serious diseases (e.g. diarrhea, calcium deficiency, asthma and fracture) when the child was between 0 and 3 years old and they seem to be exogenous, at least after controlling for unobserved family effects. They find a compensating behavior for medical expenditure and a reinforcing one for educational investments. They also estimate the effect of these health shocks on health, cognitive, and socio-emotional abilities to disentangle between the direct biological effect that operates through the production function and the indirect behavioral effect that operates through the response of parental investments to the shocks. They find that ignoring the response of parental investments leads to an underestimation of the biological effect on child's health later in life and to an overestimation of the biological effect on some educational outcomes. Attansio et al. (2015) are interested to identify the effect of parental response when evaluating the effect of a randomized intervention in early childhood on child's abilities later in life. They first estimate two models of parental investments, one for time and one for material investments, and then they estimate three CES (constant elasticity of substitution) production models for health, cognitive and socio-emotional abilities and correct for the bias caused by the endogeneity of the parental investments by adopting a control function approach (i.e. by using the estimated residuals of the two investment models as additional explanatory variables in the production models). By considering a randomized program implemented in Colombia to improve the psycho-social stimulation and to increase the nutrients intake through supplementation in early childhood, they find a positive effect

of this intervention on child's abilities, which seems to operate exclusively by an increase of parental investments for children who have been participating to the program.

Finally, some papers provide 'indirect evidence' (as called by Almond and Mazumder, 2013) on the parental investments responsiveness by comparing estimations of the impact of child's endowments on outcomes measured later in life using and without using family (sibling) fixed effect. Loughran et al. (2008) explain the logic behind this indirect evidence and suggest that a larger (smaller) effect of child's endowments when using family fixed effect would be indicative of a reinforcing (compensating) behavior. By looking at birth weight effect on child's cognitive outcomes later in life, they find that parents compensate for low birth weight, at least when looking at long term outcomes. Using this type of indirect evidence Almond et al. (2009) find that parental investments are reinforcing when evaluating the damage causes by exposure to Chernobyl radioactive fallout on educational achievements.

3 The parental time investment model

3.1 The conceptual framework

In the economics literature it is usually assumed that parents maximize a utility function that depends on parental consumption and on their child's human capital or on their child's future wage, income or wealth (see Becker and Tomes 1986; Behrman et al. 1982). We assume that parents make decisions in each of the child's life stages of development, which we denote with the subscript t, and that there are S sequential stages between birth and adulthood, $t = 1, ..., S$ (e.g. Del Boca et al. 2013). Following previous literature, we assume that parents care about their consumption and their child's human capital and consider the following parents' utility function in stage t

$$U_t(C_{i,t}, \theta_{i,t}, \theta_i^P), \tag{1}$$

where i denotes the child (household), $C_{i,t}$ is the parental consumption, $\theta_{i,t} = [\theta_{it}^H, \theta_{it}^C, \theta_{it}^S]$ is a column vector with three measures of child's human capital which are health, cognitive and socio-emotional abilities respectively, and θ_i^P is a vector of measures of parental human capital that does not change across stages. We allow parental human capital, θ_i^P, to enter the utility function because of potential heterogeneity of investment preferences across parents

with different endowments and because parents' utility can depend on the difference between their own human capital and the one of their child. For example parents might have an aversion to intergenerational inequity and prefer to transmit to their child a level of human capital similar to theirs.

In each stage t of the development process the parents are assumed to maximize the expected discounted sum of their utilities under the child's human capital production and budget constraints. Following Cunha et al. (2010) and Almlund et al. (2011) we allow the human capital to be multi-dimensional and we assume the production of human capital of type k for child i in stage t to be given by

$$\theta_{it}^k = h_{k,t}(\theta_{i,t-1}, I_{i,t}, I_{i,t}^C, I_{i,t}^S, \theta_i^P, \eta_i^k, \eta_{i,t}^k), \tag{2}$$

where θ_{it}^k is the child's human capital of type k; $k = H, C$ and S with H, C and S denoting health, cognitive and socio-emotional abilities, $I_{i,t}$ is the parental time investment, $I_{i,t}^C$ is the investment in child care, $I_{i,t}^S$ measures investment in schooling, η_i^k are time invariant child's and parental characteristics that might affect the production of human capital of type k, and $\eta_{i,t}^k$ is an idiosyncratic shock in stage t which again can affect the production of human capital of type k. We assume that what parents observe when deciding the investment level in t is $\theta_{i,t-1}$, θ_i^P, η_i^k and the shocks of the human capital production for health, cognitive and socio-emotional abilities, $\eta_{i,t}^k$.

Finally, we assume that the budget constraint is given by

$$Y_{i,t} = C_{i,t} + p_t^T I_{i,t} + p_t^C I_{i,t}^C + p_t^S I_{i,t}^S, \tag{3}$$

where $Y_{i,t}$ is the parental income; p_t^T, p_t^C and p_t^S are the prices of parental time investment, child care and schooling.

We do not impose any additional assumption on the utility function (1) and on the human capital production model (2) except general conditions (in particular the strict concavity and twice continuously differentiable properties) to allow for the existence of a unique solution for the parental time investment.

Let us approximate the optimal parental time investment in child i in stage t by the following function:

$$I_{i,t} = f_t(\theta_{i,t-1}, \theta_i^P, I_{i,t}^C, I_{i,t}^S, Y_{i,t}, p_t^T, p_t^C, p_t^S, \eta_i^H, \eta_i^C, \eta_i^S, \eta_{i,t}^H, \eta_{i,t}^C, \eta_{i,t}^S, u_{i,t}), \tag{4}$$

where $u_{i,t}$ is an idiosyncratic shock affecting parental time investment, which we assume to be independent of the production shocks $\eta_{i,t}^H$, $\eta_{i,t}^C$ and $\eta_{i,t}^S$. If $\frac{\partial I_{i,t}}{\partial \theta_{i,t-1}^k} > 0$ (< 0), then parental investments are reinforcing (compensating) in ability of type k.

3.2 Econometric Strategy

In this section we present our econometric approach to identify the effect of child's human capital on parental time investment.

In our empirical application we follow a cohort of Australian children from stage 0 (age 4-5) and we observe their parental time investment in stage 1 (age 6-7) and 2 (age 8-9), and their human capital in stage 0 and 1. By assuming that the investment model (4) is linear and additive in its inputs and does not change between stage 1 and 2 of the child's life, we can rewrite it as

$$I_{i,t} = \alpha_0 + \alpha_1 d_{i,t} + \theta_{i,t-1}'\gamma + \theta_i^P\beta + Y_{i,t}\rho + I_{i,t}^C\lambda + I_{i,t}^S\psi + \mu_i + \epsilon_{i,t}, \tag{5}$$

where $t = 1$ or 2, $d_{i,t}$ is a dummy taking value 1 for stage 2 and 0 for stage 1 therefore capturing any potential macro change between stages (e.g. changes in the price of investments p_t^T, p_t^C and p_t^S), $\theta_{i,t-1}' = [\theta_{i,t-1}^H, \theta_{i,t-1}^C, \theta_{i,t-1}^S]$ is the transpose of the vector of child's human capital measures, μ_i is an unobserved individual effect capturing time-invariant child's and parental characteristics such as η_i^k for $k = H, C, S$, $\epsilon_{i,t}$ is an idiosyncratic error independent of the explanatory variables which can be defined as a linear combination of $u_{i,t}$, $\eta_{i,t}^H$, $\eta_{i,t}^C$ and $\eta_{i,t}^S$ in model (4). γ is a column vector containing our parameters of interest γ^H, γ^C and γ^S, which measure the response of parental investments to child's health, cognitive and socio-emotional abilities. Finally, α_0 is the intercept for stage 1, α_1 is the differential intercept for stage 2, and β, ρ, λ and ψ are the effects of parental endowments, income, child care and schooling.

