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# Early, Late or Never? When Does Parental Education Impact Child Outcomes?

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**Abstract**
We study the intergenerational effects of parents' education on their children's educational outcomes. The endogeneity of parental education is addressed by exploiting the exogenous shift in education levels induced by the 1972 Raising of the School Leaving Age (RoSLA) from age 15 to 16 in England and Wales. Using data from the Avon Longitudinal Study of Parents and Children – a rich cohort dataset of children born in the early 1990s in Avon, England – allows us to examine the timing of impacts throughout the child's life, from pre-school assessments through the school years to the final exams at the end of the compulsory schooling period. We also determine whether there are differential effects for literacy and numeracy. We find that increasing parental education has a positive causal effect on children's outcomes that is evident at age 4 and continues to be visible up to and including the high stakes exams taken at age 16. Children of parents affected by the reform gain results just under 0.1 standard deviations higher than those whose parents were not impacted. The effect is focused on the lower educated parents where we would expect there to be more of an impact: children of these parents gaining results approximately 0.2 standard deviations higher. The effects appear to be broadly equal across numeracy and literacy test scores.

Key words: Intergenerational mobility, schooling, child development, ALSPAC
JEL: I20; J62; J24

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# 1 Introduction

It is a consistent finding across numerous countries that individuals with higher levels of schooling have children who also attain higher levels of schooling. There are two main sources of this intergenerational correlation and distinguishing between them is of considerable importance. The first explanation of the intergenerational link is a selection story – characteristics that lead parents to select into higher levels of education may also impact their abilities in child-raising or be related to other genetic and environmental factors shared with their children that will lead the children to also achieve higher levels of education. The second explanation is a causal story – as a result of attaining more education, the parents with high levels of schooling provide a better childhood experience and home environment and consequently their children do better in school. The design of policy to improve intergenerational mobility, which is arguably the top social policy goal of the current UK government, will differ according to the extent of causation in the link between education levels in successive generations of a family. As the UK looks to raise the Participation Age (full-time education or employment with a vocational apprenticeship) to the age of 18 by 2015, examining the intergenerational effects on mobility of raising educational participation among the lower achieving tail is timely. The empirical challenge is to differentiate between these two mechanisms and identify whether there is a causal effect of parental education on child outcomes or whether the intergenerational correlation is purely an artefact of selection.

There have been a number of recent studies using a range of techniques to isolate the causal effect of parental education (see Holmund *et al.* 2011, for a reconciliation study for the main techniques used). Oreopoulus *et al.* (2003), Black *et al.* (2005), Chevalier (2004) and Chevalier *et al*. (2005), Maurin and McNally (2008) and Carneiro *et al*. (2008) all use instrumental variables techniques with a variety of instruments and with quite diverse results. Few studies go on to assess the age at which the intergenerational education transmission emerges and the relative scale of effects across literacy and numeracy. Here, we use a rich cohort dataset – the Avon Longitudinal Study of Parents and Children (ALSPAC) – and exploit the fact that a proportion of the parents in the data were impacted by the most recent raising of the minimum school leaving age (RoSLA) in England which occurred in 1972. This policy change provides an exogenous increase in education for a cohort of the ALSPAC parents, focused on the lower achieving tail of educational attainment and in the age range 30-38 at the time of the child's birth. The high frequency longitudinal nature of the data allows us to also examine the timing of impacts throughout the child's life, from early development indicators (18-30 months) and pre-school assessments through various assessments during the school years to the final exams at the end of the compulsory schooling period. Moreover, the richness of the data also allows us to look separately at results in literacy and those in Maths. Importantly, the structure of the ALSPAC data allows us to identify the causal impact of the policy separately from the effect of the age of the child's parents at the time of the child's birth.

Our results suggest that increasing parental education has a positive causal effect on children's outcomes that is evident at age 4 and continues to be visible up to and including the high stakes exams taken at age 16. Children of parents affected by the reform gain results just under 0.1 standard deviations higher than those whose parents were not impacted. Focusing on the lower educated parents where we would expect there to be more of an impact, the effect is larger: children of affected parents gaining results approximately 0.15 standard deviations higher. There are no marked differences in the extent of elevated performance between literacy and numeracy scores.

The paper proceeds as follows: in the next section we review the recent literature on the causal effect of parents' education on child outcomes, before section 3 outlines our empirical strategy. Section 4 describes the ALSPAC data, section 5 presents the results before section 6 discusses the findings and concludes.

## 2 Previous Literature

The majority of the recent literature on the intergenerational transmission of education can be categorised into three approaches to identifying the causal effect: (a) twin studies, (b) adoption studies, (c) instrumental variables.

(a) Twin studies

The foundation of the twin approach is that by comparing the education outcomes of children born to identical twin sisters, the effect of the mother's education on the child's education can be inferred net of any genetic influences. Behrman and Rosenzweig (2002) first applied this approach using US data and found that the effect of father's education is more important than that of the mother's. This finding has been replicated in twin studies (using both identical (monozygotic, MZ) and non-identical (dizygotic, DZ) twins) in Scandinavian countries (see Holmlund *et al.* (2011) for Sweden, and Pronzato (2010) for Norway). However, Antonovics and Goldberg (2005) show the sensitivity of Behrman and Rosenzweig's conclusion to data coding and sample inclusion criteria, concluding themselves that there is not a dramatic difference in the importance of maternal and paternal schooling. There are, however, problems with the twin study methodology. Firstly it requires that twins are identical bar their difference in education which is assumed to be unrelated to any unobserved differences between the twins. This seems a very strong assumption as it appears highly unlikely that twins choose different levels of education for purely random reasons – there must be some reason why one twin gets a different level of education to the other and whatever leads to the difference cannot be assumed to be irrelevant for other later outcomes. In addition, only one parent's unobservables (the one with a twin) can be controlled using in this strategy. Moreover, it is hard to know how to control for the observable characteristics of the spouse. These may reflect the education decision but there may remain bias resulting from assortative mating on the unobservable characteristics that lie behind the decision to increase education levels. Overall the twin methodology has serious problems and it is not clear how reliable resulting estimates can be.

(b) Adoption studies.

Compared with twin studies as a methodology, adoption studies reduce the bias in the causal estimates by eliminating the genetic link between *both* parents and the child – whereas twin studies can difference out genetic factors for just one parent. The adoption estimates capture the non-genetic effect of parental education but will remain (upwardly) biased since they are also contain the effect of parental nurturing skills which differ between parents and are likely to be (positively) correlated with but not wholly driven by education level. The adoption strategy is exploited by *inter alia* Sacerdote (2002, 2007) and Plug (2004). Examining the outcomes of Korean adoptees in the US, Sacerdote (2007) finds that an additional year of maternal education for the adopting mother increases the adoptee's years of schooling by approximately 0.1 years and increases the probability of the adoptee having a 4-year college degree by 2 percentage points. Plug, using US data, finds that genetic factors account for approximately 50 percent of the mother's education effect, and 30 percent of the father's – echoing the twin study findings that father's education is more important causally for children's outcomes. In fact, when both parents' education is included in the model, only the effect of father's education is significant, suggesting that the mother's education effect is wholly accounted for by genetic and assortative mating factors. Holmlund *et al.* (2011) also examine estimates using adoptees in Sweden and in contrast find equally important effects for mothers and fathers though in each case including spouse's education sees the coefficients halve in size and become insignificant. As acknowledged by authors using this strategy, the correlation between parents' and children's educational outcomes can still be because of non-genetic factors that are shared by both the parents and the children, with the transmission via parenting style, ethos and values and the result that both parents and children select levels of education on these unobservables. In addition, the sample sizes typically available even in registry datasets are small and the placement of adoptee children may not be random.

(c) Instrumental Variable studies.

Arguably the most clear cut strategy for isolating the true causal effect of parental education on child education is instrumental variables. In this case the biases from both the genetic and environmental transmission factors that confound OLS estimates are removed, since the variation in parental education is orthogonal to unobservables. The majority of IV strategies rely, as we do, on changes in compulsory schooling requirements which induce certain cohorts of relatively low educated young people to increase their schooling relative to the previous cohorts. These changes are involuntary increases in schooling for a group who are likely to be drawn from those with lower prior educational attainment and a less positive attitude toward education. Other IV strategies which focus on unanticipated variations in opportunities for continuing education to the graduate level, such as Carneiro et al. (2008), are likely to be drawing inference from a very different part of the educational attainment distribution and there is no *a priori* reason why the effects should be similar across these groups. The 'local average treatment effect' identified at the low education part of the distribution is likely to be more important in policy terms where policy makers are concerned with low intergenerational mobility or low income in the second generation.

Oreopoulos, Page and Stevens (2006) exploit changes in compulsory schooling requirements across US states over time to identify the causal effect of parents' education on children's probability of repeating a school grade or dropping out of high school – each are reduced by 2 to 4 percentage points for an additional year of education for either parent. Black *et al.* (2005) similarly exploit a two-year increase in the compulsory schooling required by law in Norway, introduced at different times across different regions during the 1960s and early 1970s. There are however few causal effects identified, suggesting that selection explains most of the cross-sectional correlation. The exception is for mothers and their sons, where a year increase in schooling for low educated women increases their son's subsequent schooling by one tenth of a year. On their full sample, Holmlund *et al* (2011) find results of a similar magnitude for Swedish data, again exploiting a compulsory school leaving age reform, though they find that the coefficient on father's education is also significant and almost as large. Restricting the sample to just the lower educated parents where the reform should impact the most, the coefficients are incongruously smaller and only the mother's is significant and only when the partner's education is excluded from the regression.

Within the UK, a number of studies have exploited both the 1947 (to age 15) and the 1972 (to age 16) RoSLA to identify the intergenerational transmission of education. The combination of the NCDS 1958 birth cohort study and the 1947 RoSLA has been exploited by two studies looking at child cognitive and non-cognitive development indicators, as opposed to educational qualifications. Sabates and Duckworth (2010) estimate the impact of increasing mothers' schooling on children's *relative* rank within cohort along four dimensions of development: two cognitive, two behavioural. They find that amongst mothers who only attain the compulsory years of education, increasing schooling by one year positively impacted on the mathematics attainment of their children. There were no significant impacts on reading or on behavioural outcomes, though it is difficult to identify effects in the small estimation sample of only 467 children available around the education discontinuity. Silles (2010) examines the impact of fathers' as well as mothers' education on child's percentile rank in cognitive and non-cognitive outcomes at ages 7, 11 and 16. Despite large correlations between parental education and child cognitive development in the OLS estimates, the large standard errors on the IV estimates make them too imprecise to identify any significant effects. One problem here is that identification in this context relies on comparing successive cohorts of parents, only one of which was affected by the schooling reform. When the children are from a cohort study and born at almost the same time, this can lead to the treatment effect becoming confounded with the age of the parent at the child's birth, which may exert an independent effect on child outcomes. This may cause a problem for studies using the NCDS, for example, where all children were born in a single week of 1958.

The 1972 RoSLA that we exploit has also been utilised to identify causal effects of parental education by Chevalier (2004) and Chevalier, Harmon, O'Sullivan and Walker (2005). The former uses the Family Resources Survey, and finds that the causal impact of an additional year of parental schooling on the probability of the child remaining in school post-16 is roughly equal at 8 percentage points for either parent, though significant only at the 10% level. Chevalier *et al* use the UK Labour Force Survey to examine the impact of parental education and income on the probability of a child remaining in school post-16 and also on the probability of attaining five or more GCSEs graded A to C (a standard measure of educational achievement in the UK). Despite large effects of parental education on the children's educational outcomes in the OLS, when instrumenting both education and parental permanent income, the parental education effects become non-significant. Both of these studies are limited by the child outcome variables available in the respective datasets.

The US study most similar to our own is that by Carneiro *et al.* (2008) using data from the children born to women in the National Longitudinal Survey of Youth (NLSY). The authors are able to look at outcomes at different stages of the children's upbringing and consider both reading/literacy and math results at these ages. The identification strategy relies on differences in the availability and costs of higher education and therefore the education margin examined is quite different to the one that we study. Moreover, only maternal education is known thus the estimated education effects will combine the direct effect plus any impact via assortative mating. Carneiro *et al.* find that for children of white mothers, an additional year of maternal education increases child reading and math test scores at age 7-8 by 0.075 and 0.1 standard deviations respectively. By age 12-14 the effects are smaller and not significant. A year increase in maternal education also causally reduces the probability of grade repetition by just under 3 percentage points at each age, tallying with the finding of Oreopoulos *et al*. For children of black mothers the results are similar, though the maths and reading impacts remain significant at age 12-14 and are stronger. Maurin and McNally (2008) also examine the higher education margin, exploiting the French student uprising of 1968 to instrument for higher education access. The student protests disrupted the education system to such an extent that the usual examination procedures were curtailed during 1968; in particular the *baccalauréat* which if passed guarantees a place in university, was assessed using just oral examinations on a single day rather than the usual series of oral and written examinations. As a result there was a 30% increase for this cohort in the number of people attaining the qualifications to access university. Exploiting this exogenous increase in higher education, Maurin and McNally find that increased paternal education significantly reduces the probability of a child being held back a grade.

In addition, there are a small number of papers that pursue alternative identification strategies. Ermisch and Francesconi (2001) provide a theoretical model of investment by parents in the education of their children and propose conditions under which the cross-sectional associations between parents' and children's schooling can be interpreted causally. Amongst poorer parents where the authors' model suggests the education effects are causal, the estimates suggest a strong influence of both parents' education. It is clear from reviewing the recent literature that there is not a consensus regarding the *causal* effect of parents' education on the education of their children – even amongst studies employing the same identification strategy. Holmlund *et al.* (2011) suggests that the underlying causal parameter identified by each differing method is the same, with differences in estimates owing to country and time specific factors, which needs to be borne in mind when considering the wider applicability of our findings here. There are also unresolved issues over the timing of any causal effects within the upbringing of the child and also the areas affected – is any causal effect felt early on in life or is it only apparent at later school years? Moreover, is the effect universal across all subjects or specific to certain educational domains?

## 3 Data

As alluded to above, our data comes from the Avon Longitudinal Study of Parents and Children (ALSPAC), which is a cohort dataset comprising children who were expected to be born between 1st April 1991 and 31st December 1992 in the Avon area, a former administrative area in the South West of England which includes the city of Bristol and a number of smaller towns and the rural area around the city. All mothers in Avon with children due during this period were invited to join the study, resulting in 13,971 live children at 12 months, from 13,801 mothers. Additionally, eligible children who were found in the national pupil census data but who were not in the core ALSPAC sample were invited to join the study. In total we have a potential maximum of 19,966 children who would represent a full census of children born in the study area in the applicable window.[1] The ALSPAC mothers in total mirror the national picture in terms of timing of fertility: for 1991 and 1992 the national averages of age of mother across all birth parities were 27.7 and 27.9 respectively, which compares with 27.9 for the ALSPAC mothers.[2] The national average completed fertility for the cohorts of women corresponding to our main sample is between 1.98 and 2.02[3] which is below the average in our sample (2.51) thus compared to the national picture our sample mothers have slightly larger families on average. The median birth parity for the children in our sample is 2 (mean 2.1), therefore on average these are the second born child in families with 2 or 3 children. With regard to child-bearing of women of lower education in the 30-38 year old bracket, we can compare the British

[1] Triplets and quadruplets are excluded from the data since the external data is unavailable for these children due to confidentiality concerns

[2] See 'Live Births in England and Wales by Characteristics of Mother 1, 2012', Office for National Statistics.

[3] See 'Cohort Fertility, England and Wales, 2012'.

Household Panel Survey where 36.4% of women who have O-levels or less have a child during these years – thus this combination of lower education and child-bearing in this age range is quite common.

The data from the study includes information from survey questionnaires completed by the mothers, the mothers' partner and the study children at various points during the children's lives – from pre-birth through to late teenage years. Further to the main questionnaires there were several "clinics" at different ages, during which children completed various types of tests and questionnaires. Data from administrative sources has also been linked in, including the National Pupil Database and the Annual School Censuses, at school and pupil level giving test results for all Key Stages and Entry Assessment.

