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Parental Inputs and Socio-Economic Gaps in Early Child Development

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Highlights

- Previous research has shown that increasing mother's education improves their children's skills and education. But the mechanisms through which this happens are little understood.
- We analyse the role of parental inputs, both in terms of financial resources and parental investments (such as health behaviours in pregnancy, and the home learning environment), in the transmission of mother's education to children's early cognitive skills. We use a policy reform, the raising of the school leaving age (RoSLA) in 1972, to assess whether the policy changed parental inputs, and whether these inputs could explain the effect of the policy on child skills.
- We show that financial resources are an important channel through which mother's education improves their children's cognitive skills.
- However, there is also a role for parental investments, over and above financial resources, in accounting for this transmission.
- This shows that there are multiple advantages to improving educational attainment, over and above the financial returns to education within a generation.

Why does this matter?

This research shows that improving educational attainment has a number of long-lasting benefits, across generations, over and above the financial pay-off for those directly affected.

Parental inputs and socio-economic gaps in early child development.

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Abstract

By the time children start school, socio-economic gaps are evident in child skills. We document a causal effect of a reform to mothers' education on her child's skills and use mediation analysis to explore the role of parental inputs as mechanisms. The reform shifted mothers' education from no, to a low level of qualifications. Our results suggest that financial resources are an important channel, explaining up to 59% of the effect on child cognitive skills. On top of this, parental investments of health behaviours during pregnancy and monetary investments at home explain a further 14% of the test score gaps.

Keywords: Child development, test scores, socio-emotional skills, parental inputs, decomposition, ALSPAC.
JEL codes:

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1 Introduction

There is a well-documented socio-economic gap in the skills of children from an early age, in terms of both cognitive and socio-emotional skills.[1] These early gaps widen across the child's life and drive early adult outcomes including college attendance, crime and health.[2] Recent work has shown that this gap in children's early cognitive skills is, at least partly, causally driven by parental education. Using an exogenous increase in parents' education, Dickson, Gregg, and Robinson (2016) show that children of parents with more education have higher cognitive skills measured from age 5 up to age 16.[3]

While the effect of parents' education on the next generations' skills has been estimated, there is little evidence on the mechanisms through which increasing the education of parents may lead to higher skills in their children (Francesconi and Heckman, 2016). This is where we make a significant contribution to the literature, investigating the mechanisms for the causal effect of mothers' education on children's cognitive and socio-emotional outcomes during early schooling (up to age 7).[4] Through analysing for the first time the causal pathways through which a reform to mother's education impacts on child skills, we are able to offer a greater understanding of the benefits to increasing education.

To give a causal interpretation to the effect of mothers' schooling on child outcomes we exploit an exogenous change in education from the raising of the school leaving age (RoSLA). The policy extended the compulsory schooling age in England from 15 to 16 in 1972, enticing those who would otherwise have left school at 15 to stay on for one additional year. This additional year coincides with important qualifications taken at the end of secondary school at age 16 in England and hence the treatment not just raised the years of schooling but lowered the probability of leaving school with no qualifications. The low educated marginal

[1] Feinstein (2003), Doyle, Harmon, Heckman, and Tremblay (2009) and Washbrook and Waldfogel (2011) provide evidence for cognitive skills gaps; Kalil (2015), Washbrook and Waldfogel (2011) for socio-emotional skills gaps.

[2] see Heckman and Rubinstein (2001); Carneiro and Heckman (2003); Heckman, Stixrud, and Urzua (2006); Heckman, Pinto, and Savelyev (2013); Kautz, Heckman, Diris, Ter Weel, and Borghans (2014).

[3] A large literature has estimated the causal effect of parents' education on the completed education of their children, dating back to Black, Devereux, and Salvanes (2005) and reviewed in Holmlund, Lindahl, and Plug (11). Instead in this paper we focus on the effect of parents' education on early skills of children.

[4] Undoubtedly the mediation of fathers' education on child skills is an important question but the survey design of our data focuses on the mother and her partner - rather than the father. Fathers enter the analysis as we consider how mothers' education drives assortative mating patterns.

individuals who were enticed to stay in education for one additional year are arguably a policy relevant group, whose investment behaviour as parents can be improved to lower inequalities in child skills. Crucially, only a subsample of mothers from ALSPAC were affected by the 1972 RoSLA and exposed to an exogenous increase in education. Previous research has shown that exposure to this policy raised child cognitive outcomes (Dickson, Gregg, and Robinson, 2016). We extend this analysis by also considering the effect of RoSLA on socio-emotional outcomes of children during early schooling.

When considering potential mechanisms, an obvious place to start is to draw on the extensive literature on the returns to education within a generation. An increase in mothers' education is likely to increase the financial resources available to families, directly through their own capital accumulation and labour market earnings, but also through their choice of partner and therefore their combined income, which can increase child skills (see Dahl and Lochner 2012; and Carneiro, Garcia, Salvanes, and Tominey 2015). A potentially less obvious impact of the policy is that an increase in mother's education may also change the type of direct parental investments made in their child; including health behaviours in pregnancy, their home learning environment and the quantity and quality of time spent with their child.[5],[6] Therefore when considering the channels through which mothers' education raises child skills it is important to incorporate both dimensions of potential parental inputs in children.[7]

Our analysis exploits the rich dataset of the Avon Longitudinal Study of Parents and Children (ALSPAC) to decompose the treatment effect of RoSLA of mothers on child outcomes into the contribution from family resources and parental investments. The family resources we measure include i) pre-birth human capital (home ownership, marital status, employment history), ii) family income, iii) employment (participation and hours in the labour market of mothers), iv) wellbeing and v) variables for assortative mating (partner's education, partner's employment, quality of relationship). We also include a large set of

[5]For the literature on the effect of time investments in children on their skills, see Boca and Alberto (2014), Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2017)

[6]Doepke and Zilibotti (2017); Moroni, Nicoletti, and Tominey (2019) have examined the role of quality of parenting through parenting style on child development.

[7]We will refer in the paper to any decisions or investments made by parents which may drive the human capital of their child as inputs.

parental investments; vi) mothers' health during pregnancy (smoking and alcohol consumption) vii) monetary investments (purchases such as books and educational toys), viii) time investments, ix) parenting style, and x) the number of siblings or fertility choices.

It is important to consider the endogeneity of the mediators in our analysis. There may be mediators that we do not observe, which are correlated with our observed parental inputs and child outcomes. We follow Heckman and Pinto (2015) and describe the conditions under which we can infer our estimates as causal. In addition, our objective is to include a wide set of parental inputs to capture the main theoretical pathways from mothers' education to child skills. Only a subset of these parental inputs turn out to be mediators, as many are not affected by the education reform. But all measures of parental inputs are included in the decomposition analysis, to control for a wide set of environmental and behavioural inputs into child development.

There is a literature looking at how parental inputs respond causally to mothers' education (Carneiro, Meghir, and Parey 2013; Piopiunik 2014). In addition Attanasio, Cattan, Fitzsimons, Meghir, and Rubio-Codina (2017) explored potential mechanisms in the effect of a pre-school intervention in Colombia on child skills, of money and time investments of parents. However there has not yet been any study that we know of that makes the link from the maternal education, through to changes in parental inputs which drive the child's skills gap. This is an important contribution if we are to open the black box of how a reform to compulsory schooling affects child development of the next generation.

We use the mediation analysis methods used by Blanden, Gregg, and Macmillan (2007) and developed further by Heckman, Pinto, and Savelyev (2013) and Heckman and Pinto (2015). The latter two papers evaluate the mechanisms through which the Perry Preschool Programme affected long run outcomes of participants.[8] Our methodology departs from the methodology of Heckman, Pinto, and Savelyev (2013) and Heckman and Pinto (2015) because, unlike these papers we do not exploit a randomized control trial in treatment status. Instead, treatment status in our case is defined by the age of the mother at birth, whereby mothers who were at school prior to the 1972 reform were able to leave school at 15 whilst from 1972 onwards individuals could not leave school until the age of 16. This treatment

[8]This paper contributes to a growing literature of decomposing a treatment effect into the potential mediators; including Conti, Heckman, and Pinto (2016); Dix-Carneiro, Soares, and Ulyssea (2018); Oreopoulos, Brown, and Lavecchia (2017); Fagereng, Mogstad, and Ronning (2018).

variation is exploited in a cohort study, whereby children were born within a 22 month period. Consequently the treated mothers in our sample by construction are likely to be younger at the time of birth than the control group of mothers. To deal with this, we select a window of mothers' birth years 6 years either side of the reform (N=5017 mothers) and control for the mothers' age and in a second sample a window of mothers' born 1 year either side of the reform, where the treatment status has common support across the mothers' age at birth (N=1035). Whilst we lose precision in the more restrictive sample, the estimates are not qualitatively or statistically different across the two windows.

The results can be summarised by three findings. First, the policy reform raised schooling outcomes for mothers, decreasing their probability of leaving school with no qualifications and increasing their probability of leaving school with high-stake qualifications at age 16. Second there is a sizeable treatment effect of RoSLA on child outcomes. In particular, treated mothers raised their children's cognitive skills at school entry and at age 7 by around 0.12-0.14 of a standard deviation. On the other hand there was no significant treatment effect on the socio-emotional skills of children. Third, of the mechanisms considered, five constitute important mediators for the treatment effects on cognitive skills. The most important are family resources, including increased pre-birth human capital, increased family income, and higher educated partners, which explain around 49-59% of the cognitive test score gap from RoSLA. Interestingly, over and above the effect of resources, there are important channels through investments made by parents during pregnancy and in early childhood which together explain around 15% of the total cognitive test score gaps. These investments include greater monetary investments in the home learning environment, and improving health behaviours during pregnancy.

We do not find any improvements in softer parental investments including parenting style or time spent with children, as a results of the policy. RoSLA shifted mothers from having no qualifications towards a basic set of qualifications, which are still associated with low pay. Income shocks in low income families have been shown to drive essential purchases such as clothes for children and paying off bills (see for example Gregg, Waldfogel, and Washbrook 2006). Indeed, mothers impacted by the policy reduce their smoking or drinking during pregnancy and buy more home learning resources for their children, and these in turn contribute towards improved child cognitive skills in early childhood.

Our results are robust to a placebo test to confirm that the treatment effect on mother and children skills is not driven by assignment to treatment status by unobservable traits. In addition we provide tests for the sensitivity of methods to deal with missing values of mediators and in all cases our results prove robust.

The paper is structured as follows. Section 2 describes the ALSPAC dataset including a description of how we exploit the RoSLA to create exogenous variation in mother's education and Section 3 describes the methodology. Section 4 discusses our results where we identify key mediators for the effect of RoSLA on child skills and Section 5 discusses sensitivity of our analysis. Finally Section 6 concludes.

2 Data

2.1 Sample

Our data comes from the Avon Longitudinal Study of Parents and Children (ALSPAC), a longitudinal cohort study. Pregnant women resident in Avon, UK with expected dates of delivery 1st April 1991 to 31st December 1992 were invited to take part in the study. The initial number of pregnancies enrolled is 14,541 (for these at least one questionnaire has been returned or a "Children in Focus" clinic had been attended by 19/07/99). Of these initial pregnancies, there was a total of 14,676 foetuses, resulting in 14,062 live births and 13,988 children who were alive at 1 year of age (Boyd, Golding, Macleod, Lawlor, Fraser, Henderson, Molloy, Ness, Ring, and Davey Smith, 2013; Fraser, Macdonald-Wallis, Tilling, Boyd, Golding, Davey Smith, Henderson, Macleod, Molloy, Ness, et al., 2012). Mothers were interviewed during pregnancy and at frequent intervals after the birth of the child, with follow up surveys including children and partners. The survey contains very detailed information on the mothers and children, including maternal education and a range of early cognitive and socio-emotional outcome measures. Survey questionnaires related to parents were answered by the mother, who reported information on herself and her partner. [9] The questions did not relate specifically to the father of the cohort member and for this reason we focus on the effect of RoSLA on mothers' education.

[9]Please note that the study website contains details of all the data that is available through a fully searchable data dictionary and variable search tool, see http://www.bristol.ac.uk/alspac/researchers/our-data/.

Crucially, for the purpose of this paper, a number of the mothers in the survey were born before - and a number after - August 1957. The school cohort born from September 1957 onwards were subject to an exogenous policy reform in 1972 whereby the minimum school leaving age was increased from 15 to 16 years old. This meant that those born before September 1957 could leave school at age 15 while those born during or after September 1957 had to stay in school until at least age 16. Moreover, given that this is not a birth cohort study, the window of births means that we have overlapping support of the mothers' age within treatment and control groups. This study therefore combines an exogenous policy shock to mothers within a window of births, resulting in a quasi-experimental design that separates mothers' age from the policy shock. In the first stage of our analysis, we use information on mother's reported education levels to explore the impact of the exogenous policy shock on her schooling choices.

Our methodology chooses a set of mothers whose date of birth is relatively close to the RoSLA cut off. Sample 1 includes individuals in the treatment or control group if born no more than 6 years either side of the educational reform. We also show results for sample 2, constructed around a smaller window (+/-1 year) of RoSLA where there was common support across mothers' age at birth. We use statistical tests to check for similarities in our results across our two samples. Notice that the sample size of children and mothers falls from 5,017 (for test score age 6/7 outcomes) for the sample 1 to 1,035 for sample 2, illustrating the quality-quantity trade-off we are faced with.