A positive (negative) value of γ^k would imply that parental investments are reinforcing (compensating) in ability of type k. The direction of the effect of child's human capital on parental time investment is generally ambiguous and parents might have to face

an inequity-efficiency trade-off. If the human capital production model (2) is such that $\partial h_{k,t}(.)/\partial \theta^s_{i,t-1} \partial I_{i,t} > 0$ for any k and s, i.e. if there is complementarity between the parental investment in stage t and endowments in stage $(t-1)$, then a high human capital endowment at stage $(t-1)$ may increase the productivity of parental investment at stage t.[3] Therefore in the case of complementarity parents may decide to adopt a reinforcing strategy and may increase their time investment in stage t when child's human capital at stage $(t-1)$ is higher. However, the response of parental investments may also depend on specific preferences of the parents captured by the utility function (1). If parents are, for example, averse to intergenerational inequity, i.e. to inequalities between their endowments and their child's ones, then their utility may increase by adopting a compensating investment strategy i.e. by investing more when their child is performing below their standards and less when she is performing above their standards. In section 5 we assess empirically the size and the sign of the response of parental time investment to child's endowments by estimating model (5) using a child fixed effect estimation with instrumental variables, which we describe below.

We adopt a first difference approach (child-fixed effect estimation) to control for the unobserved individual effect μ_i, i.e. we estimate the model transformed using first differences

$$\Delta I_{i,2} = \alpha_1 + \Delta \theta'_{i,1} \gamma + \Delta Y_{i,2} \rho + \Delta I^C_{i,2} \lambda + \Delta I^S_{i,2} \psi + \Delta \epsilon_{i,2}, \tag{6}$$

where $\Delta I_{i,t}$ denotes the difference in the variable I between stage t and $(t-1)$, $(I_{i,t} - I_{i,t-1})$ and similarly for the other variables.

To be compatible with the human capital production function (2) we have to allow for the dependence of θ^k_{i1} on $\eta^k_{i,1}$ for $k = H, C, S$. This implies that we cannot exclude that θ^k_{i1} is correlated with the error term $\epsilon_{i,1}$, leading to a correlation between $\Delta\theta_{i,1}$ and $\Delta\epsilon_{i,2}$ in model (6) and to a potential endogeneity bias (reverse causality issue). To correct for this bias we instrument $\Delta\theta_{i,1}$ with θ_{i0}.[4] The instruments $\theta'_{i0} = [\theta^H_{i0}, \theta^C_{i0}, \theta^S_{i0}]$ are uncorrelated with $\Delta\epsilon_{i,2} = \epsilon_{i,2} - \epsilon_{i,1}$ because the production of human capital in stage 0 does not depend on future shocks in stage 1 and 2.

[3] For a definition of complementarity see Cunha and Heckman (2007), (2008); Cunha et al. (2006), (2010); Aizer and Cunha (2012).

[4] Note that this estimation is equivalent to the estimation used by Rosenzweig and Wolpin (1988) and Rosenzweig and Wolpin (1995) to solve the issue of endogeneity in a model for childbirth outcomes.

We implement this instrumental variable estimation by adopting a two-stage least squares estimation whose first stage consists in the estimation of three regressions, one for each of the three measures of human capital, which are specified as follows

$$\Delta\theta_{i,1}^{k} = \delta_0 + \theta_{i,0}^{H}\delta_H + \theta_{i,0}^{C}\delta_C + \theta_{i,0}^{S}\delta_S + \Delta X_{i,2}\delta_X + \Delta v_{i,1}, \tag{7}$$

where $k = H, C$ and S, X is the vector of other control variables in (6) and $v_{i,1}$ is an idiosyncratic error. The relevance of the instruments θ'_{i0} is guaranteed by the self-productivity and the cross-productivity assumed by the human capital production model (2), i.e. by the fact that there is dependence of the child's ability θ_{i1}^{k} on its lagged value θ_{i0}^{k} as well as on the lagged values of the other two measures of child's human capital θ_{i0}^{h} for $h \neq k$.

A final remark is needed to explain the consequences on our estimation of potential zeros observed for the parental time investments. This is a common issue when measuring time spent in specific activities over a short period, such as over a week or a day, as in the case of our parental time investment in children, which we measure considering the time use of children observed in two days. In theory we would like to measure the time parents spend with their child over a much larger time period, which is the two-year gap between wave 2 and wave 3 (between age 6-7 and 8-9). Because of this mismatch between the period of interest and the reference period in our sample, we observe some zeros for the parental investments. This issue is very similar to the problem of zeros observed when measuring the demand for items that are purchased infrequently (see Keen 1986). Stewart (2013) adapts the infrequent purchase model considered by Keen (1986) and shows that the ordinary least squares estimation of a regression model for the time spent in specific activities provides an unbiased estimation of the effects of the explanatory variables on the time even in presence of zeros. More in general this consistency result applies also to the case where the linear regression model is estimated controlling for fixed effect and using instrumental variables as in our case. The major consequence of the presence of zeros for our estimation is simply a reduction of its precision.

4 Data

Our analysis relies on the first three waves of the Longitudinal Study of Australian Children (LSAC), an ongoing biannual survey that has collected information on two nationally repre-

sentative samples of Australian children since 2004.[5] The two samples of children are called cohort B (baby), which follows 5,107 children since age 0-1, and cohort K (kindergarten), which follows 4,983 children since age 4-5.

The LSAC collects information on the time children spend in different activities using time-use diaries. Furthermore, it provides detailed information on children's human capital development, health and cognitive and socio-emotional abilities, and on family characteristics and socioeconomic background. These details are collected by interviewing parents who live with the child, teachers, home-based and centre-based carers as well as using tests administered to children.

We only use the sample of children belonging to cohort K because for these children we can observe measures of parental time investment and of child's abilities and health, that are consistent across time.

4.1 Sample selection

Our sample includes only children living in intact families, i.e. children living with both biological parents (93% of the sample). Because our empirical results are based on child fixed effect methods that require at least 3 observations for each child, we restrict the sample to children who have been observed in all the first three waves i.e. when the child is 4-5, 6-7 and 8-9 years old. Finally, we drop children with missing observations in any of the variables used in our analysis, which are: parental time investments in waves 2 and 3 (Table 1),[6] child's cognitive and socio-emotional abilities and health measured in waves 1 to 3 (Table 2), and the set of additional control variables described in Table 3, which are measured in waves 2 and 3. This leaves us with a *main sample* of 910 children.