The Key Stages in the English schooling system are formal assessments, externally set and marked, which are taken by children in all state schools, for this age cohort, at ages 7 (Key Stage 1), 11 (KS2), 14 (KS3) and 16[4] (KS4). The KS4 assessments include GCSE exams and also other more vocational qualifications (Appendix A8 shows how academic qualifications correspond to the National Vocational Qualifications equivalence scale). These data can be explored in different forms, specifically we use KS4 points (the sum of all GCSE-equivalent points for all age 16 qualifications), the total points for GCSEs only so that vocational qualifications are excluded, the total points for traditional academic GCSEs[5], the score for Maths GCSE and the score for English Language GCSE (as a measure of literacy).

At the earlier ages we also look assessments of English and Maths separately and a combined overall test score. For KS1 (age 7) the assessments are reading, writing and maths. We combine the reading and writing scores into an overall "literacy" measure. We also have information on the child's school entry assessment scores: these measures are teacher-assessed in the child's first term of Reception class (normally age 4 years), generally in late October/early November so the child has been in school for only one or two months. These assessments were not compulsory nationally at the time the ALSPAC children were entering school, however the same system was used in about 80% of schools in the Avon area at that time. We create an Entry Assessment total score by combining results for reading, writing, language and maths; we also look at maths and literacy scores separately.

We also have a number of outcomes that are not measures of formal education. One such outcome is a measure of IQ. This is taken from the Focus 8+ Clinic, to which all ALSPAC study children were invited at around 8 years of age. The children were measured using the Wechsler Intelligence Scale for Children, specifically the WISC-III [UK], which was the most up-to-date at the time of the clinic. We

[4] The ages for the KS assessments listed here refer to the age of the child at the end of the school year in which these tests are taken. Some of the younger students in the school cohort will be 6, 10, 13 and 15 when the KS tests are taken but will soon after turn 7, 11, 14 and 16 respectively.

[5] Included GCSEs: Maths, English Language, English Literature, Geography, History, French, German, Italian, Russian, Spanish, Single/Double award Science, Biology, Chemistry, Physics.

use the total score, a sum of 10 subscales[6] (split into verbal and performance categories) which are age-adjusted and also just performance IQ, which is thought to capture the more innate "fluid intelligence" dimension of IQ. Finally we have mother-reported measures of child development in several areas from the early child-focused questionnaires. We use Gross and Fine Motor Skills scores which are averages of scores taken from questionnaires when the child is aged 18 and 30 months, scaled between 0 and 100. We do not adjust the scores for age but we do include age when measured in regressions as controls when using these dependent variables.

For the parents the education data is more restricted. There is no information regarding the age parents left full-time education or indeed an IQ type test but there are qualifications achieved. We construct three different (0,1) qualification indicators capturing whether the parent has any qualifications[7], has any O-levels (the exam preceding GCSE and taken at age 16) and has any A-levels. Unfortunately there was no information on the number of each type of qualification or grades, hence our focus on the impact of the RoSLA on the broad level of qualification attainment of the parents. The increase in education experienced as a result of the RoSLA will be felt in terms of both years in education and in qualifications attained at the end of the extra year in education resulting from the reform. Thus we do not directly observe the full extent of the RoSLA on parental education within the ALSPAC study but only in the domain of qualifications. We show the size of the change in terms of the proportion of the population that stayed on for the extra year using other data sources.

Table 1 contains summary statistics for the parents in our main estimation sample (±3 years around the RoSLA). These are the characteristics of the parents who are either treated or untreated, that is they are born within the ±3 years around 1st September 1957, and so are considered to be comparable with respect to the treatment effect. We see from Table 1 that the fathers are on average slightly more educated than the mothers with fewer having no or low qualifications and more having A-levels and above. More of the mothers have teaching or nursing qualifications as we may predict. The lower part of the table shows that the ALSPAC fathers in the treatment zone are slightly older than the mothers but the difference can only be small given that by definition of inclusion in the treatment zone these parents must be born within ±3 years of RoSLA.

Table 2 contains summary statistics for the children of parents in the ±3 years sample, both the overall measures and broken down by the education level of the parents. The final column ("full sample")

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[6] The verbal subscales are: information, similarities, arithmetic, vocabulary and comprehension. The performance subscales are picture completion, coding, picture arrangement, block design and object assembly.

[7] Any qualifications includes CSE, vocational and skill qualifications, apprenticeships, intermediate, full and final City & Guilds, State Enrolled Nurse, State Registered Nurse, teaching qualifications, degrees, O- and A-levels.

shows that just over half of the sample are in the cohort that took their GCSEs in 2008.[8] Moving from parental education group 1, which represents children of parents with no or only low qualifications between them, to education group 4 which represents children of parents who both either have a degree or equivalent, there is a clear parental education gradient in child outcomes. For example, moving from children of the lowest educated parents to children the highest increases average Key Stage 4 (age 16 examinations) score from 350.65 to 502.35 which is equivalent to an additional three GCSEs at the top grade (A). Similar gradients exist for each of the education measures and IQ. Fine motor skills averaged at age 18 and 30 months, which is a developmental indicator that is correlated with later educational outcomes, exhibits a small gradient however gross motor skills recorded at the same points and which is not strongly related to later outcomes is almost constant across parental education groups.

## 4 Empirical Strategy

In England and Wales, compulsory schooling laws apply nationwide and govern the mandatory age by which children must start school and the minimum age[9] at which individuals are no longer required to be in full-time education. The most recent change to the minimum school leaving age came into effect from 1st September 1972[10] and required individuals to remain in school until the end of the academic year in which they turn 16 – a one year increase from the previous requirement. The law change therefore affected all individuals turning 15 on or after 1st September 1972 and was binding on anyone wishing to leave at the earliest opportunity.[11] The educational impact of the law change was substantial: Figure 1 shows the mean age of leaving full-time education for men and women for the 10 cohorts immediately before and after RoSLA, using data from the UK Labour Force Survey. While there is a general upward trend both before and after the RoSLA, there is a discrete jump in the average years of schooling by just under one third of a year for both men and women as a result of RoSLA (implying that just under one-third of the cohort were bound by the reform). Moreover, as Figure 2 illustrates, the proportion that left school without any qualifications dropped sharply while the proportion leaving with one or more level 1 (below O-Level) or level 2 (O-Level) qualifications increased. There is no impact on A-level qualifications (which are level 3 qualifications normally sat at age 18) or higher, which suggests that the impact of RoSLA was limited to the lower end of the

[8] These children started school in September 1996 and were born therefore between September 1991 and August 1992. ALSPAC children born before September 1991 are in the school year before this and those born after August 1992 are in the school year after this.

[9] The minimum school leaving age refers to the age that the individual will be at the end of that academic year, hence some who leave at the minimum age when that is 16 (15) will actually still only be 15 (14) on their final day in school.

[10] The Raising of the School Leaving Age Order (Statutory Instrument no. 444) was passed in March 1972, activating the clause of the Education Act 1944 which provided for the raising of the school leaving age to 16 when it was deemed possible to do so.

[11] More of the historical context can be found in McCulloch, *et al*. (2012).

education distribution, with no ripple effect further up (see Chevalier, Harmon, Walker, Zhu, 2004, for further evidence of this). Table 3 quantifies the pattern illustrated in the Figures and shows the pattern by gender, comparing the 3-year trends pre- and post- policy in mean years of schooling, the proportion who left school by age 15 and the proportion of each cohort holding various levels of qualifications, with the change in these measures induced by RoSLA. Clearly at the national level there is a significant, discontinuous education impact at the point of RoSLA with particular impact on those leaving school at age 16 or younger.[12] Thus the treatment here involves both a years of education effect, about a third of year on average, and an effect on qualifications at a little under a ten percent increase in any qualifications.

A number of studies have exploited this exogenous increase in education to estimate the causal impact of education on *inter alia* wages (Grenet, 2013; Harmon and Walker, 1995), employment (Dickson and Smith, 2011), health (Clark and Royer, 2010; Silles, 2009) and crime (Machin, Marie and Vujić, 2011). The estimated impacts of the RoSLA are substantial for wages, employment and crime, though there is mixed evidence regarding any effect on health. In each case the estimates are interpreted as 'local average treatment effects'[13] as the policy impact is limited – as illustrated above – to the lower part of the education distribution: there was no impact of the reform on educational attainment further up. Similarly, we are interested in investigating the causal effect of parental education on child outcomes amongst parents with low levels of education – a group whose children are most at risk of poor economic outcomes. Therefore though the estimated effects may be different to the average treatment effect, the LATE we estimate is arguably the most important for policy.

The availability of information on the date of birth and the qualifications of *both* parents provides an additional dimension to the "treatment" of study children, which is determined by whether none, one or both of their parents were impacted by the RoSLA. One potential issue with including information on both parents is the possibility that the RoSLA treatment of the mother (father) may have an impact on the partner that they choose or on the stability of the relationship. For this reason we do not condition on the characteristics of each partner, rather we allow the education of the mother and father to be shocked in the same way by the RoSLA event – which was exogenous to both the mother and the father of the child. There are two possible threats to this strategy: firstly, if the RoSLA affected the probability of relationships remaining intact and/or the probability of information on the father being available at all. Secondly, if education affected the *age* of the partner chosen in which case father's treatment status would be endogenous to mothers and vice-versa. We can check both of these things in our data. The results show (see Table 6b and Appendix Figures A1-A4) that the likelihood of the mother and father being together until the child is at least 12, the mother changing partner at all or the

[12] Calculations using the Quarterly Labour Force Survey, pooled from 1993q1 to 2010q2.

[13] See Angrist and Imbens (1994).

father information being missing is unaffected by the treatment. Moreover, the age gap between partners is unaffected by the RoSLA treatment – whether we look at mothers who are treated or fathers. Additional support comes from the other balancing tests reported in Table 6, which also suggest that the level of qualifications of the father (mother) is not significantly different between the treated and untreated mothers (fathers). We therefore proceed on the assumption that each partners' treatment status is exogenous and that considering fathers as well as mothers does not bias the estimates.[14]

We proceed by initially estimating the reduced form impact of the RoSLA on both parents' qualifications (equation (1) below) to illustrate the first stage effect which is a pre-requisite for there being a causal effect on child outcomes via the parents' education. For the dependent variable $Q_j$ we consider three different (0,1) qualification indicators: has any qualifications, has any O-levels and has any A-levels, and in all cases the subscript $j$ refers to the parent. The indicator $RoSLA_j$ is a dummy variable for being born on or after 1st September 1957 and the vector $\boldsymbol{X}_{1j}$ contains either a linear or a quadratic term in the month of birth of the parent. Equation (1) is estimated using a linear probability model.

(1) $$Q_j = \boldsymbol{X}'_{1j}\beta_1 + \gamma_1 RoSLA_j + \varepsilon_j$$

Compulsory school reforms lend themselves to analysis by regression discontinuity methods, however given the information on both parents' treatment, it would not be a standard implementation of RD due to there being both the mother and the father potentially affected by the treatment, effectively two running variables. One approach would be to focus only on mothers (or fathers) and implement a standard RD design.[15]

However, aside from the requirement to focus on one parent at a time, the more important reason for not using RD designs is the unique characteristic of the ALSPAC data that allows us to separately identify the treatment effect (born in or after September 1957 and therefore subject to a one-year increase in compulsory schooling requirement) and the effect of the age of the mother (and father) at the time of the child's birth.

Previous studies have not been able to separate out the effect of treatment from the age of the parent(s) at child's birth, on account of the children in other cohort studies all being born within the same week. This mechanically confounds the treatment and the age of the parent(s) at the time of the

[14] If father information being available was an outcome of the treatment, by including information on fathers we would be conditioning on an outcome. Tests suggest this is not the case, but even if it was, the bias would reduce the size of our estimates as the non-treated mothers who do provide father information (despite not having the benefit of the treatment) would have qualities associated with better child outcomes than the average non-treated mothers and so the difference between their child outcomes and the outcomes of treated mothers' children will be smaller than average.

[15] Results from implementing RD designs separately for mothers and fathers with are presented in Appendix tables A1 and A2.

child's birth. When we implement a design in which we treat the continuous variable mother's month of birth as the running variable and compare children born to mothers in a certain bandwidth around the treatment threshold, we are not able to control for the age of the mother at the time of the child's birth. As ALSPAC children in our data are born between April 1991 and January 1993, this means that even in our sample of mothers born within +/-1 year of the treatment threshold this translates to a 3 years and 7 month range of ages of the mother at time of child's birth.[16] There may be physiological reasons why younger child bearing may impact child development and outcomes or there may be an impact of lower life-experience amongst younger mothers that affects their parenting skills and may carry through to child educational outcomes. Therefore it is important in our empirical strategy to control especially for the age of the mother at the child's birth in order to prevent the treatment effect being confounded with the effect of bearing the child at a younger age. This analysis applies equally for fathers. The results below bear this out indicating for example, that for each additional year of age of the mother at the time of the child's birth, Key Stage 4 results increase by approx. 6 points – equivalent to one grade higher on one GCSE exam.

For the reduced form estimates we estimate the effect of RoSLA for each parent on the child outcomes, $S_i$, (see equation (2) below), controlling flexibly for the age of the mother and father at the child's birth, in addition to including controls in $X_{2i}$ for child demographic characteristics: gender, age in months, and school cohort.[17] Results are robust to the inclusion of the interaction of the individual parent treatment dummies though this interaction term is rarely significant and so in the interests of parsimony is not included in our main specification.[18] The subscript *i* refers to the child, though the variables themselves in some cases are characteristics of child *i*'s parents. The particular outcomes that we examine are various education outcomes from national tests at ages 7, 11, 14 and 16 along with school entry assessment (age 4), very early measures of development (18 and 30 months old) and IQ measured at age 8:

$$(2) \qquad S_i = \boldsymbol{X}'_{2i}\beta_2 + \gamma_2 RoSLA\_M_i + \gamma_3 RoSLA\_F_i + AgeMoth_i * \boldsymbol{M}'_{\boldsymbol{i}}\delta_1 + AgeFath_i * \boldsymbol{F}'_i\varphi_1 + u_{1i}$$

in which $RoSLA\_M_{,i}$ and $RoSLA\_F_{,i}$ are the mother and father RoSLA treatment dummies respectively. As noted above, it is important that we control for the age of the mother and father at the child's birth in order to prevent the treatment effect being confounded with the effect of bearing the child at a younger age. The vector $\boldsymbol{M}_i$ contains three dummy variables indicating whether the mother was born before the sample treatment window, during the window or after the window. The

[16] This is because in our data, in the +/-1 year window around 1st September 1957, the youngest mother was born in August 1958 and had her baby in April 1991 (aged 32 years and 8 months), the oldest mother was born in October 1956 and had her baby in December 1993 (aged 36 years and 3 months) hence the 3-year and 7 month age range of mothers within the +/-1 year window.

[17] We also include dummies to capture if a parent records foreign qualifications and so is ineligible for treatment on this account and for parental date of birth information being missing.

[18] Available from the authors on request.

specification allows a different slope for the age of mother at the time of the child's birth ($\text{AgeMoth}_{,i}$) for mothers born pre-, during and post- the sample treatment window as $\text{AgeMoth}_{,i}$ is interacted with $\boldsymbol{M}_i$. Allowing a different quadratic shape of the mothers' age effect for pre-, during and post-window does not alter the results and so in the interest of parsimony only the linear age splines are used. Similarly for fathers, the $\boldsymbol{F}_i$ vector contains a dummy for whether the father was born before the sample treatment window, during the window or after the window and this is interacted with the age of the father at the time of the child's birth ($\text{AgeFath}_{,i}$). Unlike in other cohort studies, the children in ALSPAC are born in a window that spans two calendar years, which means that they are placed into three different school years.[19] This is an important feature of the data as it means that the results are not being driven by cohort specific idiosyncratic factors.

Clearly the younger parents in the sample will be treated and the oldest parents in the sample will be untreated, however there is a range of ages where it is the case that the parent may have been treated or may not. Figure 3 illustrates this: the youngest parent in the data who is ***untreated*** was born in August 1957 (the last month of birth for which the individuals faced a minimum school leaving age of 15) and had their child in April 1991 and so was 33 years and 8 months old at the time of the child's birth. The oldest parent in the data who is ***treated*** was born in September 1957 (the first month of birth for which the RoSLA is in effect) and had their child in December 1992 and so was 35 years and 3 months old when the child was born. Therefore any parent who is older than 35 years and 3 months is definitely ***untreated***, while any parent younger than 33 years and 8 months is definitely ***treated*** – however, the treatment status of any parent in between these ages may not be inferred from their age at the birth of the study child.