2.2 Mother's Education

The highest qualification of the mother is recorded in ALSPAC when the mother was 32 weeks pregnant with the child. The categories record from lowest to highest; No qualifications; CSE (the Certificate of Secondary Education which is a low level set of qualifications taken at age 16); vocational qualifications; GCSE (the General Certification of Secondary Education which is a higher level set of qualifications taken at age 16); A Levels (Advanced level set of qualifications taken at age 18); and Degree. We focus on mothers' education as mothers are the primary respondents in the ALSPAC survey. We consider possible assortative mating mechanisms, through partner information, as mediators of the impact of mother's RoSLA on child skills, which we discuss in more depth in the mechanisms section below.

A set of binary indicators define the individual as having no qualification; low level of qualifications (which takes the value of 1 if they have vocational or CSEs); at least GCSEs qualifications; and at least A levels as the highest qualification. Panel a) of Table 1 shows the distribution of qualifications for mothers in the ALSPAC sample by treatment status. As expected there is a difference in the mothers' education by treatment status in the raw analysis, where mothers exposed to RoSLA are less likely to finish schooling with no qualifications (4.1% of the treatment and 9.7% of the control sample) and are more likely to have low levels of qualifications (CSE/vocational) and more likely to attain high quality GCSE qualifications at age 16. The treatment group has slightly lower years of schooling and lower probability of taking A level qualifications. This is likely driven by the different age at birth of mothers in the two samples, which the table shows to be higher for the control group. For this reason our analysis controls for the mothers' age at birth in all regressions.

Panel b) of Table 1 reports the descriptives statistics for comparison for sample 2, which imposes common support across mothers' age at birth of a one year window around the treatment. Again treated mothers are less likely to have no qualifications and are more likely to achieve at least the high quality GCSEs. Now there is no statistical difference between A'level achievement for the treatment and control groups.

Notice that both samples 1 and 2 contain a relatively older cohort of mothers at the birth of the child, with a mean of 30-36 in sample 1 and 33-35 in sample 2. In these samples, 75% of the births are for the second or third child and given this demographic, the age of the sample mother is representative for UK second or third births (see Dickson, Gregg, and Robinson 2016 for a discussion).

2.3 Child Outcomes

The focus of our paper is in decomposing the treatment effect of RoSLA on child skills early in their lifetime. ALSPAC contains a range of measures of child skills across multiple domains. Cognitive skills at ages 4/5 are recorded through national school administrative tests called the Entry Assessment Test. These tests are taken by children upon entry to school and all schools within the same Local Education Authority covering the ALSPAC area were administered the same tests.A second cognitive test outcome is recorded at age 6/7 through

the Key Stage (KS) 1 test scores.[10] The KS test score is a nationally administered test to all children in state schools and tests the child on reading, writing, spelling and mathematics. The average of these scores is the final score, used in our analysis. Test score data is obtained from the National Pupil Database, a census of all pupils in England within the state school system, which is matched into ALSPAC.

A measure of socio-emotional skills is derived through questionnaires administered to mothers, which include the Strength and Difficulties Questionnaire (SDQ), an international standardised test set to measure the behaviour and emotions of children (Goodman, 1997, 2001). The SDQ consists of five scales of child behaviour including emotional problems, conduct problems, hyperactivity, peer relationship problems and pro-social behaviour. Each scale is the composite of five measures as described in Table A.1. For each question the mother answers from the set "Doesn't apply"; "Applies somewhat"; "Certainly applies". Our analysis uses the SDQ scores when the child is 81 months old (6.75 years).

When creating the socio-emotional skills using the SDQ there are several possibilities for how best to combine the information from different measures. We follow Moroni, Nicoletti, and Tominey (2019) and create a latent factor representing internalising skills by combining emotional symptoms and peer problem subscales, and a second factor representing externalising skills by combining the conduct problems and hyperactivity problems. As explained in the psychological literature including Achenbach (1966), externalising and internalising traits have been shown to represent the latent factor for a large set of psychological traits of individuals. Externalising behaviour in children indicates a child exhibiting externally their emotions, through hitting, shouting and being generally disruptive. Internalising children on the other hand tend to keep their emotions within themselves and can seem unhappy or withdrawn. Our results are robust to using either the SDQ score or individual factors relating to each subscales.[11]

Panel a) of Table 1 provides descriptive statistics of our measures for sample 1 and panel b) of Table **??** for sample 2. The measures of skills are standardised to mean 0, standard deviation 1 in the full sample of ALSPAC respondents. The summary statistics indicate that

[10] In the UK education system, children enter schools into the Early Years level of development at age 4. Key stage 1 refers to schooling between years 1-2 when the child is aged 5-7 and the KS test score is taken at the end of this stage.

[11] Results are available on request.

in the raw data there are no statistical differences in child skills by the mothers' treatment status.

2.4 Potential Mechanisms

We observe a large set of potential mechanisms which are observed after the policy treatment and before the child outcomes. In this section we describe the measurement of the parental inputs. Section 2.4.1 describes a set of family resources including pre-birth human capital of the mother, family income, labour supply of the mother, well being of parents and assortative mating. Section 2.4.2 describes the measurement of parental investments including smoking and alcohol consumed during pregnancy, monetary investments, the number of siblings, parenting style, time investments and the quality of relationships between the child and the mother or partner. With the exception of family income and number of siblings, the parental inputs are constructed using factor analysis described in Section A.2.

2.4.1 Family Resources

An exogenous shock to education is likely to affect different dimensions of human capital and we define a latent factor for the mothers' human capital before the birth of the cohort member, by combining three questions related to the mothers' home ownership, marital status and employment status upon discovery of the pregnancy. Table A.2 reports details of each measure and the factor loadings which construct the latent variable for pre-birth human capital. Next, family income is recorded when the children cohort members were aged 2 and 3. We take the log of the average across these two periods to minimise measurement error and transitory variation. A third measure of family resources is the labour supply of the mother after pregnancy and before the child skills are measured. Table A.2 reports factor loadings on four measures including the number of hours worked at 33 months and again at 61 months (around the time of the early test score) and employment status at 47 months and again at 61 months.

A broad definition of family resources should include the mental health or well being of the parents, and Table A.2 reports the factor loadings relating to the latent variable set to capture the mothers' mental health, or well-being, recorded when the child was 33

months old. These combine different scales of the mothers's self-esteem (measured through the Bachman self-esteem score), anxiety (measured through Crown Crisp Experimental Index anxiety score which measures anxiety, depression and somatic symptoms), depression (measured through Edinburgh postnatal depression scale), enjoyment of and bonding with the child. The enjoyment scale is derived from three questions asking the mother how much she identifies with statements such as 'I really enjoy this child' and 'I feel confident with my child'. The bonding scale is measured from eight statements, again asking the mother how much she identifies with statements such as 'Children are fun' and 'Having this child has made me feel more fulfilled'. The factor loadings show that the subscales indicating mental health issues load negatively and those indicating positive mental health load positively.

Finally, a potential treatment effect of RoSLA of the mother is through assortative mating or the traits of her spouse. We include a measure of partner's years of schooling to capture assortative mating directly. Using information on partner's qualifications, his years of schooling is constructed as follows. Years of schooling is set equal to 15 if he attains CSE or vocational qualifications; 16 if he attains GCSEs as his highest qualification; 18 if he achieves A'levels and 21 if he attains a degree. We additionally construct two latent factors for the mothers' spouse, to include his employment at ages 21, 33 and 47 months (Table A.2) and a relationship quality measured at 33 months (Table A.2). This latter factor combines three composite measures of their partner's warmth, authority and communication with the mother. The communication score is derived from six items regarding the frequency that the mother and partner (for example) make plans, talk over feelings and discuss how their days have gone. The warmth and authority scores are derived from 11 and 13 questions respectively regarding how likely the partner is to be considerate of the mother, is a good companion, and is affectionate, and for authority, how likely the partner is to insist they do exactly as told, seeks to dominate, and is critical of the mother. Again, full details are contained in Section A.2.

2.4.2 Parental Investments

Parental investments are broadly defined as inputs made by parents which directly affect the child. First, health choices made by mothers during pregnancy can respond to her education. We combine information on the smoking and alcohol habits of the mother during

pregnancy, including the number of cigarettes smoked in the first 3 months, whether the mother smoked in the last two weeks of pregnancy, and glasses of alcohol consumed in the first three months. Table A.3 reports the factor loadings indicating that the factor picks up negative health behaviours during pregnancy.

To measure monetary investments of the household, ALSPAC recorded a set of questions relating to a composite toy score, at ages 24 and 42 months. The questions were the same across the two waves, but the recording of the answers differed. For the child aged 24 months, the mother was asked how many of each item was owned in the household, including cuddly toys, books and balls for example. The mother responses were recorded as "None", "One", "2 or 3", "4 or more". On the other hand at age 42 the responses to the same questions were recoded as "Yes" or "No" and consequently the measures of the toy score at age 42 months tends to distinguish between households who own none of the items versus households who own at least one. What we are able to pick up from this toy score is relevant for analysing the effect of RoSLA, to see whether the reform which raised education from a very low level of education to a slightly higher level affected the probability of owning an item such as a book. The toy score we use is the combination of the score at 24 and 42 months (see Table A.3) and is standardised to mean 0, standard deviation 1.

The quantity of time investments will be captured, in part, by the working patterns of the mother and her partner in the early years, which we include as family resources. Another potentially important factor with regards to time available is the household composition, and specifically the total number of siblings in the household, which we measure at 48 months.

The final set of potential mechanisms are intended to capture the quality of interactions between the parents and their child. Table A.3 measures the parenting style of the mother at 42 months, recording the method used by the mother to discipline her child (including whether she ignores the child, smacks or shouts at the child when naughty). A set of measures capture the time investments made by mothers in her child (see Table A.3) at 42 months including whether she sings to, plays with or cuddles the child. A comparable index for the partner time investments is recorded in Table A.4. Finally two factors relating to the mothers' and partners' relationship with the child, detailed in Table A.4 records measures including whether the mother or partner loves the child, gets on their nerves or has a battle of will with the child.

We have assumed that the measurement system for treatment and control groups is identical. In Table A.5 we report the estimated means and standard deviations of each latent factor when the mean for the control group is set equal to zero. The results show that the mean of the latent factors are close to zero in all cases an therefore suggest that our results are not sensitive to allowing the measurement system to differ for the groups of treatment and control.

3 Methodology

Our aim is to decompose the treatment effect of an increase in mothers' education on the early child skills of the second generation, into the component coming through mediators of parental inputs and the direct (or unexplained) component.

A large and recent literature has decomposed the effect of randomized control trials on outcomes (for example Heckman, Pinto, and Savelyev 2013; Heckman and Pinto 2015; Fagereng, Mogstad, and Ronning 2018). In our case, we apply the same methodology to an environment where treatment variation is not through a randomized control trial but quasi-experimental through a policy change to raise the school leaving age. In Section 3.1 we discuss the additional considerations to take into account in this setting.

Section 3.2 discusses an identification issue inherent in all decomposition analyses - including the aforementioned papers - which is the potential endogeneity of mediators. Finally, Section 3.3 and Section 3.4 describes our strategies to deal with measurement error and missing data respectively.

3.1 Decomposition with quasi-experimental variation in treatment status

Our decomposition methodology follows Heckman, Pinto, and Savelyev (2013). Applications of the method tend to exploit randomization in treatment status. For example in Heckman and Pinto (2015) families were randomly selected to participate in the Perry Preschool Programme whilst in Fagereng, Mogstad, and Ronning (2018), randomization was generated

in the treatment of family wealth through random assignment of Korean adoptees to families in Norway.

In our setting, a policy of Raising of the School Leaving Age (RoSLA) raised the compulsory age of schooling for mothers born after a particular date. Therefore treatment status is given by exposure to RoSLA, defined by the date of birth of mothers in our sample. Those born before 1 September 1957 were exposed to an education system with a compulsory minimum leaving age of 15 years, whereas those born after the date could not leave school before the age of 16. Thus treatment is stratified random, by the year the mothers were born. In our benchmark sample 1, we select a window of births 6 years either side of the policy cut-off, to ensure that treated and control mothers are as similar as possible in all traits except for their exposure to RoSLA. In sample 2, the window is narrowed to just 1 year either side of the policy date.

Our methodology will decompose the treatment effect of RoSLA on child outcomes into the effect of mediators and the unexplained component. The potential outcome for each individual is given by the equation

$$Y = DY_1 + (1 - D)Y_0 \tag{1}$$

where Y denotes the child outcome, D a binary treatment indicator for exposure to RoSLA where treated mothers were born between 1 September 1957- 1 September 1962 and control mothers were born between 31 August 1951 - 31 August 1957. Y_1 and Y_0 refer to the outcome for a child with treated and untreated mothers respectively. We aim to decompose the intention to treat effect $E(Y_1 - Y_0)$ to understand the channels through which the policy drives early life skills of children. In order to do this, consider the outcome equation defined as follows.

$$Y_d = \kappa_d + \sum_{j \in J} \alpha^j \theta_d^j + \beta X + \tilde{\epsilon_d} \tag{2}$$

where κ_d is an intercept fixed at the level of treatment d =0,1, θ_d^j denotes the j parental inputs from a set $j \in J$ at the level of treatment d and α^j the associated coefficients. X denotes a set of covariates which are observed prior to the treatment of RoSLA.