In addition to the main sample, we also consider the *ordinary-day sample* that includes 158 children for whom the time-use diaries were completed in ordinary days, i.e. excluding

[5] The two samples have been drawn from the full population of children included in the Medicare Australia enrolment database and more details on the sample design can be found in Gray and Smart (2009) and Soloff et al. (2005).

[6] The time investment measure is derived by using details on two diaries collected for each child in a weekend and in a working day. We exclude those cases where only weekend or working day diaries were filled.

unusual days such as holidays, days when the child or other family members were sick and so on.

4.2 Time-use diaries and parental investments

One of the main advantages of using the LSAC consists in the availability of time-use diaries (TUDs) that can be used to measure the amount of time fathers and mothers spend with their child doing formative activities.[7]

For each of the first three waves the LSAC collects details on the activities done by the child in two randomly assigned days, a working and a weekend day, by asking the main respondent (usually the mother) to complete two 24-hours time-use diaries. More precisely, the main respondent is asked to report the main activity done by the child (by choosing from a list of 26 pre-coded activities), where the activity took place and who was together with the child for each 15-minute interval in a 24-hour day, i.e. for a total of 96 consecutive intervals.

In the following we provide details on our definition of mother's time investment using variables collected through the time-use diaries. A similar definition is applied to father's time investment as well.

Mother's time investment is defined as the time she spends actively engaged with her child doing formative activities, i.e. activities that can be of benefit to the child's development (see Del Boca et al. 2014). A mother is defined to be actively engaged only if she is present meanwhile the activity takes place and if either the child is the primary focus of the activity or the activity is presumably involving a reasonable amount of interactions between the mother and the child (see Stafford and Yeung 2004 and Price 2008). We include both home and out-of-home activities, but we exclude time spent in school. Examples of activities that we exclude because either the activity is not formative enough or does not require an active engagement of the mother are the following: sleeping, watching television, listening to radio, playing video-games and traveling.

[7]Previous papers that have measured parental investments using time diaries include Stafford and Yeung (2004), Price (2008), Hsin (2007, 2009), Carneiro and Rodriguez (2009), Price (2008), Del Boca et al. (2012), Fiorini and Keane (2013) and Del Boca et al. (2014).

We classify the formative activities in five categories: eating together, personal care, leisure activities, psychological support and educational activities.[8] We compute the sum of the total number of minutes the child spends in each of these formative activities in presence of the mother in the randomly assigned working day (working day time) and in the randomly assigned weekend day (weekend day time) and we define the weekly mother's time investment as the working day time multiplied by five plus the weekend day time multiplied by two.

Table 1 shows how much time children spend with their mother in each of the above 5 types of activity and how it changes between waves 2 and 3 when children are 6-7 and 8-9 years old. Mothers invest on average more than 14 hours in a week (846 minutes) in formative activities with their 6-7 years old child, and the investment remains quite stable over time (747 minutes when children are 8-9 years old). Time invested in leisure activities represents 50 per cent of the overall time investment, while the least time demanding activities seem to be those related to psychological support (about 30 minutes in a week). All mothers seem to spend at least 15 minutes in doing formative activities with their child except for 6% (9% in wave 3) for whom the time investment is zero.

4.3 Child Capabilities

In our analysis we follow the approach of Borghans et al. (2008), Cunha et al. (2010), and Almlund et al. (2011) and we allow for multiple dimensions of human capital. In particular we focus on child's cognitive and socio-emotional abilities and physical health measured in each of the first three waves of the LSAC.

We measure child's cognitive ability using the Peabody Picture Vocabulary Test (PPVT - III), which has been administered to the LSAC children in a version adapted for Australia and based on work done in the United States for the Head Start Impact Study. This test is specifically designed to assess child's verbal ability and scholastic aptitude and to capture real changes in child's functioning rather than just changes in position relative to peers (Dunn and Dunn 1997; Rothman 2005).[9] The PPVT is age specific and includes different, although overlapping, sets of items for children of different ages. Higher scores indicate higher level of children's cognitive abilities.

[8] Appendix A provides a more detailed list of formative activities we consider.

[9] In Appendix B we provide some more details on this measure of cognitive ability.

We use the Strengths and Difficulties Questionnaire (SDQ) composite difficulty score to measure child's social and emotional ability (Goodman, 1997). The SDQ consists of 25 questions, which the main respondent answers, organised around five major subscales: hyperactivity, emotional symptoms, conduct problems, peer problems and pro-social behaviour. Each subscale is measured using five items. Following the literature (e.g. Del Bono, Ermisch 2009; Morefield et al. 2011; Conti and Heckman 2012) we use responses to 20 questions from the first four components, which are aggregated to form a single "difficulty" score. To ease the interpretation of our findings, once standardised the score has been re-coded so that a higher value represents a better socio-emotional ability.

Child's health is measured by the physical health subscale of the Pediatric Quality of Life Inventory (PEDS QL). This scale is composed by responses reported by the main respondent on eight items (Varni et al., 1999), which assess motor coordination and general health, scaled to range from 0 (poor) to 100 (good).[10]

In the analysis, we standardize each score by wave (with 0 mean and 1 standard deviation) to allow for comparison of children of different ages and to harmonize the different scales used to measure cognitive and socio-emotional abilities and health.

Table 2 summarizes descriptive statistics for child's capabilities, reporting both the standardized and raw values of these measures. We also measure the correlation between the different dimensions of child's human capital (using standardized scores) and we find that generally it is low and not always significant. In particular, while emotional skills are positively and significantly correlated with both cognitive abilities and physical health (Pearson coefficients are 0.10 and 0.27 respectively), physical health does not appear to be significantly correlated with cognitive abilities. These findings confirm the importance of including in the model separate measures of child's capabilities that account for the multidimensionality of human capital.

[10]See Appendix B for more details on these measures.

4.4 Additional variables of interest

In the top panel of table 3 we report basic statistics for selected time-invariant child's and mother's variables.[11] In our sample 47 per cent of children are male, and child's health endowment at birth is measured by a dummy indicating whether the child has been admitted to neonatal intensive care unit after birth (mean 0.18). Mothers' socioeconomic status is proxied by education level and employment status. 41 per cent of mothers have at least a university degree, and 24.1 per cent are inactive or unemployed at a certain stage (waves 2 and 3). Mother's general health is defined using a dummy variable which takes value one if the mother reported a fair or poor level of health. In our sample 5 per cent of mothers reports of experiencing poor health.

In the bottom part of the table 3 we report descriptive statistics for the time variant covariates pooling together waves 2 and 3. The covariates include measures of school quality, family exogenous shocks, income and childcare. School quality variables are constructed using data collected from the teacher questionnaire on composition of their class and teacher's characteristics. We use pupil-teacher ratio, which indicates child's class crowding and teacher's experience, measured in years spent in child care settings. The mean class size is just over 20 children and the average teacher has 16 years of experience.