Table 5 shows that depending on the sample used there are approximately 800-900 mothers who fall in this age range at the time of the child's birth, with about 100 fewer fathers in this range – as we would expect since fathers are on average slightly older than mothers. Amongst the parents in this age range who may be treated or untreated, just over half (52%) of the mothers are treated as are around 60% of the fathers. Therefore there is a 19 month range of ages that identify the treatment effect separately from the effect of parents' age at child's birth and a fairly even split between treated and non-treated within this age range. Figure A1 in the Appendix illustrates the density of parents' age at child's birth for mothers and fathers separately, with the vertical lines delineating the areas in which the parent is definitely treated, definitely untreated and the ambiguous 19-month range in between.

In order to capture the treatment effect as tightly as possible, we restrict our focus to parents' born in short windows around the date of the policy change. In choosing the size of the window there is a

[19] In the English school system, children are assigned to a school year according to date of birth with a school cohort being all children born between 1st September in year *t* and 31st August in year *t+1*. The ALSPAC children were born between January 1991 and January 1993 and so are in three different school years: the cohorts starting school in September 1995, September 1996 and September 1997.

trade-off between comparing parents born just before and just after the reform (which reduces any bias introduced to the treatment effect estimate when moving further away from the time of the policy change), and increasing the sample size (which improves precision of the estimates). Closing to less than 1-year either side of the discontinuity would not be advisable since in this case the comparison becomes between the older-within-school-cohort treated individuals and the younger-within-school-cohort untreated individuals, confounding the treatment effect estimate with the well-known age-within-school-cohort effect (see Crawford et al, 2010). We consider windows of ± 1 year, 3 years or 6 years around the policy change and all of our results are robust to the choice of sample window. To be included in the sample, a child must have at least one parent who was born within the sample window. If a parent is born outside of the sample window then that parent is ineligible to be considered as either treated or not (in which case only their age at time of child's birth is controlled). If they are born within the sample window and before September 1957, they are untreated, and if they are in the window and born on/after 1 September 1957, they are treated.

Therefore each child's treatment status is either no, one, which can either the mother or father, or both parents treated. This is captured in equation (2) by the two (0,1) RoSLA treatment dummies. The estimated coefficient on RoSLA_M$_{,i}$ (resp. RoSLA_F$_{,i}$) captures the intention to treat impact of increasing the education of the mother (father) by RoSLA. If both parents are born outside of the treatment window then that child is excluded from the sample. Single parents are included in the data, a dummy variable is included to pick up the effect of the other parents' information being missing, moreover if the current partner is not the same as when the child was born we exclude these parents (mostly fathers) from the treatment such that we do not consider the treatment status of the mother's partner who arrived in the household later in the ALSPAC child's childhood.

Table 4 illustrates the treatment matrix for the main estimation sample ±3 years around the RoSLA policy change for our data which is discussed in detail in the next section. Horizontally along the top of the table, the fathers of ALSPAC children are partitioned according to when they were born, while the mothers are partitioned down the left side of the table. The numbers on the right of each cell indicate the number of children in this category, and for the categories that comprise our estimation sample (highlighted cells) the number on the left gives the number of parents treated for children in this category. As outlined above, any parent born outside of the window ±3 years either side of 1$^{st}$ September 1957 (for the main sample, ± 1 year either side or ± 6 years either side for the robustness check samples) is not included in the treatment variable, and if both parents fall outside of the window then the child is thus excluded from the sample. Thus only children in the highlighted cells are included in our main estimation sample. There are 262 ALSPAC children for whom both their mother and father were born more than 3 years before RoSLA and so these children are not in our main estimation sample. There are however, 274 children whose father was born more than 3 year before

RoSLA but whose mother was born in the 3 years pre-RoSLA and so these children are included as part of the pre-RoSLA comparison group. There are 505 children for whom both parents were born in the first 3 years post-RoSLA and so these children are "doubly" treated. In total, for the main estimation sample there are 4967 children who have one or more parents within the treatment window. Of these 1477 are untreated, 2985 have one parent treated and as noted 505 have both parents treated.[20] Some 4,046 observations have no data on mothers or fathers date of birth, these are almost all drawn from the additional supplement sample identified at age 4 on entry into school. However, there are also a sizeable number of cases where the father's date of birth was not recorded with enough accuracy to isolate definitively treatment status. These are disproportionately associated with younger mothers and are thus outside our treatment window.

We later consider a narrower definition of the treatment, focusing in on the part of the education distribution where the treatment is actually biting, i.e. less educated parents. For these regressions we redefine the treatment variable such that only those parents with less than A-level qualifications are considered at risk of treatment. As before, to be included in the sample a child must have at least one parent born within the treatment window and now the additional stipulation is that this parent must also have less than A-level qualifications. We include a control to capture the A-level qualifications of the other parent if the other parent is higher educated.[21] The $RoSLA\_M_{,i}$ and $RoSLA\_F_{,i}$ variables can still take the values of (0,1) depending on the education level and date of birth of each parent, for example both will be 1 if both parents are born after the RoSLA threshold date and within the treatment window and neither has A-level qualifications.

There may be a concern that those parents born either side of the policy change are different in observable and unobservable ways that would confound the estimated treatment effects. This maybe of concern if it the increase in education altered fertility patterns of parents and hence whether they can be in our study data.  To assess this possibility Table 6 contains balancing tests of the difference between the treated and non-treated parents in terms of their fertility, demographic and relationship characteristics. These are shown in two ways: firstly, via mean differences for the parents in the ±1 year window around the treatment threshold, bearing in mind that there is a great deal of overlap in the age of parents at the birth of the ALSPAC child for the treated and untreated parents in this window. Secondly, by regression discontinuity estimates of the impact of RoSLA on the parents'

[20] In the +/-3 year window only 10.1% of the sample children are "double" treated and in the +/-1 year window this falls to 2.6%.

[21] The focus in this specification is the impact of RoSLA on the outcomes of children via its impact at the low education margin for parents. Rather than dropping any child who has one parent with A-levels or higher, we instead take out any high educated parent effect with a control. As the balancing tests suggest no changes in the partner qualifications as a result of RoSLA we do not think this conditioning is over-controlling. The treatment variable compares the outcomes for children with one low educated parent affected by the RoSLA with the outcomes for comparable children whose low educated parent was not affected, given the education of the other parent.

characteristics, using a 6-year bandwidth around the treatment threshold.[22] With respect to mother's age at first birth, the birth order of the ALSPAC child and the completed fertility of the ALSPAC child's parents (measured by the number of siblings the ALSPAC child has), in the ±1 year sample there is only a statistically significant difference between the treated and untreated in the completed fertility of the ALSPAC mothers. Moreover, despite statistical significance the magnitude of the difference is small (0.1 children). These findings are confirmed in the RD estimates. It is clear that any differences in means are small and it is also the case that for all of our estimation samples that the median birth-order (2) and number of siblings (1) is identical for the treated and untreated parents.

The UK literature on the effect of this RoSLA on fertility is unanimous in its findings. Geruso, Clark and Royer (2011) pool data from a large number of Labour Force Surveys along with live birth records, abortion records and the 1971 longitudinal study and exploiting the same 1972 RoSLA in England and Wales that we do, examine the causal effect of education on fertility. Their findings indicate that the only effect of RoSLA was to reduce the incidence of teenage fertility amongst 16 and 17 year olds, with no impact at age 18 and 19 or older. Overall the authors cannot reject that the additional education had no effect on post-teen fertility and no impact on completed fertility. The effects are estimated for narrow confidence intervals strongly suggesting no effect on overall fertility. Teenage pregnancy is a very small proportion of all pregnancies, and age 16 and 17 pregnancies only a part of teen fertility. Wilson (2014) carries out a similar analysis of the 1972 RoSLA reform and echoes the results of Geruso et al., finding no impact on fertility beyond age 20 hence this evidence suggests that for the cohorts of women that we are looking at, the additional education induced by RoSLA would have a minimal impact on the composition of our sample via a timing of fertility effect or a change to completed fertility. Thus we would not expect to find any effect on fertility among mothers in our sample who are in their early to mid-thirties at the time of the child's birth.

The lower section of Table 6a compares the pre- and post-treatment parents with respect to their own parents' education (i.e. the ALSPAC children's grand-parents), measured in terms of whether they hold O-levels or not. For the ALSPAC mothers in our ±1 year sample there is no difference at all in their parents' education between the treated and untreated and for fathers any differences are small and not statistically significant. This is also true in the RD estimates, thus the educational backgrounds of the treated and untreated ALSPAC parents seem to be well balanced.

The final part of Table 6a compares the IQ of the children of untreated versus treated parents. There are no significant differences in IQ for the children of ALSPAC mothers nor for children of ALSPAC fathers in the ±1 year sample, nor in the RD estimates. Moreover, looking at "performance IQ" which

[22] For balancing tests there is no issue with different ages of parents at time of the child's birth, we are looking purely at the parents' generation and so straightforward RDD estimates can be considered for each parent. We estimate using the higher bandwidth in order to allow more data space for the local linear functions to gain traction. Results are robust to any bandwidth chosen from 1 to 6 years. Available from authors on request. Appendix Figures A2 to A6 illustrate the balancing tests graphically for the 6 year RDD specification.

is thought to capture the more innate element of IQ ("fluid IQ"), again there are no differences between children of treated and untreated parents whether we look in the ±1 year sample mean differences or the wider RD estimates. These tests provide evidence that there is not an underlying difference in innate "ability" between the children of treated and untreated parents.

Table 6b presents balancing tests relating to the characteristics of the relationships of the pre- and post-treatment couples. As detailed above, these tests show no difference in the parental age gap or the stability of the relationship on account of the treatment, nor is the level of qualifications of the father (mother) is significantly different between the treated and untreated mothers (fathers).

In summary, the results of these balancing tests give us confidence that there is not selection into treatment on observable characteristics of the parents nor are the children of treated parents different in their more innate characteristics than the children of the untreated parents. Therefore given the nature of the exogenous policy change, there is no reason to suspect that there is selection on unobservables either, hence the treatment variables should be unbiased estimates of the intention-to-treat impact of RoSLA on child outcomes.

## 5 Results

*The impact of RoSLA on parents' education*

To illustrate that the national impact of the RoSLA on the education distribution is mirrored amongst the ALSPAC parents, Table 7a shows the results for the reduced form equation (1) estimates, using each of our three measures of educational attainment for the parents. The upper panel (a) refers to the full sample, whereas the lower panel refers to the sample when we restrict to only including parents who have less than A-level qualifications in the definition of the treatment variable.

Column (1) of panel (a) shows that the impact of RoSLA is to significantly increase the proportion of individuals with any qualifications by 4.4 percentage points, and the proportion with O-levels by 6.5 percentage points, both significant at the 1% level. This is in line with the national picture for men, though the ALSPAC women appear not to have increased qualification levels as much as the national average. These estimates are robust to the inclusion of a higher order polynomial in parents' date-of-birth (in months), the impact coefficients altering slightly to 3.9 percentage points for any qualifications, 6.0 percentage points for O-levels (as shown in columns (4) and (5) respectively).[23] As with the national picture, there is no impact on the proportion holding A-level qualifications –

[23] Table 7 reports the impact of RoSLA on the pooled sample of parents. Estimated separately for mothers and fathers the individual RoSLA coefficients are not statistically different to each other and mirror the pooled sample both in terms of size and significance. For example, panel (a) column (1) and (2) results for women: 0.052 (any qualifications), 0.056 (O-levels); for men: 0.036 (any), 0.076 (O-levels). The full Table 7 by sex is available from the authors on request.

whether we use a linear (column (3)) or a quadratic (column (6)) trend in parent's date-of-birth. This is important as later we will narrow the focus to the impact on parents with less than A-level qualifications on the basis that this is where the main impact of RoSLA is felt.

Imposing the restriction, panel (b), the impact of RoSLA is increased as we would expect to be the case. Now the increase in any qualification holding is 11.1 percentage points and 11.6 pp for holding O-levels, each significant at the 1% level. Allowing a quadratic in parents month of birth very slightly changes these impacts to 10.9 pp and 12.1 pp respectively. Thus the impact of RoSLA on parental qualifications is sizeable, especially when we focus on the part of the education distribution where the effect is most keenly felt. Moreover, given that the effect on qualifications amongst the ALSPAC parents closely mirrors the national impact on qualifications, we can surmise that a similar proportion of the parents were bound by the reform in terms of each time spent in education – around one-third receiving an extra year of education. All of these results in Table 7a are confirmed in Table 7b where we present regression discontinuity estimates of the impact of RoSLA on qualifications for various bandwidths around the discontinuity.

*The impact of RoSLA on children's education*

The results from estimating the impact of RoSLA on children's age 16 outcomes are displayed in Table 8 for the three different windows around the policy change: ±1 year, ±3 years and ±6 years. The KS4 outcomes are graded on the same equivalence scale which ranges from the lowest grade G which is worth 16 points, through increments of 6 points per grade to the highest grade A* being worth 58 points. The mean and standard deviation of each outcome variable are displayed in the table to give a sense of scale, as is each treatment effect as a proportion of a standard deviation, to allow comparison across later measures, such as the other KS outcomes.

The first thing of note in Table 8 is that the RoSLA treatment variables for mother and father are significant in all windows and for all outcomes, apart from fathers impact on the GCSE academic total for the narrow +/-1 year window. Secondly, comparison of the separate RoSLA treatment coefficients for the mother and the father finds that they are almost always very close to each other and in no case could we rule out that they are the same. Comparison of the coefficients in columns (1), (4) and (7) for KS4 total score, those in columns (2), (5) and (8) for GCSE total score and those in (3), (6) and (9) for the more academic GCSE qualifications, show that the point estimates for the treatment impacts across the different sample windows and very close to each other for the +/- 3 and +/- 6 year windows with the smaller sample size +/-1 year window estimates slightly higher compared to the other windows. For each parent affected by RoSLA, the child's KS4 total score is raised by between 12 and 16 points – which is the equivalent of between two and three GCSEs grades. Including only GCSEs – therefore excluding the vocational equivalent qualifications – the treatment impact is very similar, approximately 14 points. When we focus just on the traditional academic subject GCSEs the impact is smaller, at around 8 points, just over one GCSE grade. The impacts as a proportion of the outcome variable standard deviation are shown in the lower rows of Table 8. For each KS4 outcome the impact of mother treatment is around 8% of a standard deviation, while for fathers it is slightly higher at 10% of a standard deviation. The significant treatment effects in the +/-1 year window are higher, all close to 14%. For all outcomes, in all windows the test of the joint significance of the two parental RoSLA treatment dummies has a *p*-value of less than 0.04.

The impact of mother's age at the time of the child's birth is significant whether the mother was born before, during or after the treatment window, with the age impact higher for the younger mothers in almost all cases – we find, as we would expect, that amongst younger parents the slope of the age effect is steeper. Summarising the broad pattern, for mothers who are born before or within the treatment window an additional year of age at child's birth increases these age 16 outcomes by just under one GCSE grade (5 to 6 points) on average, whereas for the younger mothers the additional year increases these outcomes by just over one grade (6 to 7 points). The age of the father at the time of the child's birth is much less significant, only really having an impact for fathers born within the treatment window with each additional year of age adding approximately 1 point to KS4 outcomes.

The impact of the RoSLA treatment on the high stakes age 16 examinations is clear with the RoSLA raising attainment by approximately 0.1 standard deviations per parent across the alternative exam metrics; now we turn to looking at earlier assessments. Table 9 contains the estimates of the RoSLA treatment impacts on early development indicators: IQ and performance IQ, school entry assessment and the Key Stage scores at ages 7, 11 and 14 (KS1, 2 and 3 respectively). We focus on the ±3 years window here as being representative of the alternative lengths of window considered. Gross motor skills is not strongly correlated with later educational outcomes and it is interesting that column (2) of Table 9 shows that there is actually a negative impact of the mother being RoSLA treated for this outcome. Fine motor skills however *are* predictive of later outcomes but there is no significant impact of RoSLA treatment on this outcome though the point estimates for mother and father treatment are positive (column (1)). "Performance IQ" which is a component of the Wechsler Intelligence Scale for Children IQ measure that we use, is thought to capture the more innate element of IQ and as such this should not be malleable to the intervention of increased parental education. As is clear in Table 2, this IQ measure is graded by parental education, however we see in Table 9 that there is no impact of either parent being RoSLA treated on this measure, nor on the wider total IQ measure. This is re-assuring as we would expect as parental education does not influence innate child intelligence and supports the evidence from the balancing tests, showing that there is not an underlying difference between the more innate performance IQ of the children of parents either side of the treatment line.