It may be that the mediators we observe are only a subset of the full set of mediators for the effect of RoSLA on child skills. If we observe in the data only a subset $j \in J_p$, we can rewrite equation 2 to express this.

$$Y_d = \tau_d + \sum_{j \in J_p} \alpha^j \theta_d^j + \beta X + \epsilon_d \tag{3}$$

$\tau_d = \kappa_d + \sum_{j \in J | J_p} \alpha^j E(\theta_d^j)$ and ϵ_d is an error term with mean zero equal to $\tilde{\epsilon_d} + \sum_{j \in J | J_p} \alpha^j (\theta_d^j - E(\theta_d^j)$. Our objective is to decompose the treatment effect of RoSLA on child skills into mediators. Combining equations 1 and 3 leads to the following

$$Y = D(\tau_1 + \sum_{j \in J_p} \alpha^j \theta_1^j + \beta X + \epsilon_1) + (1-D)(\tau_0 + \sum_{j \in J_p} \alpha^j \theta_0^j + \beta X + \epsilon_0) = \tau_+ \tau_1 D + \sum_{j \in J_p} \alpha^j \theta^j + \beta X + \epsilon \tag{4}$$

where $\tau = \tau_1 - \tau_0$ defines the role of unmeasured variables on the mean treatment effects, $\epsilon = D\epsilon_1 + (1-D)\epsilon_0$ is a mean zero error term and $\theta^j = D\theta_1^j + (1-D)\theta_0^j$, $j \in J_p$ denotes the measured inputs. We decompose the treatment effect of RoSLA into the different measured components of parental input using equation 4.

$$E(Y_1 - Y_0 | X) = \underbrace{(\tau_1 - \tau_0)}_{\substack{\text{Treatment effect} \\ \text{unmeasured inputs}}} + \underbrace{\sum_{j \in J_p} \alpha^j E(\theta_1^j - \theta_0^j | X)}_{\substack{\text{Treatment effect} \\ \text{measured inputs}}} \tag{5}$$

Because we exploit quasi-experimental variation in treatment status defined in a cohort study of children, a difficulty is that the assignment to treatment confounds two events - the year of birth of the mothers and the age of the mother at birth. Within a given birth year of the child, the treated mothers will be born in a later year and therefore be younger at the birth of their child than the non-treated mothers. This may introduce a bias, as the age of mothers at birth is correlated with child outcomes. According to Royer (2004) there is an inverse u-shaped relationship between maternal age at birth and child outcomes, whereby mothers either particularly young or particularly old at birth are associated with relatively poor child outcomes compared to mothers in the middle of the age distribution. This could mean that as the control group of mothers tend to be older at birth than the treatment

mothers, we may find an effect of RoSLA on child outcomes through the confounding effect of mothers' age.[12]

However note that an advantage of using ALSPAC is that unlike other birth cohort studies where participants were born within a week of each other, the birth of ALSPAC participants varies across a 22 month period which means that there is not a perfect relationship between age of the mother at birth and treatment status. Given this variation, it is possible to reduce the potential bias by choosing a window of mothers birth dates close to the 1 September 1957 cut-off in which there is common support across the mothers' age at birth. Therefore when analysing equations 1 - 5, we present all results for two samples: first, using the sample of mothers born in the 6 year window either side of RoSLA eligibility - which we refer to as Sample 1 - controlling for mothers' age at birth. Second, Sample 2 restricts this window to only those mothers for whom there is common support across mothers' age at birth, by taking a window of births 1 year either side of RoSLA, again also controlling for mothers' age at birth. We present tests of equality of coefficients across the two samples for all of our analysis.

There is a trade-off in selecting the appropriate sample, whereby both the precision of the estimates the potential confounders to the treatment effect increases with a large window either side of the policy reform. As expected, the sample size for sample 2 is much lower than for sample 1 (1035 compared to 5017 for our KS1 sample). Despite this our results are qualitatively similar across samples, but are more precisely estimated in sample 1.

3.2 Potential endogeneity of mediators

The presence of unobserved mediators which are correlated with both observed mediators and the child outcomes would lead to biased estimates in equation 5. The literature has dealt with the potential endogeneity of mediators in different ways.

Heckman and Pinto (2015) and Heckman, Pinto, and Savelyev (2013) describe the conditions upon which it is possible to relax the assumption that mediators are exogenous for the treatment and control group, to the assumption that mediators are exogenous for the

[12]It is also possible that we find a negative treatment effect on mothers' education as the treated group is younger at the age of birth and may still be in education.

control group only. The conditions by which it is possible to make the weaker identification assumption are detailed in Appendix Section A.3, where we test for and cannot reject these conditions.

Even under the weaker identification assumption, there may be concerns that the mediators are not exogenous at least for the control group. Papers including Fitzsimons, Attanasio, Meghir, Cattan, and Rubio-Codina (2019) decompose the effect of a randomized control trial of a pre-school intervention on later skills of children into the two channels of monetary and time investments of parents. The authors consider only a small number of potential mediators and are therefore able to create instrumental variables for each, which potentially drive child skills only through the mediators. Similarly, Nicoletti, Salvanes, and Tominey (2019) identify the role of family income as a mediator for the effect of mothers' work hours on child outcomes by constructing two instrumental variables - one for the treatment of mothers' working hours and a second for the mediator of household income.

We take an alternative approach in our paper, relying on the wealth of information provided in our survey data. The analysis includes a vast array of measures as potential mechanisms to capture a wide set of parental inputs. These include family income, capital accumulation, monetary and time investments, patterns of assortative mating, well-being, interactions between the parent and child including parenting style and the number of siblings. We include a total of 15 potential mediators, including measures of resources which indirectly drive - and investments that parents make directly into - the human capital of their child. Therefore our strategy will identify the effect of one mediator conditional on all remaining potential mediators. For example we estimate the role of monetary investments into the child through a factor relating to the number of educational toys in a household. It may be that monetary investments in educational toys are driven by a preference for high quality investments in children which is correlated with other measures such as quality interactions between the mother and the child. The mediator of time investments would absorb this source of endogeneity, by measuring quality time that the mother spends with the child. In this way, we can improve on the method of Heckman, Pinto, and Savelyev (2013) for example, by estimating the role of one mediator conditional on a wide set of other parental inputs into child development.

3.3 Measurement error in parental inputs

An additional strength of our analytical approach is that the survey data contains a number of variables at different ages relating to multiple dimensions of parental inputs into child human capital. For example, we observe questions relating to health behaviour during pregnancy through smoking and drinking habits. While each variable measures the latent factor, in this example relating to health behaviour during pregnancy with a measurement error, the multiple observations means that we can use factor analysis to combine the set of measures into a latent factor for each parental input which is free of measurement error.

The following measurement system is applied to extract a latent for each parental input for which we observe multiple measures.[13]

$$M^j_{m^j,d} = \underbrace{v^j_{m^j}}_{\substack{\text{measure specific} \\ \text{intercept}}} + \underbrace{\phi^j_{m^j}\theta^j_d}_{\substack{\text{factor} \\ \text{loadings}}} + \underbrace{\eta^j_{m^j}}_{\substack{\text{mean 0 error} \\ \text{independent of } \theta_d}} \tag{6}$$

for $j \in J_p$ and $m^j \in M^j$ is measure m from the set $1, .., M$ related to each latent parental input j. For identification of the latent factor, we normalise the location and scale of the factors similarly to Cunha and Heckman (2008). That is, we set the intercept for the first measure in the system equal to zero (i.e. $v^j_{m^j} = 0$ for measure $m = 1$ for each $j \in J_p$) and the factor loading for the first measure equal one (i.e. $\phi^j_{m^j} = 1$ for measure $m = 1$ for each $j \in J_p$). The specific measures to include in each measurement equation was derived by exploratory factor analysis. A description of the factor analysis along with the factor loadings for each factor are reported in Section A.2 and Tables A.2-A.4.

3.4 Missing data

Our empirical analysis is demanding in the sense of requiring information on the treatment status of mothers (determined by their date of birth), test scores and socio-emotional skills of children and a total of 15 mediators, measured across a period of up to 8 years, including the period of pregnancy. We exploit quasi-experimental variation in our treatment status using longitudinal secondary data which, unlike in a randomized control trial for example,

[13] As detailed in Section 2, we do not use factor analysis for family income or the number of siblings which are observed directly.

was not collected for this purpose directly. As a result there does not exist full information on all variables for our analysis for all households and indeed, a small number of households report information on the majority of variables in our model, but miss information on a small number. A lot of information is lost by excluding these households from the analysis and so, in order to be in the sample, we specify that the households must have reported date of birth of the mother[14] have a recorded cognitive test score or socio-emotional skill[15] and report at least one mediator.[16] For individuals with missing mediators we impute the missing data using the following method from Carneiro, Garcia, Salvanes, and Tominey (2015).

There are a set of households with complete data on the treatment status, child outcome and all 15 mediators making up 70% of the sample. Using the set of households with complete data we regress

$$\theta_i^j = \delta^j + \sum_{k \neq j} \gamma_k^j \theta_i^k + \mu^j X_i^j + u_i^j \tag{7}$$

where θ_i^j is the latent factor relating to mediator j with $j = 1, .., 15$, for household i. Included in the regression are the are the remaining 14 mediators ($k \neq j$) and covariates X including treatment status and mothers' age at birth. That is, for households with complete data we run 15 regressions with the dependent variable equal to the mediator θ_i^j regressed on the remaining variables in our model. The estimated coefficients γ_k^j tell us the relationship between a mediator j and the remaining mediators $k \neq j$; whilst the vector of coefficients μ^j informs of the relationship between mediator j and the set of covariates X. Fitted values were calculated for each j regression for the total sample parents. This predicted values give the imputed level of the mediator for the households whose mediator is missing.

In order to evaluate the sensitivity of our strategy to deal with missing values for a small number of mediators, Section 5 shows that our results are robust to two alternative strategies of i) limiting the sample to households with at least two thirds of mediators non-missing; ii) an alternative mean replacement strategy including dummy variables to indicate missing data in our models. In this second sensitivity, we decompose the treatment effect into the

[14] 99% of the sample

[15] this varies across samples, as shown in Table 1

[16] Conditional on observing treatment and child outcomes, 70% of households have no mediators missing; 12% have 1 mediator missing; 6% have 2 mediators missing; 7% have 3 mediators missing; 5% have 4 or more mediators missing.

direct effect, the effect through mediators and the effect through missing dummy variables. In both cases, the proportion of the treatment effect working through our mediators is very similar and therefore we conclude that our results are not sensitive to our methods to deal with missing data.

Finally, we test for systematic attrition across treatment status by regressing a binary indicator for the household being present in one of the samples for our four outcomes on the treatment indicator and a control for mothers' age. The dependent variable takes the value of 1 if the mother is in our final estimation sample for either of the four outcomes and 0 otherwise. The analysis shows that households who are not included in our final sample due to attrition are not systematically different across treatment status.[17]

4 Results

4.1 Effect of RoSLA on education of mother

We begin by exploring the impact of RoSLA on mothers' education in Table 2. The control group of RoSLA were individuals born before 1 September 1957, who were exposed to an education system with a compulsory minimum leaving age of 15 years. This meant that they could leave school before taking any formal examinations. At the end of the school year in which an individual becomes 16 years old are the set of national examinations in the English schooling system. Therefore the treatment of RoSLA is not just an increased age at which the individuals leave school, but an increase in the probability of leaving with recognised and more valued qualifications.

The first column of Table 2 considers the impact of RoSLA on the age the mother left school while columns 2-5 considers outcomes across the distribution of mothers' education of no qualifications; low quality qualifications (which include either CSE or vocational qualifications); GCSEs and A levels.[18] Panel a) presents the results for sample 1, the broader definition of RoSLA while panel b) presents the results for a more restricted window around the policy implementation of sample 2 (with common support across mothers' age at birth).

[17]The coefficient (standard error) on the treatment indicator is 0.024(.0166).

[18]Recall that CSEs are examinations taken at the age of 16 with a relatively low quality compared to GCSEs which are also taken at the age of 16. A levels are examinations taken at the end of high school at the age of 18.

Focusing on panel a) the impact of the policy is to increase the age that mothers left school by 0.291 years on average. This is consistent with national estimates of the impact of RoSLA from external data sources such as the Labour Force Survey (see Figure 1 from Dickson, Gregg, and Robinson (2016)). Columns 2-5 show that RoSLA impacts differentially across the distribution of mothers' education. RoSLA mothers have a reduced probability of leaving school with no qualifications by 4.7 percentage points. There is no change in the probability of obtaining the low quality qualifications, but an increase in the probability of attaining the higher quality GCSE qualifications by 6.2 percentage points. Finally there is an increase even in the higher level of qualifications of A levels by 5.3 percentage points, although this is only just significant at the 10% level. Overall the results suggest that the margin through which mothers' educated was affected by RoSLA was a shift from leaving with no qualifications to achieving GCSE qualifications at the age of 16. In this case, when we consider the effect of RoSLA on children then, the policy does not just represent an increase by one year in schooling, but in addition an increased probability of leaving school with some qualifications.[19]

Panel b) illustrates that the results are very similar for our more restricted sample. The estimated effect sizes are qualitatively similar, with treated mothers less likely to attain no qualifications and more likely to attain GCSEs. The final row of 2 reports the test statistic for the hypothesis that the coefficients in sample 2 are not statistically different to the coefficients in sample 1. For each measure of mothers' education, the z-statistics are low and we cannot reject the hypothesis of equality of coefficients.