Family shocks are defined using four dummies that report whether in the year before the interview serious illness, injury or assault has happened (i) to child's parents or other household member, (ii) to a close relative or friend; and whether (iii) child's grandparents, parents, sibling or (iv) close family friend or relative died in the previous year. 5.8 and 10 per cent of children in the sample has experienced a serious illness of one of the household member or other close relative (or friend) respectively. About 34 children has experienced the death of grandparents or other family members while in 18 per cent of the cases a close family friend or relative died in the previous year.

Regular childcare is defined by a set of four variables. We define two dummies indicating the type of main childcare arrangement chosen for the child (either formal or informal), and two continuous variables measuring the number of hours the child spent in this type of child

[11] For the purpose of our analysis, we consider mother's education, employment status and health as time invariant and information for these variables is collected in wave 2, when children are 8-9 years old.

care, as deviation from the mean evaluated in each wave. Almost one on five families chooses informal care, while 15 per cent prefer formal care as main child care arrangement.

Finally, the annual income, equivalised to account for the household composition by using the OECD modified scale[12], is on average equal to 46,743 AUD.

5 Estimation results

In this section we present our empirical evidence on whether parental investments, which we measure using the weekly number of minutes mothers (fathers) spend with their child in formative activities, reinforce or compensate for child's human capital measured by physical health, cognitive and socio-emotional abilities. Section 5.1 presents our main results of the model (5) for mother's time investment using child fixed effect estimation with instrumental variables. We then extend this model to take account of family health shocks (Section 5.2) and to check whether the mother's investment behaviour is heterogenous by her level of education, labour status and health (Section 5.3). In Section 5.4 we move to analyse father's time investment and to assess potential differences between mothers and fathers in their investment behaviour for daughters and sons. Finally, in Section 5.5 we present some robustness checks to support our findings.

5.1 Main Results

Table 4 shows the estimates of our investment model where the dependent variable measures mother's time investment in weekly minutes and the set of explanatory variables includes

- three measures of child's human capital (physical health, cognitive and socio-emotional abilities) standardized to have mean zero and variance one,
- school inputs proxied by pupil-teacher ratio and teacher's years of experience,
- equivalized family income,

[12]The OECD modified scale is equal to $(1 + 0.5 * nadults + 0.3 * nchildren)$ with nadults and nchildren measuring the numbers of adults and children in the hosuehold.

- child care use, which we measure by considering two dummies indicating whether the main child care arrangement is informal and formal and two continuous variables measuring weekly hours the child spends in formal and informal child care (expressed in deviation from the sample average for the corresponding wave).

In the first column we report results obtained using child fixed effect without instrumental variables (child FE estimation), while in the second column we report the child fixed effect estimation instrumenting the first difference in the three types of child's human capital with the twice-lagged measures of human capital (child FE estimation with IVs). The child FE estimation results without instrumental variables are potentially biased by a reverse causality issue, i.e. by the fact that mother's investment in stage t can affect child's human capital in stage t, whereas the FE estimation with instrumental variables (IVs) is theoretically free of bias.

Both estimations suggest that mothers adopt a compensating behavior for changes in child's socio-emotional ability, but they are neutral to changes in child's physical health or cognitive abilities. A standard deviation decrease in child's socio-emotional ability seems to lead to an increase in the weekly time investment by 88 minutes, when considering the FE without IVs, and by 118 minutes, when adopting instrumental variable estimations. Based on these results, the reverse causality bias does not seem to be a big concern for the FE estimation without IVs.

Looking at the effect of the remaining covariates, we find the mothers' time investment does not seem to react to school inputs. In particular, changes in the pupil-teacher ratio and the teacher's years of experience do not lead to any statistically significant effect on mother's time investment (see Table 6). Differently from school inputs, we do find that the use of formal child care has a negative impact on mother's time investment. In particular, one hour of additional formal child care with respect to the average leads to a reduction of weekly mother's time by about 30 minutes. On the contrary, we find no effect of the use of informal child care on mother's time investments. This seems to suggest that formal care might be used as a substitute for the mother's time investment. A negative effect is also found for household income. The child FE estimation suggests that an increase by 10,000 AUD in the yearly equivalised household income leads to a reduction of the weekly mothers' time investment by half an hour.

In the bottom panel of Table 4 we provide evidence of the relevance of our instruments. We report the F-tests for the joint significance of the IVs in the first stage estimations, i.e. the estimations of the regression of each of the three measures of human capital on the instruments, child fixed effect and covariates (see table 5 for the full set of first stage results). The F-statistics are well above 10, suggesting a strong relevance of our instruments. We also test the endogeneity of the child's abilities and health. The statistic and p-value suggest that there is no clear evidence of endogeneity issues (p-value equal to 0.117).

5.2 Omission of time variant variables

Even after controlling for the endogeneity issue caused by the reverse causality using IVs, for unobserved time invariant characteristics using child fixed effect, and for other types of parental investments (school, child care and family income), the response of mother's time investment to changes in child's human capital estimated in Table 4 could be still biased if there are omitted time-variant variables that are correlated with the child's human capital and that are relevant to explain the mother's investment.

Previous research has identified health shocks occurred to parents or other family members as important predictors of child development (Westermaier et al., 2013, Adda et al., 2011 and Morefield et al., 2011). These shocks might also lead to time constraints that limit the time mothers can invest in their child. We account for these exogenous shocks adding to the investment model a set of four dummies variables indicating the death of a family member, the death of a close relative or family friend, serious illness of a family member, and serious illness of a relative or a close family friend. Table 6 shows results with these additional covariates for the two estimations described above, the child FE estimation without and with IVs. We find that the coefficients associated to these variables are not statistically significant, suggesting that the mother's investment is not affected by exogenous family health shocks, at least as defined in our sample.

5.3 The heterogeneity of the mothers' investment behavior

In this section we explore whether mothers' investment choices vary across mothers with different socio-economic or health status by allowing the effects of the child's physical health,

cognitive and socio-emotional abilities on mother's time investment to differ between mothers with and without a university degree, between working and non-working mothers and between mothers with good and poor general health.

Table 7 shows the results for mothers with and without a university degree. Because we do not reject the exogeneity of the human capital variables (see endogeneity test in the last row of Table 7), we focus our discussion on the estimation without IVs (see first column in the top panel of Table 7). We find that while mothers with low education show compensating behaviour for socio-emotional abilities, high educated mothers compensate for a lack of child's cognitive abilities. Evidence of differences in mother's investment behaviours by educational level are found also in Hsin(2012) and Restrepo (2012).

Mothers' time investment could be affected by time constraints mothers face when working. Indeed, mothers who are unemployed or inactive are likely to have more free time they can spend in developmental activities with their child and, as a result, they can react differently to changes in child's abilities with respect to working mothers. The results in Table 8, where we report the estimation of the mother's investment model that allows for a different effect of child's human capital measures for for mothers with and without a job (inactive or unemployed), support the hypothesis of a heterogenous investment behaviour. All mothers compensate for negative shocks in child's socio-economic abilities regardless of their employment status; but for a decrease in the child's socio-emotional ability of one standard deviation non-working mothers compensate more by spending an additional 165 minutes with their child, while working mothers spend only an additional 65 minutes.