Columns (5) to (8) of Table 9 show that it is in the education measures assessed within school that the RoSLA treatment impact starts to become significant, particularly for mothers. These assessments are marked according to their own non-comparable scales, so the treatment impact is converted to the proportion of a standard deviation of the outcome variable in the last rows of the table. The entry assessment is carried out when children are aged 4 or just turned 5 and have been in school for just one or two months. There is a significant impact of mothers' RoSLA treatment on this measure, just below 10% of a standard deviation higher results for children of mothers affected by RoSLA. The size of impact is almost the same for the KS1 and KS2 scores, both statistically significant, with only the KS3 score not reaching significance for mothers' RoSLA treatment, though for KS3 the mother and father treatments are jointly significant. For fathers it is only in KS1 and KS3 results that the RoSLA impact is significant, with similar magnitude to the mother impact, around 10% of a standard deviation. As with the KS4 results, mother's age at the time of the child's birth is significant for all outcomes and with a steeper gradient for younger mothers. Again father's age effect has a much smaller magnitude and is on the whole only important for fathers within the treatment window. Unlike Carneiro *et al.* (2008) we find no fading of the impact of parents education as children age.

Table 10 considers separately results for English/Literacy, columns (1) to (5), and Maths, columns (6) to (10). For English/Literacy, the impact of mothers' RoSLA treatment is evident at school entry and KS1 (age 7), with effect sizes of 14% to 9% of a standard deviation respectively. After age 7 assessments the point estimates are positive though not significant. For fathers there is a similar sized effect as mothers for KS1 and this remains a consistent effect of around 9% of a standard deviation at ages 14 and 16. For Maths scores the mother effects are consistent at 8% of standard deviation for KS1, KS2 (age 11) and KS4 (age 16), all marginally significant. For fathers the effects are significant at every stage from KS1 upwards and of sizes between 7% and 12% of a standard deviation. The father effect appears particularly significant for GCSE Maths (age 16), where it is 12% of a standard deviation, significant at 1% level. Overall the father effects tend to be more significant, though where mother RoSLA treatment is significant the size of the impact is comparable with the father effects, and there are no stark differences between English and Maths test scores.

*The impact of RoSLA on the education of children with lower educated parents*

We now restrict our focus to children of parents with lower levels of education – the parents most likely to be impacted by the RoSLA. As outlined above, to do this we redefine the treatment variable such that only those who attain less than A-levels are considered "at risk" of RoSLA treatment – as before, provided they are born within ±3 years around 1st September 1957. Therefore, if both of a child's parents have A-level education or higher then that child is excluded from the sample, whereas if one parent is considered at risk of treatment but the other is not and has A-levels or higher, this is controlled for in the regression. Though the partner having A-level or higher qualifications could be considered an outcome of the treatment, the balancing tests suggest there is no impact of RoSLA on partner qualifications and so we proceed on this basis, though acknowledging the possible (downward) bias in the estimated coefficients.

Table 11 considers the age 16 outcomes – KS4 total, GCSE total and GCSE academic subjects' total for this reduced sample. We know from the lower panel of Table 7 that the impact of RoSLA on qualification holding amongst parents in this sample was approximately double the impact for the larger sample and we see a sizeable increase in impact in the reduced form estimates on child outcomes. The mother and father RoSLA treatment effects now range from 12 to 19% of a standard deviation, compared with 7-8% for the results in Table 9. The largest impact is on the broader KS4 total scores which include vocational qualifications, with the father treatment having a particularly strong effect here (19% of a standard deviation). The effect on GCSE total score is equivalent to an increase of one grade for two GCSEs for each parent treated. In each column we see the strong, positive effect of one parent having A-levels equivalent or higher education on child outcomes, mother's having these levels in particular associated with higher child outcome scores. Appendix Tables A3 and A4 shows the effect of RoSLA treatment on the results at different points in the children's education progress, and separate picture for Maths and Literacy, after selecting on parents in the treatment window without A levels. The impacts on fine or gross motor skills mirror those in the full sample, and as with that sample there are no impacts on IQ or performance IQ. Each of the assessments from school entry onwards do show positive point estimates though in these smaller samples there are fewer significant effects, KS1 (age 7) apart where the father effect is strongly significant and at 18.5% of standard deviation is approximately double the effect size compared with the full sample. The pattern for English and Maths is largely the same as the full sample table, though it is notable that while the mother effect sizes do not change substantially where significant, for fathers the significant effects are all approximately double the size compared to the full sample, hinting that father's treatment is particularly important for this albeit selected sample.[24]

## 6 Discussion and Conclusions

The causal impact of parental education on children has potentially important policy implications for intergenerational mobility, especially among lower educated parents. Yet the available evidence from twin, adoptee and policy change studies is inconclusive. Using high frequency, high quality data from the Avon area of the UK we explore the impact of the 1972 Raising of the School Leaving Age on parents' qualifications and child educational outcomes throughout childhood. In summary, the findings suggest that the Raising of the School Leaving Age (RoSLA) treatment of parents impacts on child outcomes from school entry onwards and that the effect does not massively increase between the

[24] All of the estimation results are robust to an alternative specification in which we combine the separate treatment dummy variables into a single treatment variable taking the values (0,1,2) depending on the number of parents treated (imposing equal size effects for each parent). Appendix tables A5-A7 detail these results.

entry assessment and the exams taken at the end of the compulsory schooling period. For age 16 outcomes the impact sizes are comparable whether it is the mother or the father who is treated by RoSLA, whereas for earlier school assessments it is generally the mother's treatment that has the larger and more significant effect. There is some variation in impact size over the years but overall the impact seems to be significant at the start of school and then steady, without any strong increase in impact size exhibited. This remains the case when we look at results separated by English/Literacy and Maths, with the father effects being generally more significant particularly at older ages.

There is no impact of RoSLA treatment on children's IQ nor on their "performance IQ" which is re-assuring as this captures a more innate measure of ability. This and the raft of balancing tests on parent, child and grandparents' characteristics give confidence that there are no selection effects across our treatment and control groups and the effects are causal with parents born in the treated post-reform years seeing gains equal to just under 0.1 standard deviations in test scores and qualifications achieved. The 'complier' group who identify our results are those who have both lower levels of education *and* who are having children in their early to mid-30s. Child bearing in this group is quite common, especially for men but also for women: for example, figures from the British Household Panel Survey suggest that amongst the cohort of women born between 1952 and 1962, who have O-levels or lower qualifications, 36.4% have a child between the ages of 30 and 38[25] i.e. the range of ages for our main estimation sample. Thus it is not the case that low educated women complete their fertility before their 30s.

Importantly, the structure of the ALSPAC data – with children born over two calendar years – allows the treatment effect of RoSLA to be separately identified from the age of the parents at the time of the child's birth and the results demonstrate the importance of separating these effects. As we do not have years of completed education for the parents in the ALSPAC data, we cannot compute the Wald estimate of the effect of an additional year of education on child outcomes. However, the UK literature on the 1972 RoSLA consistently estimates a "first stage" effect of 0.33 additional years of schooling for the affected cohort – implying around 1/3 were bound by the reform. Taking a Two Sample Two Stage Least Squares approach and using this figure along with our reduced form results would imply a LATE impact of a 0.25 standard deviation increase in test scores for children with a parent who gained an additional year of education due to RoSLA. This is a non-trivial impact and appears from school entry and remains throughout the school career.

The policy implications of these results are important with the UK currently planning for a Raising of the Participation Age (that is in full-time education or a job with an apprenticeship) to age 18 by 2015, as they suggest a positive impact on the educational attainment of the next generation results from increasing the schooling of individuals who wish to leave school at the first opportunity. These

[25] Author's own calculations using BHPS data pooled waves 1-18 (1991 to 2008).

(future) parents who have low tastes for education or binding credit constraints identify the parental education effect, hence it is a ‘local average treatment effect’. However, from a policy point of view this is an extremely important LATE as this group of individuals are most at risk of failing to achieve their own potential and a similar risk applies to the children that they go on to have. This is in line with previous findings, for example Carneiro *et al.* (2008) find effects of a similar magnitude in the US. The *mechanisms* through which parental education causally affects children’s outcomes – the “why” question – remains a very important question for future research to answer, with implications for the design of education and family-related policy.

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**Table 1:** Summary Statistics for parents in treatment zone, main estimation sample window: parent must be born in the +/- 3 years around 1st September 1957

| | Mothers | | Fathers | |
|---|---|---|---|---|
| **Total number** | 3550 | | 2815 | |
| **Education** | N | Proportion | N | proportion |
| Education info missing | 552 | 0.155 | 125 | 0.044 |
| Education info non-missing | 2998 | 0.845 | 2690 | 0.956 |
| | Proportion | | Proportion | |
| **Highest education level:** | …of educ non-missing | …of total | …of educ non-missing | …of total |
| No qualifications | 0.100 | 0.084 | 0.095 | 0.091 |
| Less than O-Level (CSE, Intermediate C&G) | 0.118 | 0.100 | 0.072 | 0.069 |
| O-Level or equivalent (Final C&G, apprenticeship) | 0.263 | 0.222 | 0.250 | 0.239 |
| A-Level or equivalent (SEN, Full C&G) | 0.175 | 0.148 | 0.259 | 0.248 |
| SRN or Teaching Qualification | 0.100 | 0.085 | 0.017 | 0.016 |
| Degree | 0.244 | 0.206 | 0.307 | 0.293 |
| **Total** | 1.000 | 0.845 | 1.000 | 0.956 |

| **Age at ALSPAC child's birth** | N | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| Mother | 3550 | 33.31 | 1.72 | 30 | 38 |
| Father | 2815 | 33.50 | 1.72 | 30 | 38 |

**Table 2:** Summary Statistics for children main estimation sample: window +/- 3 years around 1st September 1957

| | Parental education group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** (least educated) | | **2** | | **3** | | **4** (most educated) | | **Full Sample** | | |
| | **mean** | **N** | **mean** | **N** | **mean** | **N** | **mean** | **N** | **mean** | **sd** | **N** |
| Child/Young Person is female (dummy) | 0.49 | 1000 | 0.46 | 742 | 0.48 | 1314 | 0.48 | 1322 | 0.48 | 0.50 | 4967 |
| Child/Young Person's age within sch. Year | 6.30 | 1000 | 6.17 | 742 | 6.15 | 1314 | 6.37 | 1322 | 6.28 | 3.71 | 4967 |
| Key Stage 4 Score | 350.65 | 880 | 402.11 | 673 | 451.49 | 1071 | 502.35 | 988 | 423.76 | 146.29 | 4094 |
| GCSE Total Score | 257.72 | 889 | 319.41 | 673 | 379.37 | 1078 | 444.80 | 989 | 347.42 | 143.20 | 4116 |
| GCSE Total Score (academic subjects) | 177.08 | 835 | 210.05 | 659 | 254.23 | 1057 | 300.68 | 981 | 235.87 | 98.07 | 3985 |
| Fine Motor Skills (18 and 30 months) | 80.54 | 897 | 82.20 | 707 | 83.58 | 1242 | 83.58 | 1271 | 82.64 | 9.42 | 4209 |
| Gross Motor Skills (18 and 30 months) | 84.04 | 896 | 84.45 | 707 | 84.01 | 1242 | 82.53 | 1271 | 83.59 | 10.91 | 4208 |
| IQ, aged 8 | 96.45 | 486 | 101.23 | 464 | 107.64 | 898 | 114.20 | 962 | 106.66 | 16.62 | 2877 |
| Performance IQ, aged 8 | 93.13 | 488 | 97.03 | 466 | 101.92 | 903 | 107.15 | 961 | 101.22 | 17.13 | 2886 |
| Entry Assessment Score | 19.84 | 741 | 21.01 | 539 | 21.89 | 794 | 22.68 | 641 | 21.15 | 3.29 | 3123 |
| Key Stage 1 Score | 8.09 | 878 | 9.31 | 635 | 10.47 | 963 | 11.67 | 839 | 9.68 | 3.74 | 3791 |
| Key Stage 2 Score | 78.82 | 888 | 84.20 | 682 | 88.27 | 1120 | 92.32 | 1074 | 85.73 | 12.13 | 4253 |
| Key Stage 3 Score | 98.33 | 833 | 107.66 | 634 | 114.38 | 959 | 123.56 | 778 | 109.81 | 20.13 | 3639 |
| Entry Assessment Literacy Score | 4.77 | 741 | 5.04 | 539 | 5.22 | 794 | 5.38 | 641 | 5.06 | 0.79 | 3122 |
| Key Stage 1 Literacy Score | 2.62 | 877 | 3.00 | 635 | 3.41 | 962 | 3.81 | 839 | 3.14 | 1.30 | 3789 |
| Key Stage 2 English Score | 25.62 | 883 | 27.42 | 679 | 28.90 | 1112 | 30.33 | 1067 | 28.01 | 4.76 | 4224 |
| Key Stage 3 English Score | 40.68 | 748 | 46.06 | 610 | 51.86 | 929 | 59.70 | 767 | 49.06 | 17.02 | 3442 |
| English Language GCSE | 37.30 | 812 | 40.24 | 651 | 43.90 | 1051 | 48.12 | 977 | 42.43 | 9.10 | 3931 |
| Entry Assessment Maths Score | 4.99 | 740 | 5.31 | 539 | 5.64 | 794 | 5.90 | 641 | 5.40 | 1.11 | 3120 |
| Key Stage 1 Maths Score | 2.85 | 877 | 3.31 | 633 | 3.65 | 963 | 4.05 | 839 | 3.40 | 1.36 | 3786 |
| Key Stage 2 Maths Score | 25.55 | 883 | 27.61 | 676 | 28.92 | 1116 | 30.37 | 1065 | 28.05 | 4.87 | 4217 |
| Key Stage 3 Maths Score | 75.20 | 796 | 81.88 | 624 | 87.13 | 939 | 96.08 | 767 | 84.52 | 21.95 | 3536 |
| Maths GCSE | 34.11 | 819 | 38.84 | 647 | 43.16 | 1028 | 47.81 | 904 | 40.84 | 11.00 | 3837 |
| GCSE cohort 2007 | 0.21 | 1000 | 0.20 | 742 | 0.20 | 1314 | 0.16 | 1322 | 0.19 | 0.39 | 4967 |
| GCSE cohort 2008 | 0.55 | 1000 | 0.58 | 742 | 0.50 | 1314 | 0.44 | 1322 | 0.51 | 0.50 | 4967 |
| GCSE cohort 2009 | 0.12 | 1000 | 0.13 | 742 | 0.12 | 1314 | 0.14 | 1322 | 0.13 | 0.34 | 4967 |
| GCSE cohort miss | 0.11 | 1000 | 0.09 | 742 | 0.17 | 1314 | 0.26 | 1322 | 0.17 | 0.38 | 4967 |

Note: the four parental education groups are defined as follows: each parent given score ranging from 0 = no qualifications or below GCSE qualifications, 1= GCSEs, 2 = A Levels, 3 = Degree. The parental education group is the combined parents score: group 1 = 0 or 1, 2 = 2, 3 = 3 to 4 and group 4 = 5 to 6.