4.2 Effect of RoSLA on child development

Given that RoSLA has a positive impact on maternal education, we next look at the reduced form impact of RoSLA on the skills of the next generation - the children of the mothers who were born close to the 1972 policy reform. Table 3 shows the impact of RoSLA on a range of cognitive (columns 1 and 2) and socio-emotional (columns 3 and 4) skills of children between ages 4-7. Panel a) again presents the results for sample 1 while panel b) presents the results

[19]It is for the reason that RoSLA changed two dimensions of mothers' schooling - years of schooling and qualifications - that our methodology of estimating the intention-to-treat effect is more relevant than estimating an instrumental variables regression of mothers' education on child skills, using RoSLA as an instrumental variable.

for a more restricted window around the implementation of RoSLA in sample 2. The results show that children of mothers affected by the RoSLA have higher cognitive test scores at age 4/5 by 13.9% of a standard deviation; and age 7 by 11.7% of a standard deviation. This is consistent with the findings of Dickson, Gregg, and Robinson (2016).

The analysis next considers for the first time the impact of RoSLA also on child socio-emotional skills. There is no impact of the policy on the externalising or internalising skills of children (columns 3 and 4). The results are consistent across sample 2 in panel b) of Table 3. The final row provided z-statistics for the test of equality of coefficients which indicate that we cannot reject the hypothesis of equal coefficients for any of the outcomes, in sample 2 compared to sample 1.

4.3 Mechanisms

Our main contribution is to consider the mechanisms through which RoSLA improves child skills. We focus on cognitive skills, as that there is no statistically significant treatment effect on socio-emotional skills. Our analysis considers two sets of potential mechanisms: family resources and parental investments, and analyse which inputs both respond to the treatment and drive child skills, thereby reducing the direct impact of RoSLA observed in Table 3. Individual regressions were run for each potential mediator controlling for mothers age, in order to ascertain whether the mediator is affected by treatment, i.e. if for a parental input j, $E(\theta_1^j - \theta_0^j|X) \neq 0$ in equation 5.

Table 4 reports the coefficients of RoSLA on all potential parental inputs. We estimate the effect of RoSLA on each potential mediator using two samples - the sample of test scores at age 4/5 (columns 1-3) and the sample of test scores at age 6/7 (columns 4-6) and across our two windows of mother's age at birth (sample 1 results are reported in columns 1 and 4; whilst sample 2 results in columns 2 and 5), reporting test statistics on the equality of coefficients across these windows (columns 3 and 6).

In terms of the potential mediators of financial resources for sample 1 (column 1), the estimates indicate that mothers who were exposed to RoSLA have 16.6% of a standard deviation higher pre-birth human capital, 7.5 percentage points higher average family income, and have a partner whose education is 0.412 years higher than mothers who were not exposed

to RoSLA. The coefficients on these mediators were statistically significant. For parental investments, RoSLA has a statistically significant effect on the following. RoSLA mothers score 17.6% of a SD lower in terms of (poor) health during pregnancy inputs - indicating that they smoke and drink less in pregnancy; and have 17.4% of a SD higher monetary investments in the home learning environment, compared to those not affected by RoSLA. This suggests that on top of the expected financial resource and assortative mating channels, treated mothers also change their health habits during pregnancy and their investments in the home learning environment. The estimated effect of RoSLA on the other mediators were close to zero in many cases and imprecisely estimated. The estimates are broadly similar qualitatively for sample 2 compared to sample 1 and in columns 3 we cannot reject the hypothesis that coefficients are equal between the benchmark sample 1 and the more restrictive sample which narrow the window around the implementation of RoSLA.

Columns 4-5 show that when we consider the larger sample of observations for the test score at age 6/7, the parental inputs identified as responding to RoSLA are broadly similar, with the addition of a negative coefficient on mothers' labour supply and a positive response to the partner-child relationship. The maternal labour supply effect, when taken in the context of the positive coefficient on family income, may suggest that RoSLA raised the wage of mothers whilst lowering their hours worked in the labour market, or alternatively that RoSLA enabled mothers to partner with a spouse with a higher income. The positive partner-child relationship and large impact on partner's education suggest a strong positive assortative mating channel. Again there is no statistically significant difference across estimates in samples 1 and 2, with the exception of partner's well being.

A large set of parental inputs are not impacted by RoSLA. For example, we find no impact on a set of financial resources including partner's labour supply or well being of the mother or partner. In addition the parental investments including number of siblings, parenting style, time investments or factors for the relationship with the child did not vary statistically significantly across RoSLA status. Our interpretation is that the policy change increased basic levels of education, which led to an increase in the more fundamental inputs such as family income, smoking or drinking in pregnancy and the purchase of educational toys. Instead the mediators in remaining 4 may be more responsive to changes higher up the education distribution.

Given that mediators in Table 4 were significantly affected by the RoSLA policy, we next consider whether they account for the direct effect of RoSLA on those skills. Table 5 presents the results for the direct effect of RoSLA on the child skills, conditional on the mediators (row 1) and the association between the mediators and child skills (all remaining rows). We include both the parental inputs which were shown in Table 4 to be statistically significantly affected by RoSLA, and all other parental inputs to absorb any remaining endogeneity.

Columns 1-3 of Table 5 present the results for cognitive skills of the early test score at age 4/5 and columns 4-6 for the cognitive skills measured through a test score at age 6/7. In columns 1 and 4 we report results for the wide sample window of sample 1 and in columns 2 and 5 for sample 2. Columns 3 and 6 report the z-score relating to the test of equal coefficients across sample 1 and 2. We do not show the results for socio-emotional outcomes here as there is no policy effect to decompose.

All parental inputs which were affected by RoSLA also drive child cognitive skills at age 4/5 and 6/7, significantly reducing the direct impact of RoSLA on these skills. Starting with the financial resources, an increase in the pre-birth human capital of mothers by one standard deviation raises the test score at age 4/5 (6/7) by 8.3% (10.8%) of a standard deviation. A doubling of log average family income in pre-school is associated with a 0.263 (0.277) standard deviation increase in child cognitive skill at age 4/5 (6/7). Finally, increasing partners' years of schooling by 1 year raises test scores at age 4/5 (6/7) by 7.5% (8.9%) of a standard deviation. Similarly, an increase in the parental investments of health during pregnancy and monetary inputs by one standard deviation raise test scores of the second generation by 3.1% and 11.1% (3.9% and 8.7%) of a standard deviation at the age of 4/5 (6/7). Many other inputs also drive child skills, including mothers' well-being and the number of siblings, but rather than mediators can be considered additional controls as they were not affected by RoSLA.

What is noticeable from the results is that the direct impact of RoSLA on child cognitive skills are no longer statistically distinguishable from zero. To analyse this further, Table 6 reports the decomposition analysis, combining the results from Table 4 and Table 5 as described in equation 5. Figure 2 provides a graphical representation of the decomposition analysis and illustrates that 63% and 74% of the total impact of RoSLA on cognitive outcomes at age 4/5 and 6/7 respectively can be accounted for by these mediators. Family resources

make the biggest contribution, accounting for 49-59% of the total RoSLA effect. This is not surprising given the extensive literature which has established a causal relationship between family resources and child outcomes. What is surprising however is that even conditional on the measures of financial resources, the causal effect of RoSLA is in part mediated by the investment behaviour of parents from the pregnancy onwards. Together the parental investments explain 14% (15%) of the treatment effect on the test score at age 4/5 (age 6/7).[20]

Similarly to our other results, the coefficients in Table 5 are similar in the more restrictive sample. Despite this Figure A.1 shows that we are able to explain a smaller proportion of the treatment effect on cognitive test scores (33% for both cognitive outcomes). A closer inspection into the shows that the difference in the explained treatment gap comes just from the relatively limited role of financial resources in explaining the cognitive test score gaps in our more restricted sample. On the other hand, the parental investments have more similar impacts in the two samples; explaining 10% and 15% of the treatment effect on age 4/5 and 6/7 test scores respectively.

In summary, our results have identified some important parental inputs which can be grouped into financial resources and parental investments, which mediate the effect of RoSLA on child cognitive skills. Of the explained treatment effect on the cognitive skills, financial resources do explain the largest portion. However on top of the more obvious financial and assortative mating channels, the direct investments, such as improving health behaviours in pregnancy and improving the home learning environment, are important mediators in the cognitive skills gaps.

A potential reason for the policy having no impact on the socio-emotional skills of children is that the inputs which responded to the policy were those more likely to drive cognitive skills of children. Research has shown that socio-emotional skills of children respond to "softer" inputs such as parenting style and mothers' well-being rather than inputs such as

[20]Included in the decomposition analysis is the mediation through all parental inputs, even those not statistically significant in Table 4. However, it is evident in Table 6 that our decomposition results are very similar if we exclude these inputs from the decomposition, as their contribution to the average treatment effect is close to zero.

family income. As these inputs were not changed by the policy, this could explain why there was no significant effect on externalising or internalising skills.[21],[22]

4.4 Placebo

In our analysis we have assumed that the assignment of treatment, conditional on the mothers' age at birth, is random. Care was taken to ensure that our results are not driven by the selection into treatment status by the age of the mother at birth. However even conditional on the mothers' age at birth, treatment status may be non-random. For example it may be that RoSLA was introduced in 1972 given demand from the grandparent generation; or that the grandparents timed their births so as to take advantage of the policy. If either of these are true then our results will pick up spurious correlation between RoSLA and the mothers' education and child skills. In order to test whether this is the case, we run a placebo test which creates a false policy instrument to test whether there is any statistically significant effect of the false treatment on education of mothers.

A fictitious policy variable is created by randomizing treatment status across control group mothers. In this setting, a randomly assigned false treatment status should have no effect on the skills of children. The false treatment status assigns a value of one randomly to 50% of the control sample and 0 to the remaining control sample mothers. The analysis in Table 3 estimating the policy effect on child skills are repeated using the false treatment status. Following Nicoletti, Salvanes, and Tominey (2018), this random allocation process is repeated 1000 times, which generates 1000 estimates of the effect of the treatment on each level of child skills.

Table A.8 reports the percentage of cases out of the 1000 replications in which the coefficient of interest is statistically significant at the 5 percent level. For each of the four coefficients on child skills, the false treatment variable is significant at the 95% level between 4.7-6.0% of the replications. We would expect there to be an error in 5% of cases at this significance level, which is what we find. Therefore we conclude that the treatment effect

[21] See for example Moroni, Nicoletti, and Tominey 2019

[22] Note that we tried many different methods to construct socio-emotional skills: taking the SDQ score from ALSPAC, using individual components of the score separately; running a factor analysis on all subscales. In no case was the effect of RoSLA on the socio-emotional skill measure statistically significant.

of RoSLA on mother and child skills is not driven by unobserved strategic or non-random allocation to treatment.

5 Sensitivity

Inherent in longitudinal panel datasets such as ALSPAC is a degree of missing information across the waves of data. In our case, of the 15 parental inputs which potentially mediate the effect of RoSLA on child skills, 70% of households have no missing mediators. For the sample of households with a missing mediator, we imputed the value of the parental input using equation 3.4. To check the sensitivity of our results to the imputation, we firstly tighten the conditions by which households are included in our sample, to those with at least two thirds of mediators non-missing. This reduces the sample to 84% of our benchmark sample. Figure A.2 and Tables A.9- A.10 reports the results for the restricted sample, which are very similar to our benchmark analysis, although less precisely estimated. Our mediators account for 63% (73%) of the cognitive skills gap at age 4/5 (6/7) using this approach, with a very similar proportion working through family resources and parental investments as in our main results.

Next, we take the full benchmark sample and create a dummy variable for each mediator to take the value of 1 if the mediator is missing and 0 otherwise. The value of the mediator, if missing, is then replaced with the observed mean value. The regressions of the mediators on child skills here include additionally the dummy variables relating to each missing mediator. Consequently the analysis will decompose the effect of RoSLA on child skills into the direct effect; the effect through mediators; and the effect through the missing dummy variables. Interestingly our results, reported in Figure A.3 and Tables A.11- A.12 are again very similar to our benchmark analysis, and suggest that the small sample of households who have incomplete information on meditators does not create a bias in our results. The contribution of parental investments is almost identical to our main sample, with 15% of the total effect of RoSLA on child cognitive skills working through these channels. The role of financial resources is slightly smaller, but still very large, contributing 41% and 47% of the total cognitive skills gap at age 4/5 and 6/7.

6 Conclusion

Across many developed countries, inequalities exist in the skills of young children, by the socio-economic status of their parents. In this paper we have shown that at least part of this difference in early skill accumulation is causally driven by mothers' education. In particular, a reform which raised the compulsory schooling leaving age in the UK from 15 to 16 led to improved cognitive skills of the children of affected mothers. On the other hand there was no significant effect on child socio-emotional skills.

Our main contribution is to explore the mechanisms for the treatment effect of mothers' education on children outcomes. Using rich longitudinal data, our analysis includes a wide set of potential mediators. This allows us to pinpoint whether mothers' education drives child development through a solely financial channel, through assortative mating of the spouse or whether there is any role in the investment behaviours into child human capital. We are interested in which resources and inputs of parents change in response to the exogenous increase in education, which then drive child skill accumulation.

We interpret the results as follows. The reform to mothers' schooling raised education of the marginal mother from leaving school with no qualifications to having at least a basic level of qualifications. Of the wide set of family resources and parental investments considered, there were five important mechanisms identified which were affected by the education reform. At the time of birth, treated mothers had accumulated more human capital, had matched with a higher quality partner in terms of his education and labour market attachment and during the next three years of the child's life earned a higher household income. These variables then raised the cognitive skills of the child. The decomposition analysis shows that a significant proportion of the treatment effect of mothers' education on child cognitive skills was driven by these mechanisms, with family resources accounting for up to 59% of the total treatment effect.