Finally mothers' health status could have an important impact on their ability to take care of the child and in particular on the time and type of activities they do together with their child. For this reason we allow the effect of child's human capital on mother's time investment to vary by mother's self-reported health. We find that both mothers with poor and good health compensate for negative shocks in child's socio-emotional abilities, but while the formers spend 190 minutes, the latters spend 80 minutes (Table 9). An explanation for this finding may be that women with poor health are more likely to be unemployed or to have a part-time job and therefore they can spend more time with their child.

5.4 Differences in parents' investments in daughters and sons

Previous studies have shown there exist differences in parents' preferences over the gender of their children (Butcher and Case, 1994; Thomas, 1990, 1996; Case and Deaton, 1999). Such preferences may have an impact on parents' investments, since parents who prefer boys are expected to give less attention (or devote fewer financial resources) to their daughters. In this section we want to answer to two questions: (a) whether mothers and fathers have different investment behaviors and (b) if their investment changes according to their child's gender.

In columns 1 and 2 of Table 10 we report for convenience our basic model results for mother's time investment, while in columns 3 and 4 we show the results for mother's time investment when allowing the effects of the three measures of child's human capital to differ for sons and daughters. When we account for child's gender we find no differences in how mothers compensate for negative shocks in their sons and daughters socio-emotional abilities (91 and 81 minutes respectively).

When we estimate the same model specifications using fathers' time investments (see Table 11), the child's health, cognitive and socio-emotional abilities seem to be endogenous and the child FE estimation with IVs variables is to be preferred over the child FE without IVs. Looking at the estimation results produced by the child fixed effect with IVs, we find some differences in fathers' investment behavior with respect to mothers. Firstly, on average fathers compensate less for negative shocks in their child's emotional abilities. Indeed we find that, for one standard deviation decrease in the child's socio-emotional ability, fathers increase their time investment by 67 minutes. Secondly, when we allow for differences in parenting style by child's gender the effect is statistically significant only for sons (85 minutes), while it is not for daughters (37 minutes). This leads to the conclusion that while fathers strongly compensate for their sons, they do not react to changes in their daughters' abilities. Investigating whether this is the result of fathers' preferences or constraints (fathers may be more likely to be engaged in same-sex activities) is beyond the scope of this paper. Overall these results are coherent with existing literature that documents an unequal intra-household allocation of resources according to child's gender (Lundberg, 2005) and suggest that mothers and fathers have different investment behaviors.

5.5 Robustness check

One of the limitations of using time use diaries consists in the fact that days in which the information is collected may not be representative of the parents-child typical time interaction. This can happen, for example, because diaries are filled during a holiday or when the child or the parent is sick. If this is the case, our estimates would be affected by measurement error and the results biased.

As a robustness check we estimate our main models using the ordinary-day sample, which includes only information on parental time investments in ordinary days (see Section 4 for more details). As shown in Table 12, we find results that are qualitatively similar to those obtained using the full sample. In particular mothers appear to increase their time by 137 minutes for a one standard deviation decrease in the child's socio-emotional ability. We find also a reaction of the mother's time investment to changes in the child's physical health, suggesting that mothers in ordinary days are more likely to compensate for child's physical health problems. However this reaction is statistically significant at 10% level only.

We also provide evidence of the validity of our instrumental variables by extending the number of instruments and computing a Sargan test for the validity of the instruments. Beside the twice lagged measures of child's human capital we use also their interaction with a dummy for child's neonatal intensive care. These additional instruments are justified by the fact that a negative health shock at birth might affect the child development process. Being the number of instruments greater than the number of endogenous variables, our model is overidentified and we are able to test the validity of our instruments using the Sargan test.

The estimated coefficients using the additional IVs are reported in column 2 of Table 13 and do not seem to differ from our basic results, which we report, for convenience, in the first column. The Sargan test supports the validity of the instruments used in the analysis (the p-value is equal to 0.6486).

6 Conclusions

Our empirical findings can be summarized as follows: (i) both mothers and fathers tend to compensate for socio-economic abilities but mothers' investment response is larger than

fathers' one; (ii) mothers with a university degree compensate for cognitive abilities while they do not react to changes in socio-economic abilities, (iii) inactive and unemployed mothers invest more time in their child and compensate more for socio-economic abilities with respect to working mothers, (iv) mothers with poor health compensate more for lack in socio-emotional abilities than mothers with good health and (v)mothers' investment strategies are similar for sons and daughters, whereas fathers adopt a compensating strategy for sons and a neutral strategy for daughters.

Because our empirical analysis ignore parental time investment in potential siblings, our findings must be interpreted with some caution. If we assume that parents who compensate (reinforce) for changes in their child's ability across time are also compensating (reinforcing) for differences in ability between siblings, and that differences in ability across time be positively correlated between siblings; then omitting to control for the sibling's abilities lead to an attenuation bias for the response of parents to the child's abilities. This would implies that the compensating effect we observe could be even larger in absolute term.

The main policy suggestion we can draw from our empirical analysis is that mothers with low education could benefit from school policies that raise their awareness of their child's cognitive performance and of activities they can do with their child to improve their cognitive abilities. More in general, because parents seem to be averse to inequity, policies directed to parents could represent an effective way to reduce inequalities in endowments across children.

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Tables

Table 1: Weekly mother's time investment: main and ordinary-day sample

Weekly mother's time investment - main sample				
	Children aged 6-7 years		Children aged 6-7 years	
	Mean	SD	Mean	SD
Educational activities	99.83	138.20	77.91	128.22
Psychological support	31.43	73.53	23.26	69.45
Leisure activities	425.54	444.44	407.09	494.34
Eating	181.23	164.10	160.45	162.68
Personal care	108.29	111.94	79.04	97.50
Total time	**846.31**	**626.24**	**747.75**	**642.80**
No. children	910		910	

Weekly mother's time investment - ordinary-day sample				
	Children aged 6-7 years		Children aged 6-7 years	
	Mean	SD	Mean	SD
Educational activities	90.57	111.57	83.26	145.04
Psychological support	21.65	52.36	17.28	55.82
Leisure activities	363.23	341.53	258.42	274.41
Eating	180.57	141.14	162.91	171.44
Personal care	105.57	96.89	86.11	105.00
Total time	**761.58**	**486.27**	**607.98**	**496.65**
No. children	158		158	

Table 2: Descriptive statistics of child's human capital measures by child's age

	Standardized Variables			
Variables	Mean	SD	Min	Max
Cognitive ability				
4-5 years old	0.04	0.97	-2.40	3.45
6-7 years old	0.05	0.98	-4.79	3.38
8-9 years old	0.08	0.99	-4.64	3.70
Socio-emotional ability				
4-5 years old	0.08	0.96	-3.48	1.73
6-7 years old	0.09	0.91	-3.72	1.52
8-9 years old	0.10	0.91	-4.04	1.38
Physical health				
4-5 years old	0.09	0.91	-3.66	1.56
6-7 years old	0.04	0.98	-4.68	1.22
8-9 years old	0.07	0.97	-4.39	1.17

	Raw Variables			
	Mean	SD	Min	Max
Cognitive ability				
4-5 years old	65.64	5.45	51.98	84.78
6-7 years old	74.83	4.90	50.50	91.58
8-9 years old	79.56	4.76	56.80	96.98
Socio-emotional ability				
4-5 years old	8.25	4.79	0	26
6-7 years old	6.83	4.34	0	25
8-9 years old	6.38	4.52	0	27
Physical health				
4-5 years old	83.87	9.94	42.86	100
6-7 years old	83.80	13.45	18.75	100
8-9 years old	85.14	13.06	25.00	100

The raw socio-emotional variable measures child's behavioral problems, therefore a higher score implies more socio-emotional problems. On the contrary, the standardized socio-emotional variable is higher for children with a better socio-emotional ability.