**Table 3:** The impact of RoSLA on educational attainment – comparison of trends pre-policy and post-policy with the impact at the time of the policy

| | | **All individuals** | | | **Those leaving aged 16 or younger** | | |
|---|---|---|---|---|---|---|---|
| | | **1953/4 to 1955/6 Δ3 years pre-policy** | **1956/7 to 1957/8 Δ at policy** | **1958/9 to 1960/1 Δ3 years post-policy** | **1953/4 to 1955/6 Δ3 years pre-policy** | **1956/7 to 1957/8 Δ at policy** | **1958/9 to 1960/1 Δ3 years post-policy** |
| **Mean age left full time education (years)** | Men | 0.029 | **0.287** | 0.001 | – | – | – |
| | Women | 0.014 | **0.272** | 0.040 | – | – | – |
| **Proportion left school by 15** | Men | -0.023 | **-0.203** | 0.005 | – | – | – |
| | Women | -0.017 | **-0.250** | 0.010 | – | – | – |
| **Proportion with…..No quals** | Men | -0.013 | **-0.063** | -0.009 | -0.028 | **-0.129** | -0.034 |
| | Women | -0.009 | **-0.109** | -0.004 | -0.008 | **-0.178** | -0.003 |
| **…..NVQ Level 1 quals** | Men | 0.002 | **0.037** | 0.011 | 0.006 | **0.072** | 0.012 |
| | Women | 0.010 | **0.066** | -0.001 | 0.013 | **0.103** | 0.000 |
| **…..NVQ Level 2 quals** | Men | 0.008 | **0.029** | 0.012 | 0.024 | **0.064** | 0.016 |
| | Women | -0.003 | **0.057** | 0.005 | 0.008 | **0.089** | 0.013 |
| **…..NVQ Level 3 quals** | Men | 0.002 | -0.004 | -0.008 | 0.001 | 0.002 | 0.000 |
| | Women | 0.000 | 0.004 | -0.004 | -0.006 | 0.000 | -0.002 |
| **…..NVQ Level 4 quals** | Men | 0.002 | -0.009 | 0.001 | 0.001 | -0.011 | 0.006 |
| | Women | 0.005 | -0.015 | 0.009 | -0.002 | -0.014 | -0.004 |
| **…..NVQ Level 5 quals** | Men | -0.002 | 0.010 | -0.007 | -0.003 | 0.002 | 0.001 |
| | Women | -0.003 | -0.003 | -0.006 | -0.004 | 0.000 | -0.003 |

Notes: Calculations using the Quarterly Labour Force Survey pooled from 1993q1 to 2010q2.

**Table 4:** Treatment Matrix for the +/-3 year sample

**+/- 3 year window**

**Fathers**

**Mothers**

| | **Pre-Sample** | | **Pre-RoSLA** | | **Post-RoSLA** | | **Post-Sample** | | **Missing** | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pre-Sample** | | 262 | **0** | 46 | **1** | 23 | | 31 | 261 | **623** |
| **Pre-RoSLA** | **0** | 274 | **0** | 241 | **1** | 116 | **0** | 91 | **0** 450 | **1172** |
| **Post-RoSLA** | **1** | 287 | **1** | 351 | **2** | 505 | **1** | 298 | **1** 891 | **2332** |
| **Post-Sample** | | 314 | **0** | 369 | **1** | 1011 | | 4519 | 5514 | **11727** |
| **Missing** | | 21 | **0** | 6 | **1** | 8 | | 31 | 4046 | **4112** |
| **Total** | | **1158** | | **1013** | | **1663** | | **4970** | **11162** | **19966** |

| **Treatment** | 0 | 1 | 2 | **Total** |
|---|---|---|---|---|
| **N** | 1477 | 2985 | 505 | 4967 |

**Table 5**: The breakdown of treated versus untreated for parents whose age at child's birth does not map directly into treatment status

| | +/- 1 year window | | | +/- 3 year window or +/- 6 year window | | |
|---|---|---|---|---|---|---|
| | Untreated | Treated | Total | Untreated | Treated | Total |
| Mothers | 375 | 399 | 774 | 451 | 492 | 943 |
| | 48.45% | 51.55% | 100.00% | 47.83% | 52.17% | 100.00% |
| Fathers | 294 | 414 | 708 | 339 | 515 | 854 |
| | 41.53% | 58.47% | 100.00% | 39.70% | 60.30% | 100.00% |

Note: The 19 month range in parents' age at child's birth within which parents may be treated (born on or after 1st September 1957) or untreated (born prior to 1st September 1957) is not fully captured by the restriction that parents are born within +/- 1 year of September 1957. However, all parents whose age at child's birth places them in the 19 month range are born with +/- 3 years of September 1957, hence by definition they are all born within +/- 6 years of September 1957 and so the numbers of these samples are the same.

**Table 6:** Balancing tests of characteristics of treated versus non-treated parents

**Panel a**: Child and Grandparent characteristics

| | | +/-1 year window, means | | | 6 year bandwidth RDD estimates | | |
|---|---|---|---|---|---|---|---|
| | | Untreated | Treated | Diff. | Diff. | St. Err. | N |
| Mother age at first birth | Mother | 30.60 | 30.14 | -0.461 | 0.093 | 0.303 | 4820 |
| | | 310 | 369 | | | | |
| Birth order | Mother | 2.13 | 2.09 | -0.041 | 0.056 | 0.063 | 5770 |
| | | 380 | 451 | | | | |
| | Father | 1.99 | 1.96 | -0.024 | -0.014 | 0.056 | 5135 |
| | | 391 | 490 | | | | |
| # siblings | Mother | 1.45 | 1.57 | 0.123* | 0.110* | 0.057 | 3678 |
| | | 249 | 290 | | | | |
| | Father | 1.48 | 1.48 | -0.005 | 0.021 | 0.051 | 3388 |
| | | 259 | 329 | | | | |
| (Grand)mother education | Mother | 0.18 | 0.18 | -0.009 | -0.010 | 0.022 | 7515 |
| | | 488 | 600 | | | | |
| | Father | 0.18 | 0.19 | 0.010 | -0.005 | 0.023 | 5560 |
| | | 413 | 526 | | | | |
| (Grand)father education | Mother | 0.18 | 0.18 | -0.003 | -0.010 | 0.022 | 7515 |
| | | 488 | 600 | | | | |
| | Father | 0.18 | 0.21 | 0.026 | 0.015 | 0.023 | 5560 |
| | | 413 | 526 | | | | |
| Child IQ | Mother | 107.908 | 108.024 | 0.116 | -0.297 | 1.279 | 4098 |
| | | 272 | 338 | | | | |
| | Father | 108.32 | 106.207 | -2.113 | -1.693 | 1.189 | 3650 |
| | | 275 | 348 | | | | |
| Child "Performance IQ" | Mother | 102.04 | 102.425 | 0.384 | -0.434 | 1.324 | 4112 |
| | | 273 | 339 | | | | |
| | Father | 102.964 | 101.075 | -1.889 | -1.625 | 1.212 | 3658 |
| | | 275 | 348 | | | | |

* p<0.10, ** p<0.05, *** p<0.01

**Panel b**: Relationship characteristics

| | | 1 year window, means | | | 6 year bandwidth RDD estimates | | |
|---|---|---|---|---|---|---|---|
| | | Untreated | Treated | Diff. | Diff. | St. Err. | N |
| Difference in age between parents (months) | Mother | 14.13 | 20.67 | 6.545 | 3.713 | 4.053 | 4657 |
| | | 312 | 364 | | | | |
| | Father | 37.41 | 33.76 | -3.650 | 0.908 | 2.469 | 5544 |
| | | 412 | 525 | | | | |
| Same dad throughout childhood as for treatment DoB | Mother | 0.539 | 0.517 | -0.022 | -0.010 | 0.028 | 7515 |
| | | 488 | 600 | | | | |
| Mum's relationship changes after birth of child | Mother | 0.051 | 0.057 | 0.005 | 0.008 | 0.013 | 7515 |
| | | 488 | 600 | | | | |
| No information on mother's relationships | Mother | 0.410 | 0.427 | 0.017 | 0.002 | 0.027 | 7515 |
| | | 488 | 600 | | | | |
| Father of ALSPAC child has qualifications | Mother | 0.732 | 0.728 | -0.003 | -0.005 | 0.025 | 7515 |
| | | 488 | 600 | | | | |
| Father of ALSPAC child has O-levels | Mother | 0.555 | 0.575 | 0.020 | 0.023 | 0.028 | 7515 |
| | | 488 | 600 | | | | |
| Father of ALSPAC child has A-levels | Mother | 0.408 | 0.407 | -0.001 | 0.014 | 0.027 | 7515 |
| | | 488 | 600 | | | | |
| Father of ALSPAC child has above A-levels | Mother | 0.488 | 0.493 | 0.006 | 0.010 | 0.028 | 7515 |
| | | 488 | 600 | | | | |
| Mother of ALSPAC child has qualifications | Father | 0.903 | 0.918 | 0.015 | 0.026 | 0.018 | 5560 |
| | | 413 | 526 | | | | |
| Mother of ALSPAC child has O-levels | Father | 0.746 | 0.787 | 0.041 | 0.046* | 0.026 | 5560 |
| | | 413 | 526 | | | | |
| Mother of ALSPAC child has A-levels | Father | 0.383 | 0.411 | 0.028 | 0.037 | 0.029 | 5560 |
| | | 413 | 526 | | | | |
| Mother of ALSPAC child has above A-levels | Father | 0.462 | 0.494 | 0.032 | 0.034 | 0.030 | 5560 |
| | | 413 | 526 | | | | |

* p<0.10, ** p<0.05, *** p<0.01

**Table 7a:** Impact of RoSLA on parents' qualifications, main estimation sample: parents born in +/- 3year window around 1st September 1957

**Panel (a) Full sample**

| | (1)<br>Any qualifications | (2)<br>O levels | (3)<br>A Levels | (4)<br>Any qualifications | (5)<br>O levels | (6)<br>A Levels |
|---|---|---|---|---|---|---|
| RoSLA dummy | 0.044*** | 0.065*** | 0.028 | 0.039** | 0.060** | 0.009 |
| | (0.016) | (0.024) | (0.027) | (0.016) | (0.025) | (0.027) |
| Parent's DOB in months | 0.000 | -0.001* | -0.002*** | 0.017* | 0.002 | 0.031* |
| | (0.000) | (0.001) | (0.001) | (0.010) | (0.015) | (0.017) |
| Parent's DOB in months squared | | | | -0.002 | -0.001 | -0.006*** |
| | | | | (0.001) | (0.002) | (0.002) |
| Constant | 0.866*** | 0.734*** | 0.506*** | 0.844*** | 0.716*** | 0.432*** |
| | (0.010) | (0.016) | (0.018) | (0.017) | (0.026) | (0.029) |
| R-sq | 0.007 | 0.001 | 0.004 | 0.008 | 0.002 | 0.005 |
| Obs | 5512 | 5512 | 5512 | 5512 | 5512 | 5512 |

**Panel (b) Sample restricted to parents with less than A-level qualifications**

| | (1)<br>Any qualifications | (2)<br>O levels | (3)<br>Any qualifications | (4)<br>O levels |
|---|---|---|---|---|
| RoSLA dummy | 0.111*** | 0.116*** | 0.109*** | 0.121*** |
| | (0.033) | (0.041) | (0.034) | (0.042) |
| Parent's DOB in months | 0.001 | -0.001 | 0.001 | -0.002 |
| | (0.001) | (0.001) | (0.002) | (0.003) |
| Parent's DOB in months squared | | | -0.000 | 0.000 |
| | | | (0.000) | (0.000) |
| Constant | 0.680*** | 0.459*** | 0.672*** | 0.477*** |
| | (0.021) | (0.026) | (0.034) | (0.042) |
| R-sq | 0.025 | 0.008 | 0.025 | 0.008 |
| Obs | 2479 | 2479 | 2479 | 2479 |

**Table 7b:** Impact of RoSLA on parents' qualifications, RDD estimates of the effect of being born after 1st September 1957 and thus subject to RoSLA

**Panel (a) Full sample**

| | Any qualifications | O-levels | A-levels |
|---|---|---|---|
| Bandwidth 3 years | 0.040* | 0.063* | 0.014 |
| N=5512 | (0.017) | (0.025) | (0.027) |
| | | | |
| Bandwidth 6 years | 0.056*** | 0.049** | 0.014 |
| N=11429 | (0.012) | (0.018) | (0.020) |
| | | | |
| Bandwidth 10 years | 0.053*** | 0.065*** | 0.007 |
| N=17421 | (0.011) | (0.015) | (0.016) |

* p<0.10, ** p<0.05, *** p<0.01.

**Panel (b) Sample restricted to parents with less than A-level qualifications**

| | Any qualifications | O-levels |
|---|---|---|
| Bandwidth 3 years | 0.109** | 0.119** |
| N=2479 | (0.036) | (0.041) |
| | | |
| Bandwidth 6 years | 0.128*** | 0.090** |
| N=5685 | (0.026) | (0.030) |
| | | |
| Bandwidth 10 years | 0.128*** | 0.114*** |
| N=9747 | (0.022) | (0.025) |

* p<0.10, ** p<0.05, *** p<0.01.

**Table 8:** The impact of RoSLA on child Key Stage 4 (age 16) outcomes, three windows around the policy change

| | 1 year window | | | 3 year window | | | 6 year window | | |
|---|---|---|---|---|---|---|---|---|---|
| | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total |
| RoSLA Treatment of mother | 25.702*** | 19.359** | 13.280** | 11.731* | 13.402** | 7.519* | 10.697* | 14.565** | 7.651* |
| | (9.789) | (9.252) | (6.219) | (6.480) | (6.298) | (4.346) | (5.816) | (5.756) | (3.940) |
| RoSLA Treatment of father | 22.345** | 17.866* | 9.213 | 16.077*** | 14.918*** | 9.637** | 19.245*** | 18.101*** | 9.026*** |
| | (9.595) | (9.426) | (6.700) | (5.860) | (5.705) | (3.975) | (4.357) | (4.209) | (2.898) |
| Mother's age at child's birth: | 7.130*** | 7.829*** | 5.193*** | 5.252*** | 6.063*** | 4.172*** | 3.946*** | 4.852*** | 3.016*** |
| pre-window | (2.195) | (1.950) | (1.289) | (1.204) | (1.193) | (0.850) | (0.991) | (0.921) | (0.652) |
| Mother's age at child's birth: | 8.241*** | 9.272*** | 5.693*** | 6.283*** | 6.884*** | 4.574*** | 4.282*** | 5.750*** | 3.830*** |
| in window | (2.281) | (2.022) | (1.323) | (1.232) | (1.196) | (0.850) | (0.757) | (0.757) | (0.521) |
| Mother's age at child's birth: | 8.635*** | 9.391*** | 6.026*** | 6.749*** | 7.051*** | 4.783*** | 3.983*** | 5.569*** | 3.678*** |
| post-window | (2.592) | (2.300) | (1.505) | (1.520) | (1.479) | (1.057) | (1.046) | (1.048) | (0.723) |
| Father's age at child's birth: | 0.553* | 0.882*** | 0.430** | 0.211 | 0.318 | 0.271** | 0.244 | 0.331* | 0.19 |
| pre-window | (0.320) | (0.308) | (0.196) | (0.211) | (0.202) | (0.132) | (0.205) | (0.187) | (0.122) |
| Father's age at child's birth: | 1.211*** | 1.486*** | 0.772*** | 1.056*** | 1.289*** | 0.783*** | 0.909*** | 1.086*** | 0.705*** |
| in window | (0.436) | (0.420) | (0.297) | (0.207) | (0.202) | (0.136) | (0.143) | (0.140) | (0.093) |
| Father's age at child's birth: | 1.125** | 1.286*** | 0.612* | 0.369 | 0.589* | 0.289 | -0.382 | -0.33 | -0.164 |
| post-window | (0.465) | (0.448) | (0.317) | (0.328) | (0.324) | (0.226) | (0.348) | (0.321) | (0.215) |
| R squared | 0.095 | 0.114 | 0.150 | 0.095 | 0.101 | 0.136 | 0.089 | 0.103 | 0.135 |
| Obs | 1523 | 1531 | 1481 | 4094 | 4116 | 3985 | 7570 | 7621 | 7378 |
| Outcome Mean | 430.9 | 358.02 | 243.09 | 423.76 | 347.42 | 235.87 | 416.82 | 337.31 | 227.91 |
| Outcome SD | 145.65 | 141.86 | 97.05 | 146.29 | 143.2 | 98.07 | 147.87 | 144.32 | 97.41 |
| Treatment as % of SD (mum only) | 17.65 | 13.65 | 13.68 | 8.02 | 9.36 | 7.67 | 7.23 | 10.09 | 7.85 |
| Treatment as % of SD (dad only) | 15.34 | 12.59 | 9.49 | 10.99 | 10.42 | 9.83 | 13.02 | 12.54 | 9.27 |
| Treatment as % of SD (both) | 32.99 | 26.24 | 23.18 | 19.01 | 19.78 | 17.49 | 20.25 | 22.64 | 17.12 |
| Treatment joint significance p-value | 0.003 | 0.019 | 0.039 | 0.003 | 0.002 | 0.009 | 0.000 | 0.000 | 0.001 |

* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy.