Interestingly, we found also an important role for parental investments, over and above family resources, with monetary and health inputs accounting for a further 14-15% of the total treatment effect of RoSLA on age 4/5 and 6/7 cognitive child skills. Treated mothers smoked and drank less alcohol during pregnancy and invested more in educational toys and books at home, which raised cognitive skills of their children at school starting age. These

results are robust to a number of alternative specifications, across a range of windows, and suggest that improving education has wider ranging impacts, over and above the standard impact on financial channels.

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Figures and Tables

Figure 1: Impact of RoSLA on women across cohorts from the Labour Force Survey

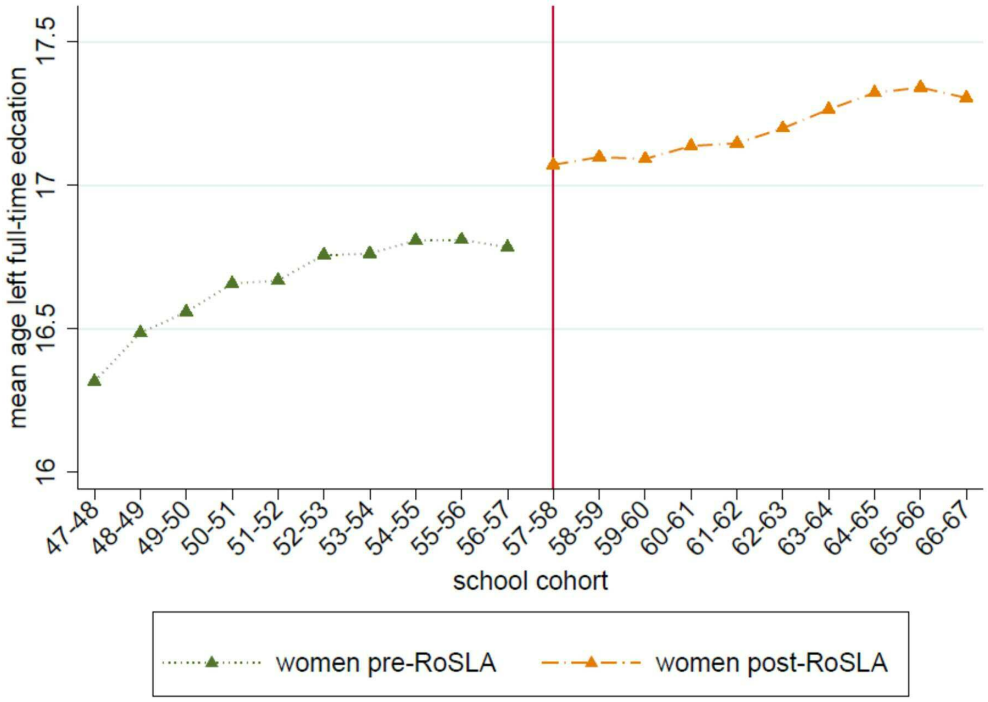


Figure 2: Decomposition of the Effect of RoSLA on Child Cognitive Skills

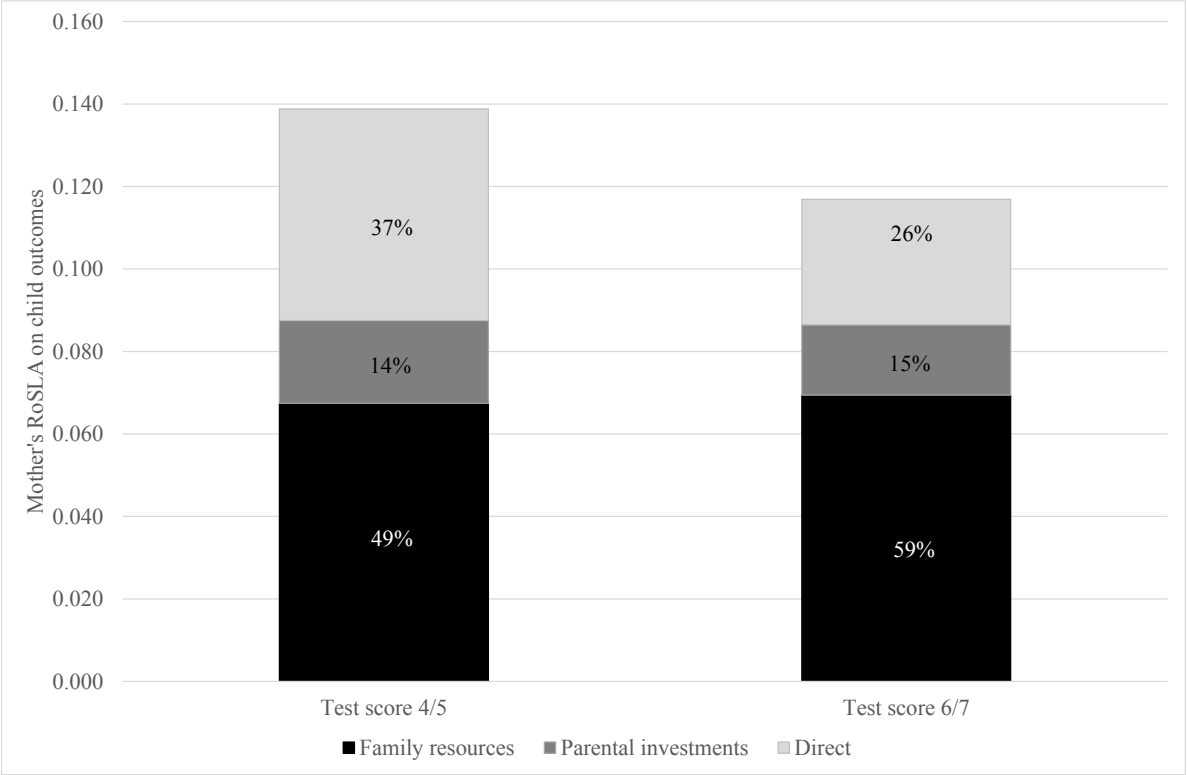


Figure relating to Equation 5 and results in Table **??**. Column 1 (2) decomposes the total effect of RoSLA on cognitive skills at age 4-5 (test scores at age 6-7) into the effect explained by financial resources; parental investments and the unexplained component.

Table 1: Descriptive Statistics

	(1) Control		(2) Treated		(3)
	Mean	sd	Mean	sd	Difference
a) Sample 1					
No quals.	0.097	0.297	0.041	0.197	0.057***
CSE / Voc.	0.183	0.387	0.226	0.418	-0.043**
GCSE	0.720	0.449	0.734	0.442	-0.014
A level	0.515	0.500	0.388	0.487	0.127***
Age at birth	36.157	1.725	30.291	1.807	5.866***
Test scores 4/5	0.174	1.013	0.165	0.980	0.009
Test scores 6/7	0.229	0.971	0.184	0.968	0.046
Externalising 7	-0.103	0.956	-0.029	0.975	-0.074
Internalising 7	0.006	1.058	-0.065	0.964	0.070
Observations	1017		4000		5017
b) Sample 2					
No quals.	0.098	0.298	0.036	0.186	0.062***
CSE / Voc.	0.187	0.390	0.193	0.395	-0.006
GCSE	0.715	0.452	0.771	0.420	-0.056*
A level	0.506	0.501	0.497	0.500	0.009
Age at birth	34.606	0.533	33.326	0.508	1.280***
Test scores 4/5	0.172	0.997	0.284	0.999	-0.112
Test scores 6/7	0.175	0.988	0.262	0.991	-0.087
Externalising 7	-0.117	1.004	-0.009	0.961	-0.108
Internalising 7	0.039	1.157	-0.050	0.960	0.089
Observations	449		586		1035

Notes: CSE refer to relatively low level qualifications taken at age 16; GCSE refer to higher level qualifications taken at age 16. In panel a) Sample 1 consists of a window of 6 years either side of the reform; and in panel b) sample 2 a window of 1 year either side of the reform.

Table 2: Effect of RoSLA on mothers' education

	(1) Years of Ed.	(2) No quals.	(3) Low quality quals.	(4) GCSE	(5) A level
	a) +/- 6 yrs				
RoSLA	0.291***	-0.047***	-0.015	0.062**	0.053*
	(0.112)	(0.013)	(0.024)	(0.026)	(0.028)
Mother's age	0.125***	0.002	-0.010***	0.008**	0.031***
	(0.015)	(0.002)	(0.003)	(0.003)	(0.004)
Observations	5,017	5,017	5,017	5,017	5,017
R-squared	0.021	0.011	0.000	0.001	0.023
	(1)	(2)	(3)	(4)	(5)
CS	Years of Ed.	No quals.	Low quality quals.	GCSE	A level
	b) +/- 1 yr				
RoSLA	0.290	-0.064***	-0.007	0.071*	0.054
	(0.211)	(0.024)	(0.039)	(0.043)	(0.050)
Mother's age	0.192	-0.002	-0.010	0.012	0.049
	(0.128)	(0.014)	(0.024)	(0.026)	(0.030)
Observations	1,035	1,035	1,035	1,035	1,035
R-squared	0.002	0.016	0.000	0.004	0.003
Z test	0.00	0.62	-0.17	-0.18	-0.02

Notes: Sample 1 in panel a) consists of births within a 6 year window of RoSLA; Sample 2 in panel b) restricts to common support across mothers' age within treatment and control. Regressions control for mothers' age at birth. Low quality quals refer to CSE examinations or vocational qualifications. GCSEs are the relatively high quality examinations taken at the age of 16 whilst A'levels are taken at age 18.

Table 3: Effect of RoSLA on child outcomes

	(1) Test score 4/5	(2) Test score 6/7	(3) Externalising	(4) Internalising
	a) +/- 6 yrs			
RoSLA	0.139**	0.117**	0.067	-0.071
	(0.063)	(0.056)	(0.058)	(0.058)
Mother's age	0.027***	0.028***	-0.004	-0.004
	(0.008)	(0.008)	(0.008)	(0.008)
Observations	4,248	5,017	4,694	4,575
R-squared	0.003	0.003	0.002	0.000
	(1) Test score 4/5	(2) Test score 6/7	(3) Externalising	(4) Internalising
	b) +/- 1 yr			
RoSLA	0.190*	0.214**	0.072	-0.025
	(0.106)	(0.098)	(0.098)	(0.102)
Mother's age	0.090	0.099*	-0.050	0.010
	(0.064)	(0.059)	(0.059)	(0.062)
Observations	872	1,035	1,014	988
R-squared	0.004	0.005	0.005	0.000
Z stat.	-0.414	-0.859	-0.044	-0.392

Notes: Sample 1 in panel a) consists of births within a 6 year window of RoSLA; Sample 2 in panel b) restricts to common support across mothers' age within treatment and control; Regressions control for mothers' age at birth.

Table 4: Effect of RoSLA on potential mediators

	Test score 4/5			Test score 6/7		
	(1) RoSLA (+/- 6 yrs)	(2) RoSLA (+/- 1 yr)	(3) Z-score	(4) RoSLA (+/- 6 yrs)	(5) RoSLA (+/- 1 yr)	(6) Z-score
Family resources						
Pre-birth capital	0.166***	0.104	0.677	0.149***	0.140*	0.105
	(0.051)	(0.076)		(0.047)	(0.072)	
Log average family income	0.075**	0.043	0.565	0.071**	0.033	0.695
	(0.030)	(0.048)		(0.028)	(0.047)	
Mother's labour supply	-0.063	-0.011	-0.443	-0.112**	-0.047	-0.571
	(0.060)	(0.101)		(0.056)	(0.099)	
Partner's years of education	0.412***	0.213	0.753	0.286**	0.009	1.090
	(0.130)	(0.230)		(0.122)	(0.223)	
Partner's employment	0.027	0.087	-0.548	0.014	-0.009	0.224
	(0.056)	(0.094)		(0.051)	(0.089)	
Mother's wellbeing	0.008	0.062	-0.480	-0.006	0.045	-1.728
	(0.057)	(0.097)		(0.053)	(0.091)	
Partner's wellbeing	0.034	0.131	-0.869	0.031	0.176*	2.061
	(0.057)	(0.096)		(0.053)	(0.091)	
Parental investments						
Health during pregnancy	-0.176***	-0.268***	0.909	-0.132***	-0.186**	0.554
	(0.055)	(0.085)		(0.051)	(0.083)	
Monetary inputs	0.174***	0.177*	-0.034	0.163***	0.173*	-0.091
	(0.061)	(0.101)		(0.056)	(0.094)	
No. of siblings	0.014	-0.064	0.652	0.006	-0.051	0.513
	(0.059)	(0.104)		(0.054)	(0.097)	
Mother's parenting style	0.009	0.005	0.036	0.056	0.066	-0.096
	(0.057)	(0.095)		(0.053)	(0.090)	
Mother's time investments	0.048	0.010	0.336	0.036	-0.012	0.456
	(0.058)	(0.097)		(0.053)	(0.091)	
Partner's time investments	0.067	0.005	0.558	0.033	-0.015	0.462
	(0.056)	(0.096)		(0.052)	(0.090)	
Mother-child relationship	0.086	-0.032	1.076	0.074	-0.019	0.975
	(0.053)	(0.096)		(0.047)	(0.083)	
Partner-child relationship	0.058	0.007	0.462	0.115**	0.035	0.776
	(0.056)	(0.095)		(0.052)	(0.089)	
Observations	4248	872		5017	1035	

Notes: Coefficients of a regression of RoSLA on each mediator, controlling for mothers' age at birth. The analysis restricts to the sample for which test scores were observed at ages 4-5 (columns 1-3) and 6-7 (columns 4-6).