Table 3: Descriptive statistics of control variables

Variables	Mean	SD
Time invariant variables		
Intensive care at birth (dummy)	0.14	0.35
Male (dummy)	0.50	0.50
Mother with degree (dummy)	0.42	0.49
Poor mother's general health (dummy)	0.05	0.22
Unemployed or inactive mother (dummy)	0.24	0.43
Time varying variables		
Pupil-teacher ratio	20.85	6.85
Teacher's years of experience	16.29	11.05
Equivalised family income	46,743.07	30,682.13
Family shocks		
Sickness of a close relative (dummy)	0.06	0.23
Sickness of a close friend (dummy)	0.10	0.30
Death of a close relative (dummy)	0.04	0.19
Death of a close friend (dummy)	0.18	0.39
Hours of informal care (deviation from the mean)	-0.15	2.79
Hours of formal care (deviation from the mean)	-0.17	2.56
Informal care (dummy)	0.19	0.39
Formal care (dummy)	0.15	0.36

Statistics of time invariant variables are computed using information in wave 1, when children are 4-5 years old, except for mother's variable which are measured in wave 2. Statistics of time variant variables are obtained pooling observations when children are 6-7 and 8-9 years old.

Table 4: Mother's time investment model: Main estimation results.

	Child fixed effects models	
	without IV	with IV
Cognitive ability	-16.611	52.236
	(25.286)	(47.090)
Socio-emotional ability	-88.203***	-117.509*
	(31.385)	(61.407)
Physical health	-2.090	-70.874
	(27.259)	(57.359)
Pupil-teacher ratio	19.366	10.609
	(15.869)	(16.233)
Pupil-teacher ratio (squared)	-0.628	-0.388
	(0.424)	(0.436)
Teacher experience (years)	0.248	1.019
	(1.899)	(1.924)
Family income	-0.003**	-0.002
	(0.001)	(0.001)
Hours of informal care	-0.491	-10.298
	(15.072)	(15.474)
Hours of formal care	-31.383**	-29.033*
	(15.671)	(15.663)
Informal care	-3.944	55.706
	(84.525)	(87.063)
Formal care	99.889	72.862
	(103.891)	(104.291)
Constant	806.865***	-85.907***
	(157.982)	(29.107)
No. observations	1,820	1,820
No. children	910	910
F tests (first stages)		
Cognitive ability	-	122.65 [0.000]
Socio-emotional ability	-	102.07 [0.000]
Physical health	-	85.78 [0.000]
Endogeneity test	-	5.89 [0.117]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. In column 2 twice-lagged abilities are used as instruments (IV).

Table 5: First stage regressions for the mother's time investment model.

	First stages		
	Cognitive ability	Socio-emotional ability	Physical health
Cognitive ability (t-2)	-0.584***	0.042*	0.053*
	(0.031)	(0.026)	(0.030)
Socio-emotional ability (t-2)	0.038	-0.460***	0.076**
	-0,032	(0.027)	(0.031)
Physical health (t-2)	-0.035	0.0520*	-0.518***
	(0.034)	(0.028)	(0.033)
Pupil-teacher ratio	-0,028	-0.000	0.014
	(0.018)	(0.015)	(0.018)
Pupil-teacher ratio (squared)	0.001*	0.000	-0.000
	(0.000)	(0.000)	(0.000)
Teacher experience (years)	-0,002	0.001	0.003
	(0.002)	(0.002)	(0.002)
Family income	1.26e-06	0.000	-0.000
	(1.39e-06)	(0.000)	(0.000)
Hours of informal care	0.009	-0.010	0.012
	(0.017)	(0.014)	(0.017)
Hours of formal care	0.016	0.004	-0.008
	(0.018)	(0.015)	(0.017)
Informal care	0.084	-0.002	-0.086
	(0.097)	(0.081)	(0.095)
Formal care	-0.011	0.072	0.012
	(0.116)	(0.097)	(0.114)
Constant	0.003	0.034	0.015
	(0.033)	(0.027)	(0.032)
No. observations	1,820	1,820	1,820
No. children	910	910	910

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis.

Table 6: Mother's time investment model adding family shocks covariates

	Child fixed effects models	
	without IV	with IV
Cognitive ability	-16.324	53.999
	(25.346)	(47.054)
Socio-emotional ability	-87.323***	-119.066*
	(31.520)	(61.580)
Physical health	-1.219	-70.879
	(27.356)	(57.511)
Pupil-teacher ratio	19.297	10.745
	(15.911)	(16.266)
Pupil-teacher ratio (squared)	-0.627	-0.394
	(0.425)	(0.436)
Teacher experience (years)	0.199	1.004
	(1.906)	(1.931)
Family income	-0.003**	-0.002
	(0.001)	(0.001)
Hours of informal care	-0.089	-9.633
	(15.130)	(15.519)
Hours of formal care	-30.361*	-28.260*
	(15.734)	(15.698)
Informal care	-0.758	55.516
	(84.849)	(87.262)
Formal care	99.685	73.005
	(104.071)	(104.316)
Family shocks		
Sickness of a close relative	8.530	-2.553
	(89.299)	(90.252)
Sickness of a close friend	81.035	58.953
	(66.795)	(66.999)
Death of a close relative	47.675	24.403
	(99.918)	(99.787)
Death of a close friend	10.540	15.970
	(48.903)	(49.170)
Constant	794.452***	-83.175***
	(158.589)	(29.342)
No. observations	1,820	1,820
No. children	910	910
F tests (first stages)		
Cognitive ability	-	123.01 [0.000]
Socio-emotional ability	-	101.80 [0.000]
Physical health	-	85.56 [0.000]
Endogeneity test	-	6.20 [0.102]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. In the estimation with IV we use twice-lagged abilities as instruments.