**Table 9:** The impact of RoSLA on outcomes throughout childhood, +/- 3 year window

| | Fine Motor Skills (18 and 30 months) | Gross Motor Skills (18 and 30 months) | IQ, aged 8 | Fluid IQ, aged 8 | Entry Assessment Score | Key Stage 1 Score | Key Stage 2 Score | Key Stage 3 Score |
|---|---|---|---|---|---|---|---|---|
| RoSLA Treatment of mother | 0.154 | -1.056** | 0.682 | 0.887 | 0.310** | 0.330** | 1.116** | 1.440 |
| | (0.425) | (0.469) | (0.869) | (0.895) | (0.151) | (0.167) | (0.537) | (0.949) |
| RoSLA Treatment of father | 0.483 | -0.026 | -0.068 | 0.077 | 0.022 | 0.393** | 0.650 | 1.806** |
| | (0.361) | (0.422) | (0.792) | (0.816) | (0.146) | (0.155) | (0.467) | (0.859) |
| Mother's age at child's birth: | 0.004 | -0.245*** | 0.683*** | 0.616*** | 0.098*** | 0.109*** | 0.454*** | 0.714*** |
| pre-window | (0.072) | (0.071) | (0.147) | (0.148) | (0.027) | (0.031) | (0.101) | (0.174) |
| Mother's age at child's birth: | 0.011 | -0.222*** | 0.763*** | 0.707*** | 0.101*** | 0.128*** | 0.532*** | 0.833*** |
| in window | (0.073) | (0.067) | (0.146) | (0.147) | (0.024) | (0.030) | (0.101) | (0.175) |
| Mother's age at child's birth: | 0.026 | -0.247*** | 0.785*** | 0.776*** | 0.120*** | 0.141*** | 0.572*** | 0.890*** |
| post-window | (0.090) | (0.082) | (0.181) | (0.181) | (0.030) | (0.038) | (0.125) | (0.217) |
| Father's age at child's birth: | 0.023 | 0.003 | 0.063** | 0.051* | 0.007 | 0.014*** | 0.037** | 0.048 |
| pre-window | (0.014) | (0.017) | (0.028) | (0.029) | (0.005) | (0.005) | (0.017) | (0.031) |
| Father's age at child's birth: | 0.041*** | 0.011 | 0.147*** | 0.124*** | 0.021*** | 0.024*** | 0.113*** | 0.174*** |
| in window | (0.014) | (0.017) | (0.029) | (0.030) | (0.005) | (0.005) | (0.016) | (0.030) |
| Father's age at child's birth: | 0.042** | 0.053** | 0.089* | 0.091* | 0.009 | 0.011 | 0.066** | 0.085* |
| post-window | (0.021) | (0.026) | (0.047) | (0.048) | (0.008) | (0.008) | (0.027) | (0.048) |
| R squared | 0.036 | 0.011 | 0.056 | 0.039 | 0.181 | 0.147 | 0.090 | 0.098 |
| Obs | 4209 | 4208 | 2877 | 2886 | 3123 | 3791 | 4253 | 3639 |
| Outcome Mean | 82.64 | 83.59 | 106.66 | 101.22 | 21.15 | 9.68 | 85.73 | 109.81 |
| Outcome SD | 9.42 | 10.91 | 16.62 | 17.13 | 3.29 | 3.74 | 12.13 | 20.13 |
| Treatment as % of SD (mum only) | 1.64 | -9.68 | 4.10 | 5.18 | 9.45 | 8.82 | 9.20 | 7.15 |
| Treatment as % of SD (dad only) | 5.13 | -0.24 | -0.41 | 0.45 | 0.67 | 10.50 | 5.36 | 8.97 |
| Treatment as % of SD (both) | 6.76 | -9.92 | 3.69 | 5.63 | 10.11 | 19.33 | 14.56 | 16.12 |
| Treatment joint significance p-value | 0.367 | 0.074 | 0.735 | 0.598 | 0.115 | 0.003 | 0.030 | 0.025 |

* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy. Child age in months is included as an additional covariate for the early development scores.

**Table 10:** The impact of RoSLA on child English/literacy and Maths outcomes throughout childhood, +/-3 year sample window

| | Entry Assessment Literacy | Key Stage 1 Literacy Score | Key Stage 2 English Score | Key Stage 3 English Score | English Language GCSE | Entry Assessment Maths | Key Stage 1 Maths Score | Key Stage 2 Maths Score | Key Stage 3 Maths Score | Maths GCSE |
|---|---|---|---|---|---|---|---|---|---|---|
| RoSLA Treatment of mother | 0.108*** | 0.115* | 0.332 | 1.001 | 0.476 | 0.049 | 0.103* | 0.396* | 0.410 | 0.890* |
| | (0.036) | (0.059) | (0.210) | (0.826) | (0.418) | (0.051) | (0.059) | (0.212) | (0.999) | (0.527) |
| RoSLA Treatment of father | 0.002 | 0.127** | 0.248 | 1.470* | 0.800** | 0.000 | 0.131** | 0.320* | 2.009** | 1.359*** |
| | (0.035) | (0.054) | (0.187) | (0.758) | (0.362) | (0.051) | (0.057) | (0.194) | (1.007) | (0.455) |
| Mother's age at child's birth: | 0.024*** | 0.033*** | 0.153*** | 0.672*** | 0.312*** | 0.028*** | 0.042*** | 0.159*** | 0.355** | 0.348*** |
| pre-window | (0.006) | (0.011) | (0.040) | (0.149) | (0.075) | (0.009) | (0.010) | (0.038) | (0.159) | (0.104) |
| Mother's age at child's birth: | 0.025*** | 0.038*** | 0.189*** | 0.671*** | 0.331*** | 0.030*** | 0.050*** | 0.184*** | 0.522*** | 0.416*** |
| in window | (0.006) | (0.011) | (0.040) | (0.153) | (0.076) | (0.008) | (0.010) | (0.038) | (0.150) | (0.102) |
| Mother's age at child's birth: | 0.031*** | 0.042*** | 0.202*** | 0.685*** | 0.328*** | 0.033*** | 0.056*** | 0.199*** | 0.500*** | 0.436*** |
| post-window | (0.007) | (0.013) | (0.050) | (0.190) | (0.094) | (0.010) | (0.012) | (0.047) | (0.187) | (0.127) |
| Father's age at child's birth: | 0.002 | 0.006*** | 0.008 | 0.054** | 0.033** | 0.001 | 0.003 | 0.015** | 0.058* | 0.015 |
| pre-window | (0.001) | (0.002) | (0.007) | (0.027) | (0.014) | (0.002) | (0.002) | (0.007) | (0.034) | (0.016) |
| Father's age at child's birth: | 0.005*** | 0.009*** | 0.038*** | 0.129*** | 0.069*** | 0.006*** | 0.006*** | 0.038*** | 0.101*** | 0.073*** |
| in window | (0.001) | (0.002) | (0.006) | (0.026) | (0.013) | (0.002) | (0.002) | (0.007) | (0.034) | (0.016) |
| Father's age at child's birth: | 0.005** | 0.005 | 0.011 | 0.014 | 0.014 | -0.002 | 0.002 | 0.022* | 0.074 | 0.003 |
| post-window | (0.002) | (0.003) | (0.010) | (0.040) | (0.022) | (0.003) | (0.003) | (0.011) | (0.052) | (0.028) |
| R squared | 0.167 | 0.142 | 0.099 | 0.109 | 0.095 | 0.134 | 0.133 | 0.065 | 0.049 | 0.069 |
| Obs | 3122 | 3789 | 4224 | 3442 | 3931 | 3120 | 3786 | 4217 | 3536 | 3837 |
| Outcome Mean | 5.06 | 3.14 | 28.01 | 49.06 | 42.43 | 5.40 | 3.40 | 28.05 | 84.52 | 40.84 |
| Outcome SD | 0.79 | 1.30 | 4.76 | 17.02 | 9.10 | 1.11 | 1.36 | 4.87 | 21.95 | 11.00 |
| Treatment as % of SD (mum only) | 13.78 | 8.79 | 6.97 | 5.88 | 5.23 | 4.45 | 7.56 | 8.13 | 1.87 | 8.09 |
| Treatment as % of SD (dad only) | 0.30 | 9.77 | 5.21 | 8.64 | 8.79 | 0.01 | 9.65 | 6.56 | 9.16 | 12.35 |
| Treatment as % of SD (both) | 14.08 | 18.56 | 12.18 | 14.52 | 14.02 | 4.45 | 17.21 | 14.69 | 11.02 | 20.44 |
| Treatment joint significance p-value | 0.011 | 0.005 | 0.087 | 0.059 | 0.036 | 0.628 | 0.011 | 0.031 | 0.118 | 0.002 |

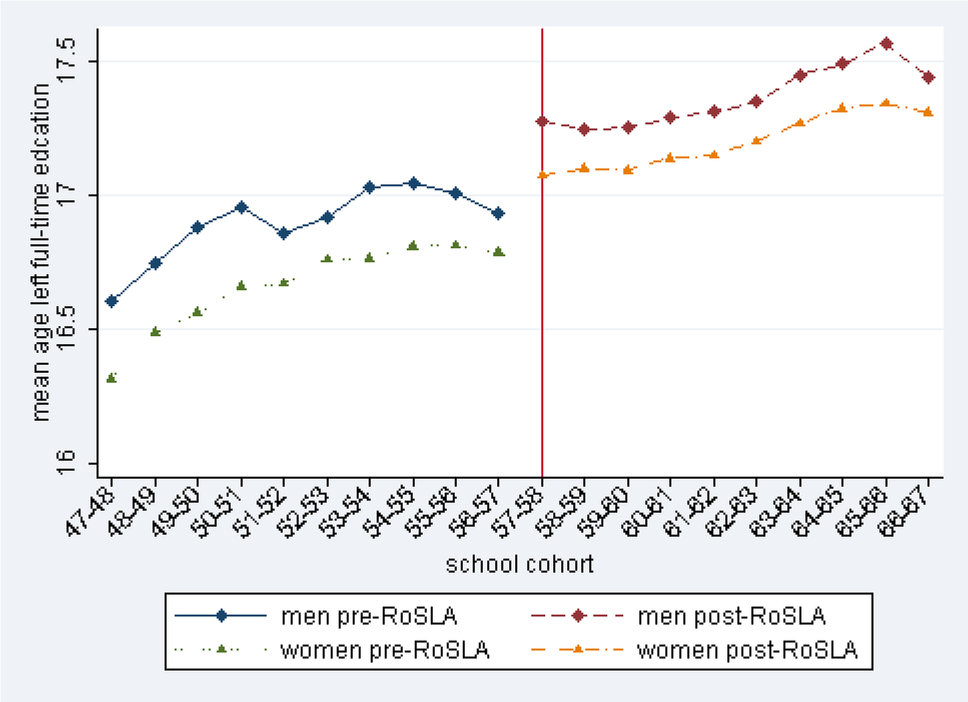
* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy.

**Table 11:** The impact of RoSLA on child Key Stage 4 (age 16) outcomes, parents with lower levels of education, +/-3 year sample window

| | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total |
|---|---|---|---|
| RoSLA Treatment of mother | 17.010** | 16.209** | 4.991 |
| | (7.872) | (7.481) | (4.857) |
| RoSLA Treatment of father | 27.647*** | 18.173** | 10.813** |
| | (8.850) | (8.052) | (5.349) |
| Mother has A levels, equivalent or higher | 73.829*** | 90.560*** | 53.508*** |
| | (9.805) | (8.880) | (6.426) |
| Father has A levels, equivalent or higher | 59.797*** | 70.904*** | 47.670*** |
| | (8.529) | (7.972) | (5.246) |
| Mother's age at child's birth: | 3.418** | 3.219** | 1.811** |
| pre-window | (1.369) | (1.336) | (0.862) |
| Mother's age at child's birth: | 5.150*** | 4.794*** | 2.742*** |
| in window | (1.371) | (1.344) | (0.850) |
| Mother's age at child's birth: | 6.147*** | 5.657*** | 3.367*** |
| post-window | (1.670) | (1.650) | (1.050) |
| Father's age at child's birth: | -0.124 | -0.117 | 0.116 |
| pre-window | (0.296) | (0.266) | (0.164) |
| Father's age at child's birth: | 0.227 | 0.245 | 0.105 |
| in window | (0.284) | (0.263) | (0.166) |
| Father's age at child's birth: | 0.154 | 0.424 | 0.219 |
| post-window | (0.410) | (0.399) | (0.272) |
| R squared | 0.108 | 0.118 | 0.163 |
| Obs | 2452 | 2467 | 2359 |
| Outcome Mean | 385.52 | 302.04 | 205.03 |
| Outcome SD | 147.43 | 138.85 | 90.97 |
| Treatment as % of SD (mum only) | 11.54 | 11.67 | 5.49 |
| Treatment as % of SD (dad only) | 18.75 | 13.09 | 11.89 |
| Treatment as % of SD (both) | 30.29 | 24.76 | 17.37 |
| Treatment joint significance p-value | 0.001 | 0.010 | 0.083 |

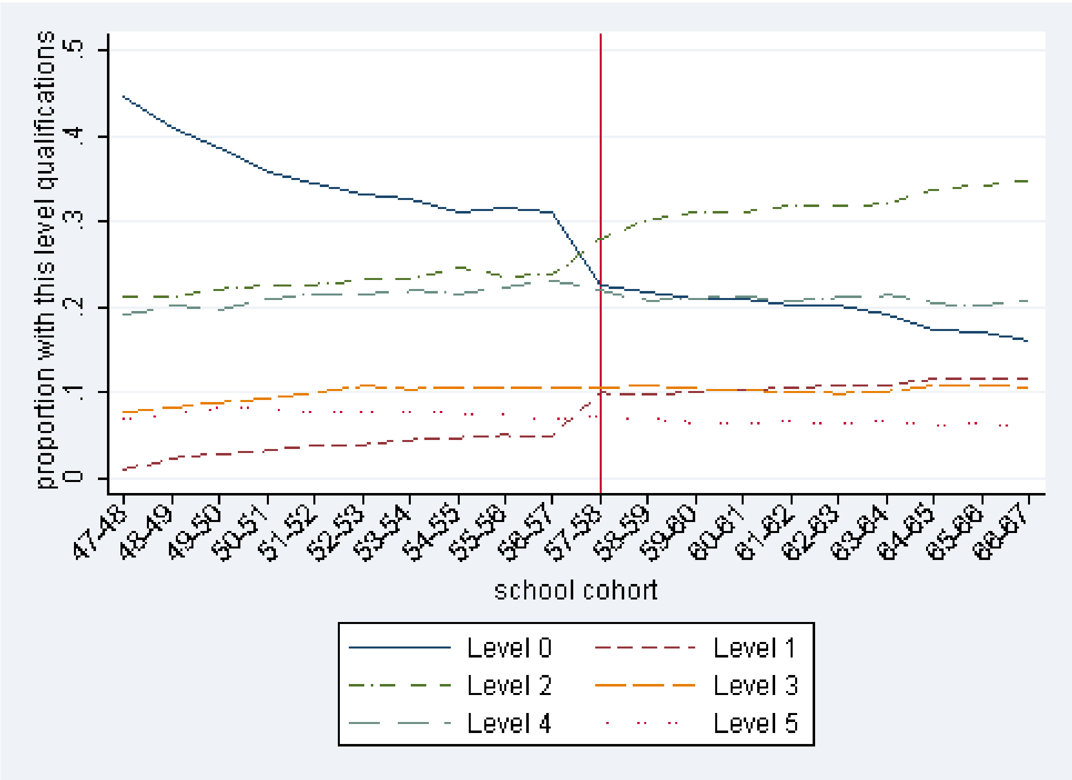
* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy.