Table 5: RoSLA on child outcomes, conditional on mediators

	Test score 4/5			Test score 6/7		
	(1) RoSLA (+/- 6 yrs)	(2) RoSLA (+/- 1 yr)	(3) Z-score	(4) RoSLA (+/- 6 yrs)	(5) RoSLA (+/- 1 yr)	(6) Z-score
Conditional RoSLA	0.051	0.128	-0.668	0.030	0.144	-1.097
	(0.059)	(0.099)		(0.052)	(0.090)	
Family resources						
Pre-birth capital	0.083***	0.020	1.170	0.108***	0.072*	0.772
	(0.020)	(0.050)		(0.018)	(0.043)	
Log average family income	0.263***	0.437***	-1.767	0.277***	0.344***	-0.801
	(0.040)	(0.090)		(0.035)	(0.076)	
Mother's labour supply	-0.036**	-0.029	-0.182	-0.071***	-0.084***	0.393
	(0.016)	(0.035)		(0.014)	(0.030)	
Partner's years of education	0.075***	0.062***	0.727	0.089***	0.091***	-0.128
	(0.008)	(0.016)		(0.007)	(0.014)	
Partner's employment	0.008	-0.055	1.407	-0.002	-0.075**	1.853
	(0.018)	(0.041)		(0.016)	(0.036)	
Mother's wellbeing	0.031*	0.115***	-3.329	0.042***	0.151***	-2.767
	(0.018)	(0.040)		(0.016)	(0.036)	
Partner's wellbeing	0.013	0.051	-0.832	0.017	0.029	-0.305
	(0.018)	(0.042)		(0.016)	(0.036)	
Parental investments						
Health during pregnancy	-0.031*	0.060	-2.050	-0.039**	-0.011	-0.735
	(0.017)	(0.041)		(0.015)	(0.035)	
Monetary inputs	0.111***	0.130***	-0.494	0.087***	0.119***	-0.916
	(0.016)	(0.035)		(0.014)	(0.032)	
No. of siblings	-0.138***	-0.199***	1.585	-0.107***	-0.158***	1.481
	(0.016)	(0.035)		(0.015)	(0.031)	
Mother's parenting style	-0.001	-0.030	0.682	0.020	0.015	0.135
	(0.017)	(0.039)		(0.015)	(0.034)	
Mother's time investments	0.006	-0.006	0.288	0.027*	0.079**	-1.435
	(0.017)	(0.038)		(0.015)	(0.033)	
Partner's time investments	-0.016	0.000	-0.361	-0.043***	-0.071**	0.703
	(0.019)	(0.040)		(0.017)	(0.036)	
Mother-child relationship	-0.014	0.016	-0.745	-0.019	0.010	-0.772
	(0.018)	(0.036)		(0.016)	(0.034)	
Partner-child relationship	-0.012	-0.029	0.388	-0.007	-0.006	-0.025
	(0.018)	(0.040)		(0.016)	(0.036)	
Observations	4,248	872		5,017	1,035	
R-squared	0.137	0.160		0.165	0.196	

Notes: Sample 1 in columns 1 and 4 consists of births within a 6 year window of RoSLA; Sample 2 in columns 2 and 5 restricts to common support across mothers' age within treatment and control. Regressions control for mothers' age at birth.

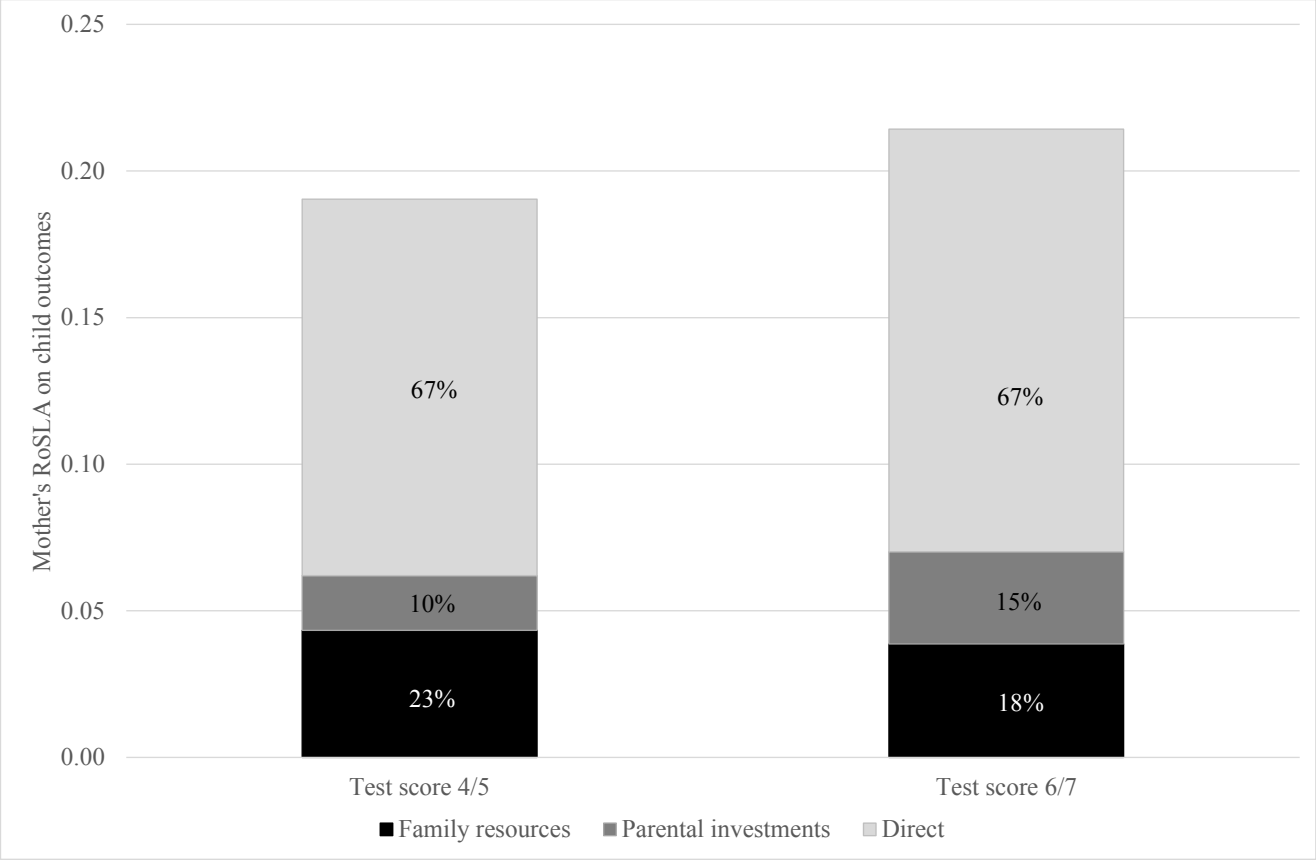
Table 6: Decomposing effect of RoSLA on Child Cognitive Skills

	Test score 4/5		Test score 6/7	
	(1) RoSLA (+/- 6 yrs)	(2) RoSLA (+/- 1 yr)	(3) RoSLA (+/- 6 yrs)	(4) RoSLA (+/- 1 yr)
Family resources				
Pre-birth capital	0.014	0.002	0.016	0.010
Log average family income	0.020	0.019	0.020	0.011
Mother's labour supply	0.002	0.000	0.008	0.004
Partner's years of education	0.031	0.013	0.025	0.001
Partner's employment	0.000	-0.005	0.000	0.001
Mother's wellbeing	0.000	0.007	0.000	0.007
Partner's wellbeing	0.000	0.007	0.001	0.005
Total through family resources	**0.067**	**0.043**	**0.069**	**0.039**
Parental investments				
Health during pregnancy	0.005	-0.016	0.005	0.002
Monetary inputs	0.019	0.023	0.014	0.021
No. of siblings	-0.002	0.013	-0.001	0.008
Mother's parenting style	0.000	0.000	0.001	0.001
Mother's time investments	0.000	0.000	0.001	-0.001
Partner's time investments	-0.001	0.000	-0.001	0.001
Mother-child relationship	-0.001	-0.001	-0.001	0.000
Partner-child relationship	-0.001	0.000	-0.001	0.000
Total through parental investments	**0.020**	**0.019**	**0.017**	**0.031**
Total through mediators	**0.088**	**0.062**	**0.086**	**0.070**
Direct	**0.051**	**0.128**	**0.031**	**0.144**
Total	**0.139**	**0.190**	**0.117**	**0.214**

Notes: Sample 1 in columns 1 and 3 consists of births within a 6 year window of RoSLA; Sample 2 in columns 2 and 4 restricts to common support across mothers' age within treatment and control. Regressions control for mothers' age at birth.

A Appendix

Figure A.1: Decomposition of the Effect of RoSLA on Child Cognitive Skills (+/- 1 yr sample)



A.1 Components of the child socio-emotional skills

We measure socio-emotional skills of children with the strengths and difficulties questionnaire (SDQ), a validated measure of child skills.

The SDQ consists of five sub-scales each which are constructed from 5 measures. The sub-scales include i) emotional problems; ii) conduct problems; iii) hyperactivity; iv) peer relationship; and v) pro-social behaviour. All measures are reported in Table A.1.

Table A.1: Components of Strength and Difficulties sub scales

Emotional problems	Has many worries, often seems worried
	Is often unhappy, down hearted or tearful
	Is nervous and clingy in new situations, easily loses confidence
	Has many fears, is easily scared
	Often complains of headaches, stomach-aches or sickness
Conduct problems	Is generally obedient, usually does what adult requests
	Often fights with other children or bullies them
	Steals from home, school or elsewhere
	Often has temper tantrums or hot tempers
	Is considerate of other peoples' feelings
Hyperactivity	Is constantly fidgeting or squirming
	Is easily distracted, concentration wanders
	Thinks things out before acting
	Sees tasks through to the end, has good attention span
	Is restless, overactive, cannot stay still for long
Peer relationship	Is rather solitary, tends to play alone
	Has at least one good friend
	Is generally liked by other children
	Is picked on or bullied by other children
	Gets on better with adults than with other children
Pro-social	Is helpful if someone is hurt, upset or feeling ill
	Is kind to younger children
	Often lies or cheats
	Often volunteers to help others (parents, teachers, other children)
	Shares readily with other children

A.2 Factor analysis

In this section we report factor loadings for each parental input for which we want to construct a latent factor and we discuss and test the assumptions of the same system of measurement across the treatment and control groups. We follow Cunha and Heckman (2008) and include continuous scores on particular measures of parental inputs where available and use individual measures on parental inputs otherwise.

The factor loadings for the parental inputs included in family resources are reported in Table A.2. The latent factor pre-birth human capital is constructed from three measures - whether the mother owns her house at the start of pregnancy, whether she is married early in pregnancy and whether she is working in early pregnancy. As noted in the text we identify the factor by setting the factor loading of the first measure equal to one. All factor loadings are positive suggesting that each measure contributes positively towards the latent, and the measure "own house" has the largest factor loading. Second, four measures are used to construct the factor for mothers' labour supply. The measure mother hours at 61 months has the largest factor loading contributing to the latent variable, followed by the number of hours worked at 33 months, whether the mother was employed at 61 months and finally whether the mother was employed at 61 months.

The latent factor for mothers' well being is constructed from four measures of mothers' self-esteem, anxiety, depression, enjoyment and bonding scores. The factor picks up a positive measure of well-being, as self-esteem, enjoyment and bonding load positively whilst anxiety and depression load negatively.

The partners' labour supply is constructed from three measures all of which have similar factor loadings close to one - employment at 21, 33 and 47 months.

The latent factor of relationship quality with the partner measures a positive relationship, as seen by the positive loading of the score for partner warmth compared to the negative loading of authority score and (lack of) communication score. The measure with the highest factor loading is partner warmth.

Regarding the parental investments, firstly, we can see that all of the measures of health during pregnancy - including measures of smoking and alcohol - load positively to the variable

for health during pregnancy. Each measure is coded such that a high value represents poor health choices, such as smoking a greater quantity of cigarettes and as such the latent factor measures poor health during pregnancy.

Monetary investments are constructed from two scores measuring the home learning environment at age 24 and 42 months. The early toy score has the highest loading suggesting that the factor predominantly picks up monetary investments early in the life of the child. To give information on the components of the toy scores, the toy score at 24 is constructed from questions on the number of goods in the home including: the number of books; number of cuddly animals; number of dolls; the number of swings; the number of toy vehicles; the number of jigsaw puzzles; the number of mobiles; the number of building blocks; the number of balls; the number of walkers; the number of sit in walkers and the number of interlocking toys. The toy score at age 42 was constructed from questions relating to the presence in the home of: books; cuddly toys; push-pull toys; coordination toys; jigsaw puzzles; computer games; and construction toys.

The mothers' parenting style was constructed from a set of questions measuring the discipline and to some extent warmth. The answers to each measure was recorded as "Yes usually", "Yes sometimes", "No". The factor loads positively on whether the child dominates the household and the mother gives in to the child; but negatively on all other measures including the mother ignoring, smacking, shouting at the child and taking away treats for example. This means that for low values of the mothers' parenting style, the mother disciplines her child using different methods when naughty and for high values she feels dominated and gives into the child.