Table 7: Mother's time investment model by educational level

	Child fixed effects models	
	without IV	with IVs
Mothers without a degree		
Cognitive ability	52.895	61.328
	(32.157)	(58.218)
Socio-emotional ability	-92.227**	-149.305**
	(39.253)	(75.843)
Physical health	13.041	-89.396
	(34.010)	(72.511)
Mothers with a degree		
Cognitive ability	-126.022***	35.983
	(40.483)	(79.846)
Socio-emotional ability	-75.439	-54.975
	(51.905)	(106.346)
Physical health	-22.275	-41.059
	(45.373)	(94.794)
Constant	840.595***	-84.136***
	(158.539)	(29.684)
No. observations	1,820	1,820
No. children	910	910
F tests (first stages)		
Cognitive ability	-	61.59 [0.000]
Socio-emotional ability	-	50.97 [0.000]
Physical health	-	43.01 [0.000]
Cognitive ability (interaction)	-	52.31 [0.000]
Socio-emotional ability (interaction)	-	44.96 [0.000]
Physical health (interaction)	-	42.74 [0.000]
Endogeneity test	-	9.070 [0.170]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. In the estimation with IV we use twice-lagged abilities as instruments. All models include the full set of covariates: pupil-teacher ratio, teacher's years of experience, family income and child care measures.

Table 8: Mother's time investment model by employment status

	Child fixed effects models	
	without IV	with IVs
Mothers with a job		
Cognitive ability	-6.942	59.968
	(28.906)	(53.697)
Socio-emotional ability	-64.564*	-72.523
	(35.933)	(71.394)
Physical health	6.376	-72.866
	(30.886)	(64.907)
Mothers without a job		
Cognitive ability	-42.514	17.524
	(52.371)	(102.257)
Socio-emotional ability	-164.955**	-254.490**
	(64.544)	(119.753)
Physical health	-32.344	-76.335
	(58.174)	(122.333)
Constant	796.221***	-82.053***
	(158.145)	(29.389)
No. observations	1,820	1,820
No. children	910	910
F tests (first stages)		
Cognitive ability	-	61.48 [0.000]
Socio-emotional ability	-	51.37 [0.000]
Physical health	-	42.78 [0.000]
Cognitive ability (interaction)	-	54.71 [0.000]
Socio-emotional ability (interaction)	-	61.60 [0.000]
Physical health (interaction)	-	43.08 [0.000]
Endogeneity test	-	7.04 [0.317]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. In the estimation with IV we use twice-lagged abilities as instruments. All models include the full set of covariates: pupil-teacher ratio, teacher's years of experience, family income and child care measures.

Table 9: Mother's time investment model by health status

	Child fixed effects models	
	without IV	with IVs
Mothers with good or excellent health		
Cognitive ability	-16.315	51.128
	(25.861)	(49.010)
Socio-emotional ability	-79.661**	-123.790*
	(32.778)	(63.844)
Physical health	-3.738	-67.706
	(28.444)	(59.559)
Mothers with poor health		
Cognitive ability	-7.475	55.296
	(133.122)	(239.546)
Socio-emotional ability	-189.903*	-14.561
	(113.298)	(239.271)
Physical health	30.877	-112.227
	(100.630)	(205.970)
Constant	794.994***	-84.941***
	(158.725)	(29.247)
No. observations	1,820	1,820
No. children	910	910
F tests (first stages)		
Cognitive ability	-	61.27 [0.000]
Socio-emotional ability	-	51.82 [0.000]
Physical health	-	45.04 [0.000]
Cognitive ability (interaction)	-	105.12 [0.000]
Socio-emotional ability (interaction)	-	54.24 [0.000]
Physical health (interaction)	-	55.53 [0.000]
Endogeneity test	-	7.40 [0.286]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. In the estimation with IV we use twice-lagged abilities as instruments. All models include the full set of covariates: pupil-teacher ratio, teacher's years of experience, family income and child care measures.

Table 10: Mother's time investment model by child's gender

	Child fixed effects			
	without IVs (baseline)	with IVs (interactions)	without IVs (baseline)	with IVs (interactions)
Baseline / Sons				
Cognitive ability	-16.611	52.236	-47.127	53.196
	(25.286)	(47.090)	(35.956)	(71.947)
Socio-emotional ability	-88.203***	-117.509*	-91.598**	-135.455*
	(31.385)	(61.407)	(41.782)	(81.316)
Physical health	-2.090	-70.874	20.773	-15.192
	(27.259)	(57.359)	(40.484)	(83.845)
Daughters				
Cognitive ability	-	-	15.417	51.456
			(35.753)	(66.913)
Socio-emotional ability	-	-	-80.604*	-104.744
			(48.041)	(98.354)
Physical health	-	-	-23.020	-122.231
			(36.819)	(76.957)
Constant	806.865***	-85.907***	800.352 ***	-87.675***
	(157.982)	(29.107)	(158.427)	(30.289)
No. observations	1,820	1,820	1,820	1,820
No. children	910	910	910	910
F tests (first stages)				
Cognitive ability	-	122.65 [0.000]	-	62.27 [0.000]
Socio-emotional ability	-	102.07 [0.000]	-	52.63 [0.000]
Physical health	-	85.78 [0.000]	-	43.27 [0.000]
Cognitive ability (interaction)	-	-	-	70.00 [0.000]
Socio-emotional ability (interaction)	-	-	-	52.18 [0.000]
Physical health (interaction)	-	-	-	44.52 [0.000]
Endogeneity test	-	5.89 [0.117]	-	6.16 [0.406]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. *P – values* are reported in brackets. In the estimation with IV we use twice-lagged abilities as instruments. All models include the full set of covariates: pupil-teacher ratio, teacher's years of experience, family income and child care measures.

Table 11: Father's time investment model by child's gender

	Child fixed effects			
	without IVs (baseline)	with IVs (interactions)	without IVs (baseline)	with IVs (interactions)
Baseline / Sons				
Cognitive ability	-6.883	0.420	-9.719	-28.083
	(12.977)	(24.399)	(18.472)	(37.423)
Socio-emotional ability	12.397	-66.599**	7.568	-84.847**
	(16.108)	(31.817)	(21.465)	(42.296)
Physical health	-10.047	9.492	-16.670	32.502
	(13.990)	(29.720)	(20.798)	(43.611)
Daughters				
Cognitive ability	-	-	-3.788	29.519
			(18.368)	(34.804)
Socio-emotional ability	-	-	20.286	-36.631
			(24.680)	(51.158)
Physical health	-	-	-4.606	-14.792
			(18.915)	(40.028)
Constant	241.306***	3.182	239.437***	7,121
	(81.079)	(15.081)	(81.389)	(15.755)
No. observations	1,820	1,820	1,820	1,820
No. children	910	910	910	910
F tests (first stages)				
Cognitive ability	-	122.65 [0.000]	-	62.27 [0.000]
Socio-emotional ability	-	102.07 [0.000]	-	52.63 [0.000]
Physical health	-	85.78 [0.000]	-	43.27 [0.000]
Cognitive ability (interaction)	-	-	-	70.00 [0.000]
Socio-emotional ability (interaction)	-	-	-	52.18 [0.000]
Physical health (interaction)	-	-	-	44.52 [0.000]
Endogeneity test	-	9.61 [0.022]	-	15.42 [0.017]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. In the estimation with IV we use twice-lagged abilities as instruments. All models include the full set of covariates: pupil-teacher ratio, teacher's years of experience, family income and child care measures.