**Figure 1:** Mean age left full-time education, by birth (school) cohort and sex



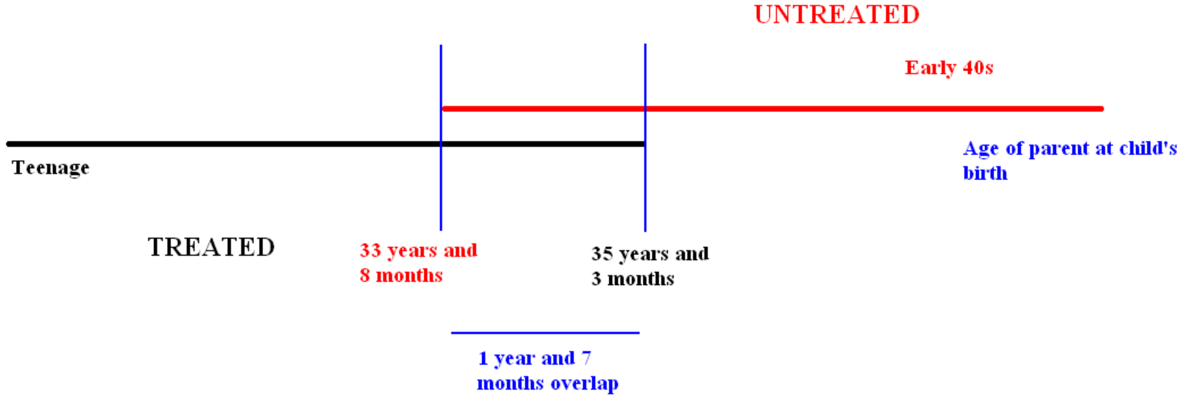

Source: Quarterly Labour Force Survey, pooled 1993q1 to 2010q2

**Figure 2** Qualification Attainment Levels in NVQ equivalence scale, by birth (school) cohort




Source: Quarterly Labour Force Survey, pooled 1993q1 to 2010q2

**Figure 3:** Schematic representation of the overlap in age range for treated and untreated parents



**APPENDIX**

**Table A.1:** Regression Discontinuity estimates of the impact of RoSLA on child Key Stage 4 (age 16) outcomes**, Mothers,** various bandwidths

| Bandwidth | | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total |
|---|---|---|---|---|
| 1-year | Coeff. | 18.974 | -0.759 | 7.629 |
| | Std. Err. | (22.626) | (21.296) | (14.389) |
| | N | 865 | 868 | 842 |
| 2-year | Coeff. | 25.923* | 5.594 | 7.513 |
| | Std. Err. | (15.675) | (14.759) | (10.049) |
| | N | 1863 | 1870 | 1814 |
| 3-year | Coeff. | 21.539* | 6.806 | 7.343 |
| | Std. Err. | (12.797) | (12.112) | (8.302) |
| | N | 2856 | 2870 | 2774 |
| 4-year | Coeff. | 15.949 | 5.644 | 7.276 |
| | Std. Err. | (11.013) | (10.521) | (7.229) |
| | N | 3904 | 3930 | 3800 |
| 5-year | Coeff. | 12.921 | 6.12 | 6.77 |
| | Std. Err. | (9.849) | (9.483) | (6.515) |
| | N | 5028 | 5062 | 4896 |
| 6-year | Coeff. | 12.577 | 7.19 | 6.869 |
| | Std. Err. | (9.095) | (8.798) | (6.036) |
| | N | 6188 | 6229 | 6025 |

*Notes: RDD estimated using local linear regressions either side of the discontinuity, rectangular kernel.*

**Table A.2:** Regression Discontinuity estimates of the impact of RoSLA on child Key Stage 4 (age 16) outcomes, **Fathers**, various bandwidths

| Bandwidth | | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total |
|---|---|---|---|---|
| 1-year | Coeff. | 14.547 | 25.608 | 33.659** |
| | Std. Err. | (22.905) | (21.303) | (15.179) |
| | N | 796 | 800 | 777 |
| 2-year | Coeff. | 19.172 | 19.242 | 15.628 |
| | Std. Err. | (15.843) | (15.268) | (10.859) |
| | N | 1561 | 1570 | 1530 |
| 3-year | Coeff. | 16.469 | 12.09 | 8.79 |
| | Std. Err. | (12.787) | (12.521) | (8.910) |
| | N | 2292 | 2303 | 2252 |
| 4-year | Coeff. | 15.563 | 9.893 | 6.73 |
| | Std. Err. | (11.069) | (10.954) | (7.811) |
| | N | 3151 | 3164 | 3099 |
| 5-year | Coeff. | 16.293 | 9.752 | 6.399 |
| | Std. Err. | (9.935) | (9.888) | (7.057) |
| | N | 3937 | 3953 | 3872 |
| 6-year | Coeff. | 15.783* | 9.483 | 6.147 |
| | Std. Err. | (9.110) | (9.095) | (6.487) |
| | N | 4710 | 4729 | 4633 |

*Notes: RDD estimated using local linear regressions either side of the discontinuity, rectangular kernel.*

**Appendix Table A.3:** The impact of RoSLA on child outcomes throughout childhood, parents with lower levels of education, +/-3 year sample window

| | Fine Motor Skills (18 and 30 months) | Gross Motor Skills (18 and 30 months) | IQ, aged 8 | Fluid IQ, aged 8 | Entry Assessment Score | Key Stage 1 Score | Key Stage 2 Score | Key Stage 3 Score |
|---|---|---|---|---|---|---|---|---|
| RoSLA Treatment of | -0.128 | -1.149* | -0.642 | -0.426 | 0.148 | 0.353* | 0.784 | 1.123 |
| mother | (0.621) | (0.662) | (1.173) | (1.242) | (0.182) | (0.205) | (0.664) | (1.098) |
| RoSLA Treatment of | 0.829 | -0.616 | 0.652 | 0.998 | 0.201 | 0.690*** | 1.014 | 1.897 |
| father | (0.566) | (0.669) | (1.213) | (1.287) | (0.208) | (0.224) | (0.740) | (1.237) |
| Mother has A levels, | 1.872*** | -1.741** | 8.162*** | 7.543*** | 1.256*** | 1.681*** | 5.886*** | 9.727*** |
| equivalent or higher | (0.629) | (0.756) | (1.308) | (1.388) | (0.246) | (0.251) | (0.781) | (1.363) |
| Father has A levels, | 2.470*** | 0.607 | 6.084*** | 4.625*** | 0.785*** | 1.460*** | 5.180*** | 9.424*** |
| equivalent or higher | (0.569) | (0.668) | (1.177) | (1.235) | (0.204) | (0.218) | (0.694) | (1.188) |
| Mother's age at child's birth: | -0.011 | -0.143 | 0.493*** | 0.527*** | 0.052 | 0.041 | 0.241** | 0.425** |
| pre-window | (0.107) | (0.092) | (0.183) | (0.175) | (0.034) | (0.036) | (0.117) | (0.194) |
| Mother's age at child's birth: | -0.03 | -0.217** | 0.489*** | 0.473*** | 0.052* | 0.080** | 0.316*** | 0.539*** |
| in window | (0.102) | (0.085) | (0.173) | (0.172) | (0.029) | (0.036) | (0.112) | (0.188) |
| Mother's age at child's birth: | -0.018 | -0.233** | 0.571*** | 0.582*** | 0.064* | 0.098** | 0.388*** | 0.688*** |
| post-window | (0.124) | (0.102) | (0.209) | (0.208) | (0.035) | (0.045) | (0.136) | (0.231) |
| Father's age at child's birth: | 0.02 | -0.016 | 0.019 | 0.017 | -0.002 | 0.004 | 0.010 | -0.010 |
| pre-window | (0.021) | (0.025) | (0.041) | (0.044) | (0.007) | (0.007) | (0.025) | (0.042) |
| Father's age at child's birth: | 0.044** | 0.050** | -0.009 | -0.001 | 0.009 | 0.000 | 0.031 | 0.027 |
| in window | (0.021) | (0.024) | (0.041) | (0.045) | (0.007) | (0.007) | (0.023) | (0.039) |
| Father's age at child's birth: | 0.056* | 0.082** | 0.031 | 0.051 | 0.010 | 0.005 | 0.029 | 0.040 |
| post-window | (0.030) | (0.035) | (0.063) | (0.069) | (0.010) | (0.011) | (0.036) | (0.058) |
| R squared | 0.045 | 0.026 | 0.088 | 0.066 | 0.175 | 0.148 | 0.088 | 0.104 |
| Obs | 2186 | 2185 | 1373 | 1381 | 2008 | 2358 | 2498 | 2285 |
| Outcome Mean | 81.69 | 83.91 | 101.38 | 97.31 | 20.48 | 8.82 | 82.27 | 104.17 |
| Outcome SD | 10.00 | 11.44 | 16.10 | 17.11 | 3.27 | 3.73 | 12.43 | 19.70 |
| Treatment % of SD (mum) | -1.28 | -10.04 | -3.99 | -2.49 | 4.53 | 9.45 | 6.31 | 5.70 |
| Treatment % of SD (dad) | 8.29 | -5.39 | 4.05 | 5.83 | 6.15 | 18.49 | 8.16 | 9.63 |
| Treatment % of SD (both) | 7.01 | -15.43 | 0.06 | 3.34 | 10.68 | 27.94 | 14.47 | 15.32 |
| T'ment joint signif p-value | 0.316 | 0.159 | 0.740 | 0.688 | 0.473 | 0.003 | 0.196 | 0.199 |

* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: see Table 9.

**Appendix Table A.4:** The impact of RoSLA on child English/literacy and Maths outcomes, parents with lower levels of education, +/-3 year sample window

| | Entry Assessment Literacy | Key Stage 1 Literacy Score | Key Stage 2 English Score | Key Stage 3 English Score | English Language GCSE | Entry Assessment Maths | Key Stage 1 Maths Score | Key Stage 2 Maths Score | Key Stage 3 Maths Score | Maths GCSE |
|---|---|---|---|---|---|---|---|---|---|---|
| RoSLA Treatment of mother | 0.088** | 0.112 | 0.011 | 0.39 | 0.409 | 0.009 | 0.130* | 0.326 | -0.370 | 0.743 |
| | (0.044) | (0.071) | (0.265) | (0.944) | (0.517) | (0.062) | (0.075) | (0.266) | (1.206) | (0.625) |
| RoSLA Treatment of father | 0.072 | 0.230*** | 0.243 | 1.588 | 0.567 | 0.055 | 0.222*** | 0.596** | 1.536 | 1.853*** |
| | (0.050) | (0.078) | (0.295) | (1.063) | (0.550) | (0.072) | (0.083) | (0.302) | (1.434) | (0.680) |
| Mother has A levels, equivalent or higher | 0.273*** | 0.554*** | 1.881*** | 7.080*** | 4.641*** | 0.419*** | 0.573*** | 2.054*** | 6.065*** | 5.573*** |
| | (0.059) | (0.088) | (0.312) | (1.188) | (0.573) | (0.087) | (0.095) | (0.337) | (1.646) | (0.729) |
| Father has A levels, equivalent or higher | 0.182*** | 0.494*** | 1.615*** | 6.321*** | 3.321*** | 0.298*** | 0.488*** | 2.011*** | 9.454*** | 5.795*** |
| | (0.049) | (0.076) | (0.273) | (1.007) | (0.561) | (0.069) | (0.081) | (0.287) | (1.317) | (0.633) |
| Mother's age at child's birth: | 0.016** | 0.006 | 0.079* | 0.274* | 0.132 | 0.011 | 0.030** | 0.096** | 0.136 | 0.14 |
| pre-window | (0.008) | (0.012) | (0.047) | (0.165) | (0.095) | (0.011) | (0.013) | (0.046) | (0.203) | (0.132) |
| Mother's age at child's birth: | 0.015** | 0.021* | 0.115** | 0.366** | 0.200** | 0.013 | 0.036*** | 0.111*** | 0.279 | 0.277** |
| in window | (0.007) | (0.013) | (0.048) | (0.169) | (0.083) | (0.009) | (0.012) | (0.043) | (0.178) | (0.115) |
| Mother's age at child's birth: | 0.019** | 0.026* | 0.134** | 0.428** | 0.241** | 0.014 | 0.045*** | 0.140*** | 0.373* | 0.345** |
| post-window | (0.008) | (0.016) | (0.059) | (0.209) | (0.101) | (0.012) | (0.015) | (0.052) | (0.220) | (0.141) |
| Father's age at child's birth: | 0.000 | 0.003 | 0.004 | 0.023 | 0.024 | -0.002 | -0.002 | -0.002 | -0.035 | -0.014 |
| pre-window | (0.002) | (0.003) | (0.010) | (0.035) | (0.020) | (0.002) | (0.003) | (0.010) | (0.044) | (0.022) |
| Father's age at child's birth: | 0.003* | 0.001 | 0.015 | 0.021 | 0.018 | 0.002 | -0.002 | 0.003 | -0.038 | -0.012 |
| in window | (0.002) | (0.002) | (0.009) | (0.033) | (0.017) | (0.002) | (0.003) | (0.010) | (0.044) | (0.021) |
| Father's age at child's birth: | 0.005** | 0.003 | 0.002 | -0.038 | 0.005 | -0.002 | -0.002 | 0.001 | 0.014 | -0.038 |
| post-window | (0.002) | (0.004) | (0.014) | (0.048) | (0.028) | (0.004) | (0.004) | (0.015) | (0.063) | (0.036) |
| R squared | 0.167 | 0.144 | 0.099 | 0.128 | 0.114 | 0.126 | 0.134 | 0.067 | 0.052 | 0.09 |
| Obs | 2007 | 2356 | 2479 | 2119 | 2316 | 2005 | 2353 | 2476 | 2203 | 2313 |
| Outcome Mean | 4.92 | 2.85 | 26.79 | 44.62 | 39.69 | 5.18 | 3.13 | 26.84 | 80.23 | 37.58 |
| Outcome SD | 0.79 | 1.30 | 4.87 | 16.26 | 9.24 | 1.09 | 1.37 | 5.00 | 21.43 | 10.98 |
| Treatment as % of SD (mum only) | 11.17 | 8.61 | 0.22 | 2.40 | 4.43 | 0.84 | 9.46 | 6.52 | -1.73 | 6.76 |
| Treatment as % of SD (dad only) | 9.12 | 17.70 | 4.98 | 9.77 | 6.13 | 5.06 | 16.17 | 11.91 | 7.17 | 16.88 |
| Treatment as % of SD (both) | 20.29 | 26.32 | 5.19 | 12.16 | 10.56 | 5.89 | 25.63 | 18.43 | 5.45 | 23.64 |
| Treatment joint significance p-value | 0.060 | 0.005 | 0.711 | 0.307 | 0.433 | 0.741 | 0.008 | 0.075 | 0.524 | 0.014 |

* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy.

**Table A.5:** Estimates of the impact of RoSLA treatment on child Key Stage 4 (age 16) outcomes, combined treatment variable, all and lower educated parents

| | All parents | | | Parents with lower education | | |
|---|---|---|---|---|---|---|
| | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total | Key Stage 4 Score | GCSE Total Score | GCSE Academic Total |
| RoSLA Treatment (0,1,2 parents treated) | 30.192*** | 16.210*** | 20.516*** | 41.376*** | 21.478*** | 19.875*** |
| | (6.601) | (6.263) | (4.408) | (8.454) | (7.508) | (5.196) |
| Mother has A levels, equivalent or higher | | | | 81.674*** | 90.216*** | 59.323*** |
| | | | | (9.721) | (8.892) | (6.650) |
| Father has A levels, equivalent or higher | | | | 59.471*** | 69.416*** | 47.863*** |
| | | | | (8.801) | (8.047) | (5.463) |
| Mother's age at child's birth: | 7.788 | -0.483 | -3.02 | 26.437 | 10.323 | -3.163 |
| pre-window | (12.073) | (13.288) | (10.064) | (22.790) | (21.707) | (12.997) |
| Mother's age at child's birth: | 12.371*** | 7.337*** | 9.458*** | 13.452*** | 6.552*** | 8.246*** |
| in window | (2.198) | (2.088) | (1.452) | (2.588) | (2.340) | (1.578) |
| Mother's age at child's birth: | 10.288*** | 11.490*** | 8.952*** | 8.242*** | 8.958*** | 5.892*** |
| post-window | (1.691) | (1.607) | (1.096) | (2.119) | (1.869) | (1.309) |
| Father's age at child's birth: | -2.539 | -1.932 | -1.622 | -1.213 | -0.526 | -0.628 |
| pre-window | (1.887) | (1.602) | (1.000) | (2.638) | (2.056) | (1.252) |
| Father's age at child's birth: | 4.640** | 1.404 | 3.588** | 3.836 | 0.833 | 2.027 |
| in window | (2.256) | (2.142) | (1.533) | (2.735) | (2.503) | (1.737) |
| Father's age at child's birth: | 18.739*** | 18.790*** | 11.793*** | 12.050*** | 12.640*** | 6.690*** |
| post-window | (3.269) | (3.026) | (2.132) | (3.938) | (3.568) | (2.405) |
| R squared | 0.098 | 0.106 | 0.083 | 0.102 | 0.119 | 0.102 |
| Obs | 4094 | 4116 | 3985 | 2452 | 2467 | 2359 |
| Outcome Mean | 423.76 | 347.42 | 235.87 | 385.52 | 302.04 | 205.03 |
| Outcome SD | 146.29 | 143.20 | 98.07 | 147.43 | 138.85 | 90.97 |
| Treatment as % of SD | 20.64 | 11.32 | 20.92 | 28.06 | 15.47 | 21.85 |

* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy.