A latent factor for mothers time investments was constructed from a set of questions including whether the mother bathes the child, sings to the child and others. The answers were recorded similarly to the mother parenting style as "Yes usually", "Yes sometimes", "No". The table shows that measures including singing, reading and playing with the child aswell as playing imitation games with the child load positively with a relatively high factor loading between 2-3. Playing physically has an equally high factor loading but with a negative sign. Therefore high values of the latent variable pick up intimate interactions between the mother and the child and low values more physical interactions. We constructed a latent factor for the interactions between the mothers' partner and the child based on the same

set of measures as those related to the mother. Again, the strongest loading comes from measures of reading with the child, playing with toys and playing imitation games. All factors have a relatively high loading for the latent variable.

The final two latent factors measure the mother and partner relationship with the child, respectively. Both factors measure positive relationship with the child, as whether the mother (partner) loves the child, the child makes the mother (partner) happy and the child is affectionate to the mother (partner) load positively; whilst variables such as the mother (partner) being irritated by the child load negatively.

Table A.2: Factor Loadings: Family resources

(1)	(2)	(3)
Latent factor	Measures	Factor loading
Pre-birth human capital	Own house	1.000
	Married early pregnancy	0.424
	Working early pregnancy	0.340
Mother labour supply	No of hours mum works per week 33 months	1.000
	Mum employed at 47 months	0.044
	Mum employed at 61 months	0.063
	Mum hours 61 months	1.678
Mother well being	Mother self esteem	1.000
	Mother anxiety	-0.696
	Mother depression	-1.031
	Mother enjoyment	0.259
	Mother bonding	0.538
Partner labour supply	Partner employed at 21 months	1.000
	Partner employed at 33 months	1.139
	Partner employed at 47 months	1.031
Relationship quality with partner	Partner warmth	1.000
	Partner authority	-0.314
	Partner communication	-0.274

Table A.3: Factor loadings: Parental investments: 1/2

(1)	(2)	(3)
Health during pregnancy	Smoked cigarettes in first 3 months pregnancy	1.000
	Smoked cigarettes in last 2 weeks pregnancy	0.832
	Number smoked per day in first 3 months	10.510
	Glasses alcohol consumed in first 3 months	0.159
Monetary investments	Toy score 24 months	1
	Toy score 42 months	0.246
Mother parenting style	Mum Feels Child Dominates household 42 months	1.000
	Mum Eventually Gives in to Child 42 months	0.638
	Mum Ignores Child when Naughty 42 months	-2.941
	Mum Smacks Child when Naughty 42 months	-4.586
	Mum Shouts at Child when Naughty 42 months	-5.198
	Mum Sends Child to Room when Naughty 42 months	-3.778
	Mum Takes Away Treats when Naughty 42 months	-3.488
	Mum Tells Child Off when Naughty 42 months	-3.319
	Mum Bribes when Naughty 42 months	-2.894
Mother time investments	Mother Bathes CH 42 months	1.000
	Mother Feeds CH 42 months	1.142
	Mother Sings to CH 42 months	2.717
	Mother Reads CH Stories 42 months	2.035
	Mother Plays W Toys W CH 42 months	2.466
	Mother Cuddles CH 42 months	0.209
	Mother & CH Play Imitation Games 42 months	3.174
	Mother Plays W CH Physically 42 months	-2.842
	Mother Takes CH for Walk 42 months	-1.417
	Mother does Other Activities W CH 42 months	-0.494

Table A.4: Factor loadings: Parental investments: 2/2

(1)	(2)	(3)
Partner time investments	Partner Bathes CH 42 months	1.000
	Partner Feeds CH 42 months	0.970
	Partner Sings to CH 42 months	1.324
	Partner Reads CH Stories 42 months	1.545
	Partner Plays W Toys W CH 42 months	1.571
	Partner Cuddles CH 42 months	0.586
	Partner & CH Play Imitation Games 42 months	1.467
	Partner Plays W CH Physically 42 months	1.088
Mother relationship with child	Mother really loves child 44 months	1.000
	Mother often irritated by child 44 months	-3.232
	Mother dislikes mess from child 44 months	-1.426
	Child makes mother happy 44 months	1.838
	Mother has battles of will with child 44 months	-2.293
	Child is affectionate to mother 44 months	2.200
	Child gets on mum's nerves 44 months	-2.332
	Mother feels close to child 44 months	3.646
Partner relationship with child	Partner really loves child 44 months	1.000
	Partner often irritated by child 44 months	-34.257
	Partner dislikes mess from child 44 months	-14.221
	Child makes Partner happy 44 months	2.184
	Partner has battles of will with child 44 months	-26.480
	Child is affectionate to Partner 44 months	4.078
	Child gets on mum's nerves 44 months	-25.421
	Partner feels close to child 44 months	4.643

Table A.5: Estimated mean of latent factors for the treated sample

		Estimate	Standard error
Pre-birth human capital	5,782	-0.0100	0.3188
Mother labour supply	5,782	-0.3525	6.6910
Mother well being	5,782	0.0979	3.4627
Partner labour supply	5,782	0.0108	0.3234
Relationship quality with partner	5,782	-0.4371	6.3686
Health during pregnancy	5,764	-0.0002	0.3436
Monetary investments	5,782	-0.0008	0.0122
Mother parenting style	5,493	-0.0201	0.1071
Mother time investments	5,740	-0.0074	0.1983
Partner time investments	5,441	-0.0444	0.5188
Mother relationship with child	5,782	0.0007	0.0219
Partner relationship with child	5,782	0.0000	0.0076

A.3 Test for structural invariance assumption

The decomposition analysis is causal if the parental investments and financial resources, which occur after the treatment, are exogenous to child skills. Put another way, the assumption is that there are no unmeasured inputs which are correlated with the measured inputs in our paper and the child skills. Heckman and Pinto (2015) outlines conditions under which it is possible to relax this assumption and still interpret the analysis as causal. Instead assume that the mediators are exogenous for the control group and additionally that for an individual the level of parental resources and investments in the presence of treatment equals the level in the absence of treatment plus some increment. The latter means that the effect of the treatment is to incrementally raise parental inputs. Under these weaker assumptions, Heckman and Pinto (2015) show that if $\alpha_1^j = \alpha_0^j$ for $j = 1, .., J$ measured parental inputs, then it is also true that the unmeasured inputs for the treatment are independent of measured inputs for treatment.

We show now in Tables A.6-A.7 for each child outcome, a model estimated is equivalent to in Table 5 but with the addition of a full set of interactions between each parental input and the treatment status for sample 1 and sample 2 respectively. Reported in Tables A.6-A.7 is the coefficient of the interaction between each mediator and treatment status along with the p-value which shows that in the case of sample 1 the assumption $\alpha_1^j = \alpha_0^j$ is not rejected by the data. The same is true on the whole for sample 2. Consequently we can identify

the causal mechanisms for the effect of mothers' education on child outcomes under the weaker identification assumptions that the mediators observed are independent to unobserved mediators for the control group and that the impact of treatment was to incrementally raise the parental inputs.

Table A.6: Test for equality of input coefficients in outcome equation: Sample 1

	(1) Test score 4-5	(2) Test score 6-7	(3) Externalising	(4) Internalising
Pre-birth human capital	0.753	0.670	-0.440	0.219
	(0.452)	(0.503)	(0.660)	(0.827)
Household income	2.733	4.146	-1.814	-1.945
	(0.006)	(0.000)	(0.070)	(0.052)
Mother labour supply	-0.910	-2.235	1.725	-0.229
	(0.363)	(0.025)	(0.085)	(0.819)
Partner schooling	3.842	5.187	-2.446	1.006
	(0.000)	(0.000)	(0.015)	(0.314)
Partner labour supply	0.684	-0.672	1.533	0.748
	(0.494)	(0.501)	(0.125)	(0.455)
Mother well being	2.126	1.852	-4.773	-4.475
	(0.034)	(0.064)	(0.000)	(0.000)
Relationship quality with partner	-0.145	0.071	1.003	-0.016
	(0.885)	(0.943)	(0.316)	(0.987)
Health during pregnancy	-0.406	-0.528	-0.533	1.638
	(0.684)	(0.597)	(0.594)	(0.102)
Monetary investments	2.877	2.462	-1.551	-1.046
	(0.004)	(0.014)	(0.121)	(0.296)
Number siblings	-5.136	-3.270	0.555	0.042
	(0.000)	(0.001)	(0.579)	(0.967)
Mother parenting style	0.834	2.806	-7.853	-1.779
	(0.404)	(0.005)	(0.000)	(0.075)
Mother time investments	-1.435	1.816	0.625	-0.568
	(0.151)	(0.069)	(0.532)	(0.570)
Partner time investments	0.935	-1.288	-0.213	0.737
	(0.350)	(0.198)	(0.832)	(0.461)
Mother relationship with child	0.400	0.222	0.699	1.756
	(0.689)	(0.824)	(0.484)	(0.079)
Partner relationship with child	-0.688	-0.579	-6.965	-3.056
	(0.492)	(0.562)	(0.000)	(0.002)
Observations	4,248	5,017	4,694	4,575

Notes: Wald test statistics with p-values in parentheses. These provide test statistics for the equality of coefficients on inputs in the outcome equation, across treatment and control group. Test follows Heckman and Pinto (2015).

Table A.7: Test for equality of input coefficients in outcome equation: Sample 2

	(1) Test score 4-5	(2) Test score 6-7	(3) Externalising	(4) Internalising
Pre-birth human capital	-0.264	0.120	-0.366	0.187
	(0.792)	(0.905)	(0.714)	(0.852)
Household income	2.008	3.020	-0.333	-2.345
	(0.045)	(0.003)	(0.739)	(0.019)
Mother labour supply	0.039	-1.651	1.097	0.292
	(0.969)	(0.099)	(0.273)	(0.770)
Partner schooling	2.425	3.479	-2.178	0.763
	(0.016)	(0.001)	(0.030)	(0.446)
Partner labour supply	0.446	-0.904	0.859	1.359
	(0.655)	(0.366)	(0.391)	(0.174)
Mother well being	1.536	2.631	-3.764	-3.500
	(0.125)	(0.009)	(0.000)	(0.000)
Relationship quality with partner	-0.427	0.789	0.244	-1.220
	(0.669)	(0.430)	(0.807)	(0.223)
Health during pregnancy	0.204	-0.994	-0.455	1.018
	(0.839)	(0.321)	(0.649)	(0.309)
Monetary investments	1.237	2.309	-1.497	-0.829
	(0.216)	(0.021)	(0.135)	(0.407)
Number siblings	-3.328	-2.467	0.564	2.292
	(0.001)	(0.014)	(0.573)	(0.022)
Mother parenting style	0.052	0.594	-4.298	-2.396
	(0.959)	(0.553)	(0.000)	(0.017)
Mother time investments	-0.672	2.279	0.439	-0.430
	(0.502)	(0.023)	(0.661)	(0.668)
Partner time investments	-0.271	-2.368	-0.227	0.810
	(0.786)	(0.018)	(0.821)	(0.418)
Mother relationship with child	0.061	0.472	1.487	2.718
	(0.951)	(0.637)	(0.137)	(0.007)
Partner relationship with child	-1.589	-0.609	-4.868	-1.016
	(0.113)	(0.542)	(0.000)	(0.310)
Observations	872	1,035	1,014	988

Notes: Wald test statistics with p-values in parentheses. These provide test statistics for the equality of coefficients on inputs in the outcome equation, across treatment and control group. Test follows Heckman and Pinto (2015).

A.4 Placebo analysis

Table A.8: Placebo test randomizing treatment in the control sample

	Percent of significant coefficients at 5% level
Child skills	
Test score 4-5	6.0
Test score 6-7	5.0
Externalising	4.7
Internalising	5.4

A.5 Missing information

In this section we test for the sensitivity of our results to the imputation method for missing values of the 15 potential mediators. Firstly Tables A.9- A.10 restrict the sample to households with at least two thirds of mediators non-missing. 84% of the benchmark sample are included in the restricted analysis. Figure A.2 shows the decomposition results which are very similar to our benchmark estimations, although due to the smaller sample size are less precisely estimated.

Second for the full sample of households, a dummy variable is created for each mediator to take the value of 1 if the mediator is missing for our sample and 0 otherwise. Then the value for the missing mediators is replaced with the sample mean, whilst for households with non-missing mediators the value of the input is unchanged. Tables A.11- A.12 illustrate that the estimated coefficients for our imputed sample are very similar to those estimated with this mean replacement method. Figure A.3 shows that the main difference between this specification and our main results is working through the 'direct' unexplained component: the 'unexplained' part is reduced by 12 ppts for test scores at 4/5 and by 13ppts for test scores at 6/7. The contribution of parental investments is almost identical, while the family resources contribution diminishes by 7ppts for test scores at 4/5 and 12 ppts for test scores at 6/7.

Figure A.2: Decomposition of the Effect of RoSLA on Child Cognitive Skills: Sample restricted to at least 2/3 non-missing mediators.

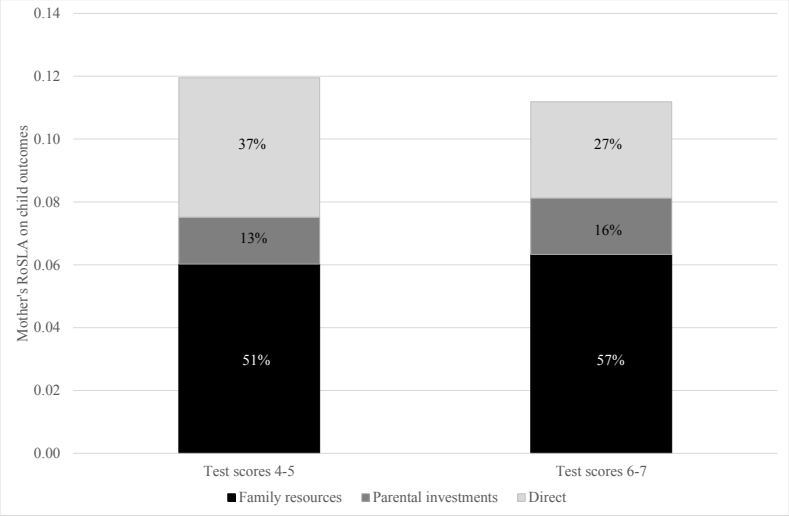


Figure relating to Equation 5. Column 1 (2) decomposes the total effect of RoSLA on cognitive skills at age 4-5 (test scores at age 6-7) into the effect explained by financial resources; parental investments and the unexplained component. Sample restricted to households with at least two-thirds of mediators non-missing.