Table 12: Mother's time investment model using ordinary days

	Child fixed effects models	
	without IV	with IVs
Cognitive ability	22.814	-56.614
	(52.027)	(94.788)
Socio-emotional ability	-137.236**	-113.530
	(61.650)	(104.408)
Physical health	-101.827*	-105.679
	(56.160)	(92.807)
Constant	598.425**	-174.206***
	(301.410)	(58.057)
No. observations	316	316
No. children	158	158
F tests (first stages)		
Cognitive ability	-	24.91 [0.000]
Socio-emotional ability	-	25.04 [0.000]
Physical health	-	30.54 [0.000]
Endogeneity test	-	1.050 [0.789]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. In the estimation with IV we use twice-lagged abilities as instruments. All models include the full set of covariates: pupil-teacher ratio, teacher's years of experience, family income and child care measures.

Table 13: Mother's time investment model: Estimation using additional instruments

	Child fixed effects models	
	with IVs	with IVs
	exactly identified	over-identified
Cognitive ability	52.236	53.725
	(47.090)	(46.999)
Socio-emotional ability	-117.509*	-120.704**
	(61.407)	(61.126)
Physical health	-70.874	-62.730
	(57.359)	(56.974)
Pupil-teacher ratio	10.609	10.507
	(16.233)	(16.224)
Pupil-teacher ratio (squared)	-0.388	-0.385
	(0.436)	(0.436)
Teacher experience (years)	1.019	0.990
	(1.924)	(1.923)
Family income	-0.002	-0.002
	(0.001)	(0.001)
Hours of informal care	-10.298	-10.542
	(15.474)	(15.465)
Hours of formal care	-29.033*	-29.154*
	(15.663)	(15.654)
Informal care	55.706	56.427
	(87.063)	(87.015)
Formal care	72.862	74.159
	(104.291)	(104.229)
Constant	-85.907***	-85.704***
	(29.107)	(29.091)
No. observations	1,820	1,820
No. children	910	910
F tests (first stages)		
Cognitive ability	122.65 [0.000]	61.34 [0.000]
Socio-emotional ability	102.07 [0.000]	51.44 [0.000]
Physical health	85.78 [0.000]	43.43 [0.000]
Endogeneity test	5.89 [0.117]	5.640 [0.131]
Sargan test	-	1.648 [0.6486]

Notes. *** p <0.01, ** p <0.05, * p <0.1. Standard errors are reported in parenthesis. $P-values$ are reported in brackets. Column 1 shows results from the exactly identified model, where twice-lagged abilities. Column 2 provides results from the overidentified model, where twice-lagged abilities as well as their interactions with a dummy for child's neonatal intensive care are used as instruments.

Appendix A

Table 1: List of developmental activities included in the parental time investment measure

Activity Category	**List of Activities**
Eating	eating, drinking
Personal Care	bathing, dressing, hair care, health care
Educational Activities	read a story, talked/sung to, sing/talk, helping with chores, job
Leisure Activities	organised sport or physical activity (e.g.swim/dance), other organised lesson or activity (e.g.music, drama), active free play (e.g. running, climbing, ball game), quiet free play (e.g. craft, dress-ups), taken places with adult (e.g.shopping), visiting people or special event, walking (for travel or fun), ride bicycle or trike (for travel or fun)
Psychological Support	held, cuddled, hugged, comforted, soothed

In the LSAC, time-use diares allow to record contemporaneous activities in each time interval, implying that the sum of child's time could exceed 24 hours in a day. Differently than other datasets that comprise time use diaries (as the Child Development Supplement from the Panel Study of Income Dynamics), the LSAC does not distinguish among primary and secondary activities. Therefore we have defined an algorithm in order to define the main (or primary) activity when two or more activities are recorded:

1. Educational Activities
2. Psychological Support
3. Leisure Activities
4. Eating
5. Personal Care

Appendix B

The **Peabody Picture Vocabulary Test (PPVT)** provides a measure of listening comprehension for spoken words in standard English and a screening test for verbal ability. The main part of the test involves items presented in picture plates, arranged in a multiple-choice format. Children are asked to "select the picture that best illustrates the meaning of the stimulus word presented orally by the examiner" (Dunn and Dunn 1997).

The **Strength and Difficulty Questionnaire (SDQ)** is a behavioural screening questionnaire composed by 25 items divided in 5 subscales (peer problems, emotional symptoms, hyperactivity, conduct problems and prosocial behaviour) . The parent, who was the main carer, reports whether the description was 'certainly true", "somewhat true" or "not true". Each item scores from 0 (non true) to 2 (certainly true). Higher scores indicate more negative symptoms, except for the scores indicating prosocial behaviour. Here below we report the questions asked in the SDQ.

- *SDQ Peer problems subscale*: mean of 5 parent-rated items assessing problems in the child's ability to form positive relationships with other children
  - rather solitary, tends to play alone
  - does not havehas at least a good friend
  - generally not liked by other children
  - picked on or bullied y other children
  - gets on better with adults than with other children
- *SDQ Emotional symptoms subscale* : mean of 5 parent-rated assessing a child's frequency of display of negative emotional states :
  - often complains of headaches, stomach aches or sickness
  - many worries, often seems worried
  - often unhappy, down-hearted or tearful
  - nervous or clingy in new situations, easily loses confidence
  - many fears, easily scared
- *SDQ Hyperactivity subscale*: mean of 5 parent-rated items assessing child's fidgetiness, concentration span and impulsiveness:
  - restless, overactive, cannot stay still for long
  - constantly fidgeting or squirming
  - easily distracted, concentration wanders
  - does not stop and thinks things out before acting
  - doesn not sees tasks through to the end, poor attention span

- S*DQ Conduct subscale*: mean of 5 parent-rated items assessing child's tendency to display problem behaviours when interacting with others:
  - often has temper tantrums or hot tempers
  - not generally obedient, usually does not what adult requests
  - often fights with other children or bullies them
  - often argumentative with adults
  - can be spiteful with others
- *SDQ Prosocial subscale:* mean of 5 parent-rated items assessing the child's propensity to behave in a way that is considerate helpful to others:
  - considerate of other people's feelings
  - shares readily with other children
  - helpful if someone is hurt, upset or feeling ill
  - kind to younger children
  - often volunteers to help others

The **PEDS Physical health subscale** is part of the Paediatric Quality of Life Inventory that measures health-related quality of life in children and adolescents. It integrates a variety of scales that capture different aspects of child's health: physical functioning, emotional functioning, social functioning and school functioning.

We focus on the physical health subscale composed by the following 8 items:

- Problems with walking
- Problems with running
- Problems with sports and exercise
- Problems with heavy lifting
- Problems in bathing
- Problems helping to pick up toys
- Problems with hurts or aches
- Problems with low energy levels

For each item the parent is asked to choose among 5 alternatives to describe the frequency of these problems in the last month: (1) never, (2) almost never, (3) sometimes, (4) often, (5) almost always.