Figure A.3: Decomposition of the Effect of RoSLA on Child Cognitive Skills: Missing Dummies.

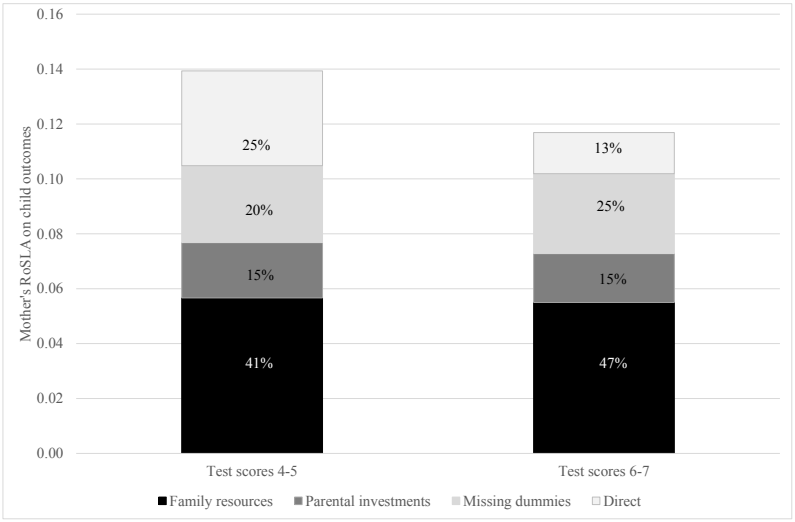


Figure relating to Equation 5. Column 1 (2) decomposes the total effect of RoSLA on cognitive skills at age 4-5 (test scores at age 6-7) into the effect explained by financial resources; parental investments; missing dummies and the unexplained component.

Table A.9: Effect of RoSLA on potential mediators: Sample restricted to at least 2/3 non-missing mediators.

	Test score 4/5			Test score 6/7		
	(1) RoSLA (+/- 6 yrs)	(2) RoSLA (+/- 1 yr)	(3) Z-score	(4) RoSLA (+/- 6 yrs)	(5) RoSLA (+/- 1 yr)	(6) Z-score
Family resources						
Pre-birth capital	0.149***	0.071	0.84	0.140***	0.102	0.44
	(0.052)	(0.077)		(0.047)	(0.073)	
Log average family income	0.063**	0.037	0.44	0.058**	0.007	0.91
	(0.032)	(0.050)		(0.029)	(0.048)	
Mother's labour supply	-0.047	0.019	-0.49	-0.092	-0.009	-0.63
	(0.069)	(0.117)		(0.065)	(0.114)	
Partner's years of education	0.439***	0.293	0.50	0.333**	0.058	0.99
	(0.142)	(0.252)		(0.133)	(0.243)	
Partner's employment	0.032	0.059	-0.22	0.024	-0.051	0.66
	(0.063)	(0.105)		(0.057)	(0.099)	
Mother's wellbeing	0.044	0.095	-0.40	0.017	0.069	-0.43
	(0.066)	(0.110)		(0.061)	(0.104)	
Partner's wellbeing	0.027	0.155	-1.00	0.022	0.212**	-1.56
	(0.066)	(0.109)		(0.061)	(0.105)	
Parental investments						
Health during pregnancy	-0.172***	-0.283***	1.02	-0.142***	-0.211**	0.67
	(0.058)	(0.092)		(0.053)	(0.088)	
Monetary inputs	0.145**	0.169	-0.19	0.150**	0.167*	-0.15
	(0.066)	(0.106)		(0.060)	(0.099)	
No. of siblings	0.001	-0.057	0.42	-0.016	-0.056	0.31
	(0.068)	(0.120)		(0.062)	(0.113)	
Mother's parenting style	0.017	0.012	0.04	0.062	0.074	-0.10
	(0.066)	(0.111)		(0.061)	(0.104)	
Mother's time investments	0.047	0.022	0.19	0.034	-0.008	0.35
	(0.066)	(0.112)		(0.061)	(0.104)	
Partner's time investments	0.068	0.001	0.52	0.024	-0.031	0.46
	(0.065)	(0.111)		(0.060)	(0.104)	
Mother-child relationship	0.085	-0.056	1.10	0.072	-0.039	0.99
	(0.062)	(0.112)		(0.055)	(0.098)	
Partner-child relationship	0.056	-0.000	0.44	0.125**	0.031	0.79
	(0.065)	(0.111)		(0.060)	(0.103)	
Observations	3,586	749		4,240	885	

Notes: Sample 1 consists of births within a 6 year window of RoSLA; Sample 2 restricts to common support across mothers' age within treatment and control; Regressions control for mothers' age at birth.

Table A.10: RoSLA on child outcomes, conditional on mediators: Sample restricted to at least 2/3 non-missing mediators.

	Test score 4/5			Test score 6/7		
	(1) RoSLA (+/- 6 yrs)	(2) RoSLA (+/- 1 yr)	(3) Z-score	(4) RoSLA (+/- 6 yrs)	(5) RoSLA (+/- 1 yr)	(6) Z-score
Conditional RoSLA	0.044	0.099	-0.45	0.031	0.105	-0.67
	(0.063)	(0.106)		(0.055)	(0.096)	
Family resources						
Pre-birth capital	0.069***	0.008	1.01	0.103***	0.063	0.77
	(0.023)	(0.056)		(0.020)	(0.048)	
Log average family income	0.253***	0.376***	-1.17	0.247***	0.276***	-0.32
	(0.043)	(0.096)		(0.037)	(0.082)	
Mother's labour supply	-0.023	-0.009	-0.36	-0.057***	-0.068**	0.33
	(0.016)	(0.036)		(0.014)	(0.030)	
Partner's years of education	0.071***	0.059***	0.64	0.085***	0.091***	-0.36
	(0.008)	(0.017)		(0.007)	(0.015)	
Partner's employment	0.003	-0.065	1.48	-0.005	-0.074**	1.69
	(0.019)	(0.042)		(0.017)	(0.037)	
Mother's wellbeing	0.032*	0.116***	-3.31	0.042***	0.147***	-2.67
	(0.018)	(0.041)		(0.016)	(0.036)	
Partner's wellbeing	0.017	0.064	-1.02	0.021	0.040	-0.48
	(0.019)	(0.042)		(0.016)	(0.036)	
Parental investments						
Health during pregnancy	-0.020	0.044	-1.36	-0.036**	-0.023	-0.31
	(0.019)	(0.043)		(0.017)	(0.038)	
Monetary inputs	0.100***	0.144***	-1.06	0.080***	0.119***	-1.05
	(0.017)	(0.038)		(0.015)	(0.034)	
No. of siblings	-0.144***	-0.206***	1.61	-0.112***	-0.172***	1.74
	(0.016)	(0.035)		(0.015)	(0.031)	
Mother's parenting style	-0.000	-0.030	0.71	0.023	0.024	-0.03
	(0.017)	(0.039)		(0.015)	(0.034)	
Mother's time investments	-0.000	-0.014	0.34	0.027*	0.087***	-1.66
	(0.017)	(0.038)		(0.015)	(0.033)	
Partner's time investments	-0.017	0.005	-0.50	-0.045***	-0.073**	0.72
	(0.019)	(0.040)		(0.017)	(0.035)	
Mother-child relationship	-0.014	0.015	-0.73	-0.020	0.011	-0.82
	(0.017)	(0.036)		(0.016)	(0.034)	
Partner-child relationship	-0.008	-0.026	0.42	-0.005	-0.006	0.03
	(0.018)	(0.039)		(0.015)	(0.035)	
Observations	3,586	749		4,240	885	
R-squared	0.123	0.156		0.147	0.187	

Notes: Sample 1 consists of births within a 6 year window of RoSLA; Sample 2 restricts to common support across mothers' age within treatment and control. Regressions control for mothers' age at birth.

Table A.11: Effect of RoSLA on potential mediators: Missing dummies.

	Test score 4/5		Test score 6/7	
	(1) Main Sample	(2) Missing Dummies	(3) Main Sample	(4) Missing Dummies
Family resources				
Pre-birth capital	0.166***	0.161***	0.149***	0.146***
	(0.051)	(0.051)	(0.047)	(0.046)
Log average family income	0.075**	0.063**	0.071**	0.061**
	(0.030)	(0.028)	(0.028)	(0.026)
Mother's labour supply	-0.063	-0.049	-0.112**	-0.099*
	(0.060)	(0.059)	(0.056)	(0.055)
Partner's years of education	0.412***	0.326***	0.286**	0.218*
	(0.130)	(0.125)	(0.122)	(0.117)
Partner's employment	0.027	0.008	0.014	-0.001
	(0.056)	(0.055)	(0.051)	(0.050)
Mother's wellbeing	0.008	0.002	-0.006	-0.013
	(0.057)	(0.057)	(0.053)	(0.053)
Partner's wellbeing	0.034	0.035	0.031	0.037
	(0.057)	(0.056)	(0.053)	(0.052)
Parental investments				
Health during pregnancy	-0.176***	-0.172***	-0.132***	-0.130**
	(0.055)	(0.055)	(0.051)	(0.051)
Monetary inputs	0.174***	0.164***	0.163***	0.153***
	(0.061)	(0.061)	(0.056)	(0.056)
No. of siblings	0.014	0.002	0.006	-0.004
	(0.059)	(0.059)	(0.054)	(0.054)
Mother's parenting style	0.009	0.011	0.056	0.057
	(0.057)	(0.057)	(0.053)	(0.052)
Mother's time investments	0.048	0.047	0.036	0.037
	(0.058)	(0.058)	(0.053)	(0.053)
Partner's time investments	0.067	0.060	0.033	0.021
	(0.056)	(0.056)	(0.052)	(0.051)
Mother-child relationship	0.086	0.067	0.074	0.056
	(0.053)	(0.053)	(0.047)	(0.047)
Partner-child relationship	0.058	0.039	0.115**	0.088*
	(0.056)	(0.055)	(0.052)	(0.051)
Observations	4,248	4,248	5,017	5,017

Notes: Sample 1 consists of births within a 6 year window of RoSLA; Sample 2 restricts to common support across mothers' age within treatment and control; Regressions control for mothers' age at birth.

Table A.12: RoSLA on child outcomes, conditional on mediators: Missing dummies.

	Test score 4/5		Test score 6/7	
	(1) Main Sample	(2) Missing Dummies	(3) Main Sample	(4) Missing Dummies
Conditional RoSLA	0.051	0.035	0.030	0.015
	(0.059)	(0.058)	(0.052)	(0.051)
Family resources				
Pre-birth capital	0.083***	0.088***	0.108***	0.107***
	(0.020)	(0.020)	(0.018)	(0.018)
Log average family income	0.263***	0.255***	0.277***	0.241***
	(0.040)	(0.043)	(0.035)	(0.038)
Mother's labour supply	-0.036**	-0.021	-0.071***	-0.054***
	(0.016)	(0.016)	(0.014)	(0.014)
Partner's years of education	0.075***	0.077***	0.089***	0.089***
	(0.008)	(0.008)	(0.007)	(0.007)
Partner's employment	0.008	0.009	-0.002	0.004
	(0.018)	(0.018)	(0.016)	(0.016)
Mother's wellbeing	0.031*	0.036**	0.042***	0.045***
	(0.018)	(0.017)	(0.016)	(0.015)
Partner's wellbeing	0.013	0.009	0.017	0.016
	(0.018)	(0.018)	(0.016)	(0.016)
Parental investments				
Health during pregnancy	-0.031*	-0.035**	-0.039**	-0.046***
	(0.017)	(0.017)	(0.015)	(0.015)
Monetary inputs	0.111***	0.098***	0.087***	0.077***
	(0.016)	(0.016)	(0.014)	(0.014)
No. of siblings	-0.138***	-0.125***	-0.107***	-0.098***
	(0.016)	(0.016)	(0.015)	(0.014)
Mother's parenting style	-0.001	-0.008	0.020	0.016
	(0.017)	(0.017)	(0.015)	(0.015)
Mother's time investments	0.006	0.005	0.027*	0.023
	(0.017)	(0.017)	(0.015)	(0.015)
Partner's time investments	-0.016	-0.014	-0.043***	-0.042***
	(0.019)	(0.018)	(0.017)	(0.016)
Mother-child relationship	-0.014	-0.011	-0.019	-0.017
	(0.018)	(0.017)	(0.016)	(0.016)
Partner-child relationship	-0.012	-0.007	-0.007	-0.003
	(0.018)	(0.017)	(0.016)	(0.015)
Observations	4,248	4,248	5,017	5,017
R-squared	0.137	0.158	0.165	0.185

Notes: Sample 1 consists of births within a 6 year window of RoSLA; Sample 2 restricts to common support across mothers' age within treatment and control. Regressions control for mothers' age at birth.

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