**Table A.6:** Estimates of the impact of RoSLA treatment on child outcomes throughout childhood, combined treatment variable

| | Fine Motor Skills (18 and 30 months) | Gross Motor Skills (18 and 30 months) | IQ, aged 8 | Fluid IQ, aged 8 | Entry Assessment Score | Key Stage 1 Score | Key Stage 2 Score | Key Stage 3 Score |
|---|---|---|---|---|---|---|---|---|
| RoSLA Treatment | -0.286 | -0.607 | 0.404 | 0.361 | 0.532*** | 0.765*** | 1.424*** | 2.250** |
| (0,1,2 parents treated) | (0.431) | (0.509) | (0.885) | (0.901) | (0.165) | (0.171) | (0.525) | (0.963) |
| Mother's age at child's birth: | 0.637 | 1.334* | 0.566 | 1.579 | -0.107 | 0.019 | -0.471 | 0.428 |
| pre-window | (0.754) | (0.774) | (2.085) | (2.171) | (0.485) | (0.460) | (1.111) | (1.984) |
| Mother's age at child's birth: | -0.033 | -0.007 | 0.744** | 0.603** | 0.185*** | 0.264*** | 0.634*** | 1.024*** |
| in window | (0.143) | (0.188) | (0.296) | (0.307) | (0.056) | (0.056) | (0.178) | (0.325) |
| Mother's age at child's birth: | -0.056 | -0.325** | 0.881*** | 0.840*** | 0.223*** | 0.212*** | 1.016*** | 1.326*** |
| post-window | (0.111) | (0.128) | (0.240) | (0.243) | (0.042) | (0.044) | (0.146) | (0.240) |
| Father's age at child's birth: | 0.001 | -0.163 | -0.116 | -0.161 | -0.049 | 0.017 | 0.006 | -0.185 |
| pre-window | (0.098) | (0.116) | (0.220) | (0.236) | (0.057) | (0.051) | (0.136) | (0.233) |
| Father's age at child's birth: | -0.311** | -0.269* | 0.243 | 0.137 | 0.147** | 0.118** | 0.318* | 0.236 |
| in window | (0.138) | (0.152) | (0.313) | (0.324) | (0.057) | (0.058) | (0.173) | (0.317) |
| Father's age at child's birth: | -0.01 | -0.454** | 1.308** | 1.409*** | 0.284*** | 0.409*** | 1.436*** | 2.727*** |
| post-window | (0.192) | (0.227) | (0.522) | (0.505) | (0.090) | (0.077) | (0.269) | (0.466) |
| R squared | 0.035 | 0.019 | 0.035 | 0.028 | 0.1 | 0.108 | 0.083 | 0.094 |
| Obs | 4209 | 4208 | 2877 | 2886 | 3123 | 3791 | 4253 | 3639 |
| Outcome Mean | 82.64 | 83.59 | 106.66 | 101.22 | 21.15 | 9.68 | 85.73 | 109.81 |
| Outcome SD | 9.42 | 10.91 | 16.62 | 17.13 | 3.29 | 3.74 | 12.13 | 20.13 |
| Treatment as % of SD | -3.04 | -5.56 | 2.43 | 2.11 | 16.20 | 20.44 | 11.74 | 11.18 |

* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy. Child age in months is included as an additional covariate for the early development scores.

**Table A.7:** Estimates of the impact of RoSLA treatment on child outcomes throughout childhood, combined treatment variable, lower educated parents

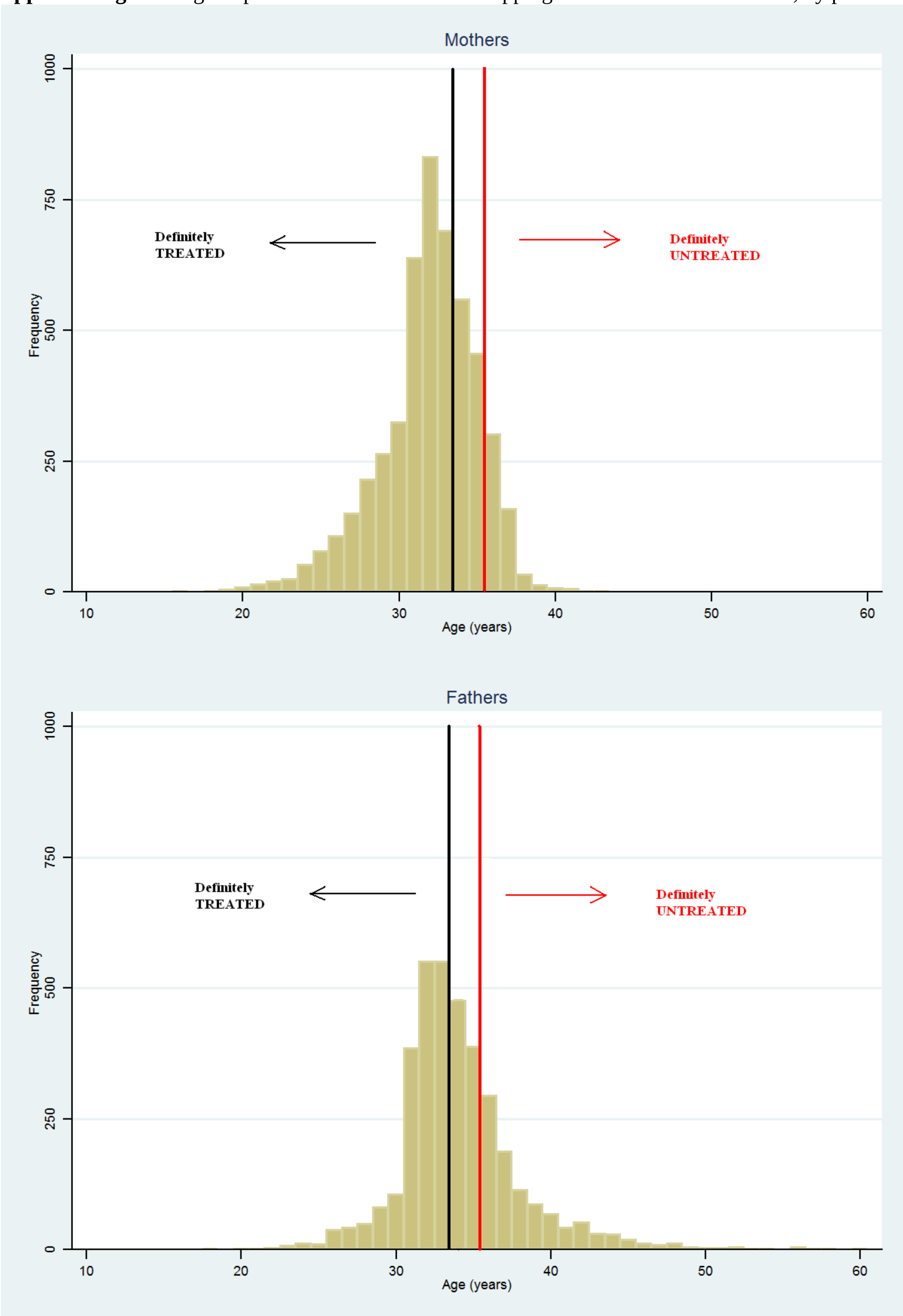
| | Fine Motor Skills (18 and 30 months) | Gross Motor Skills (18 and 30 months) | IQ, aged 8 | Fluid IQ, aged 8 | Entry Assessment Score | Key Stage 1 Score | Key Stage 2 Score | Key Stage 3 Score |
|---|---|---|---|---|---|---|---|---|
| RoSLA Treatment | -0.130 | -0.513 | 0.732 | 0.795 | 0.512** | 0.859*** | 1.597** | 2.690** |
| (0,1,2 parents treated) | (0.629) | (0.762) | (1.156) | (1.244) | (0.199) | (0.217) | (0.702) | (1.164) |
| Mother has A levels, equivalent or | 1.919*** | -1.669** | 9.099*** | 8.505*** | 1.438*** | 1.913*** | 6.142*** | 10.240*** |
| higher | (0.611) | (0.729) | (1.296) | (1.378) | (0.250) | (0.251) | (0.783) | (1.376) |
| Father has A levels, equivalent or | 2.319*** | 0.45 | 6.453*** | 4.821*** | 0.823*** | 1.372*** | 5.113*** | 9.408*** |
| higher | (0.561) | (0.656) | (1.172) | (1.241) | (0.216) | (0.222) | (0.702) | (1.208) |
| Mother's age at child's birth: | -2.857 | -1.235 | 0.140 | 3.044 | -0.593 | 0.504 | 1.137 | 3.906 |
| pre-window | (2.005) | (1.658) | (4.789) | (4.594) | (0.969) | (0.483) | (2.326) | (3.539) |
| Mother's age at child's birth: | 0.07 | 0.131 | 1.100*** | 0.918** | 0.179*** | 0.259*** | 0.563** | 1.017*** |
| in window | (0.187) | (0.259) | (0.375) | (0.404) | (0.064) | (0.067) | (0.223) | (0.362) |
| Mother's age at child's birth: | -0.15 | -0.317** | 0.582* | 0.608* | 0.129** | 0.158*** | 0.638*** | 0.921*** |
| post-window | (0.148) | (0.155) | (0.320) | (0.339) | (0.051) | (0.055) | (0.194) | (0.294) |
| Father's age at child's birth: | 0.116 | -0.326** | 0.066 | -0.02 | -0.052 | 0.071 | 0.116 | -0.179 |
| pre-window | (0.150) | (0.164) | (0.347) | (0.395) | (0.080) | (0.065) | (0.188) | (0.328) |
| Father's age at child's birth: | -0.318* | -0.100 | -0.173 | -0.201 | 0.078 | 0.039 | 0.219 | 0.216 |
| in window | (0.188) | (0.199) | (0.405) | (0.419) | (0.070) | (0.070) | (0.220) | (0.368) |
| Father's age at child's birth: | -0.088 | -0.255 | 0.583 | 0.795 | 0.224** | 0.303*** | 0.934*** | 1.604*** |
| post-window | (0.250) | (0.280) | (0.660) | (0.640) | (0.100) | (0.089) | (0.304) | (0.526) |
| R squared | 0.041 | 0.038 | 0.074 | 0.057 | 0.098 | 0.108 | 0.074 | 0.092 |
| Obs | 2186 | 2185 | 1373 | 1381 | 2008 | 2358 | 2498 | 2285 |
| Outcome Mean | 81.69 | 83.91 | 101.38 | 97.31 | 20.48 | 8.82 | 82.27 | 104.17 |
| Outcome SD | 10.00 | 11.44 | 16.10 | 17.11 | 3.27 | 3.73 | 12.43 | 19.70 |
| Treatment as % of SD | -1.30 | -4.49 | 4.55 | 4.65 | 15.65 | 23.01 | 12.85 | 13.66 |

* p<0.10, ** p<0.05, *** p<0.01. Additional controls included: child gender, month of birth, GCSE cohort, parent foreign qualifications, missing education info dummy.

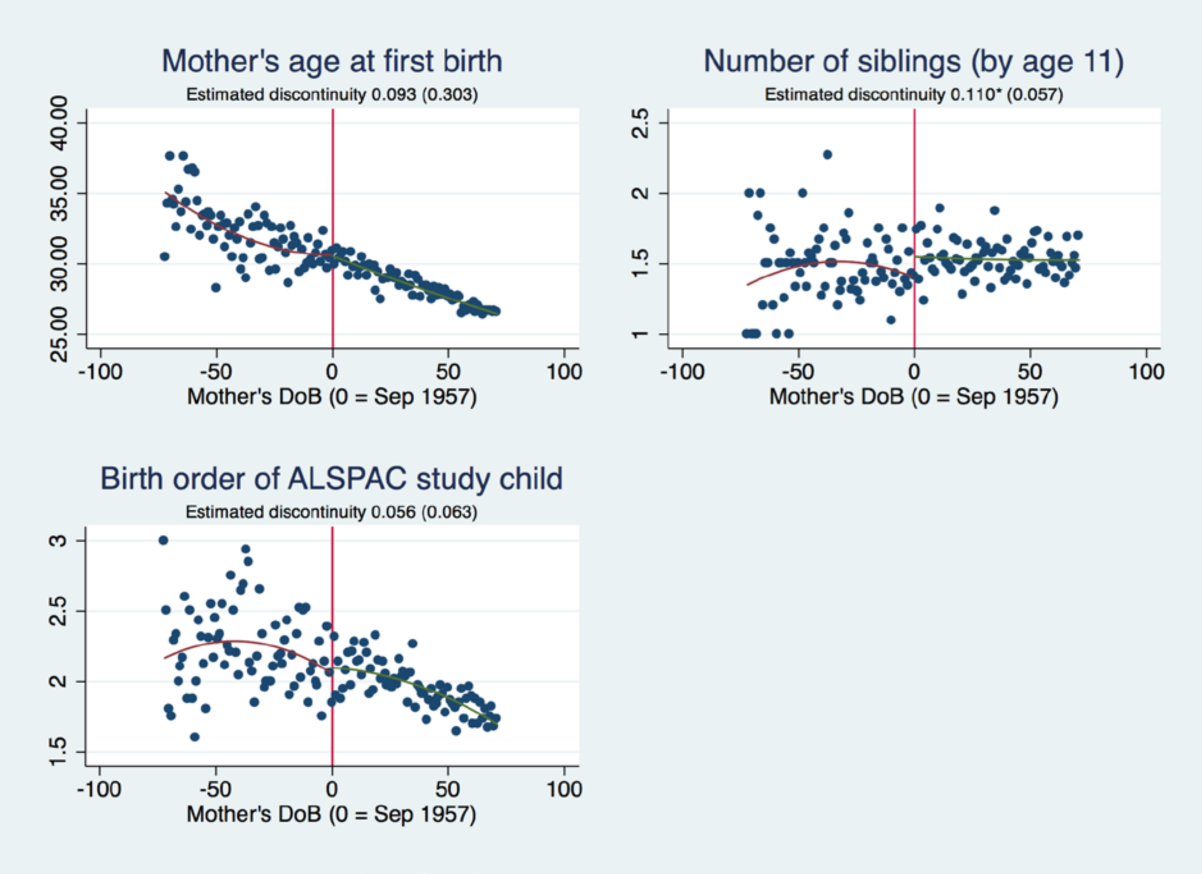
**Appendix Table A8:** National Vocational Qualifications Equivalent Qualifications Classification

| NVQ equivalent | Academic qualification |
|---|---|
| Level 0 | No nationally recognised academic qualifications |
| Level 1 | CSE below grade 1, GCSE below grade C |
| Level 2 | CSE grade 1, O-levels, GCSE grade A-C |
| Level 3 | A-levels, A/S levels, SCE Higher, Scottish certificate of sixth year studies, international baccalaureate |
| Level 4 | First/foundation degree, other degree, diploma in higher education |
| Level 5 | Higher degree |

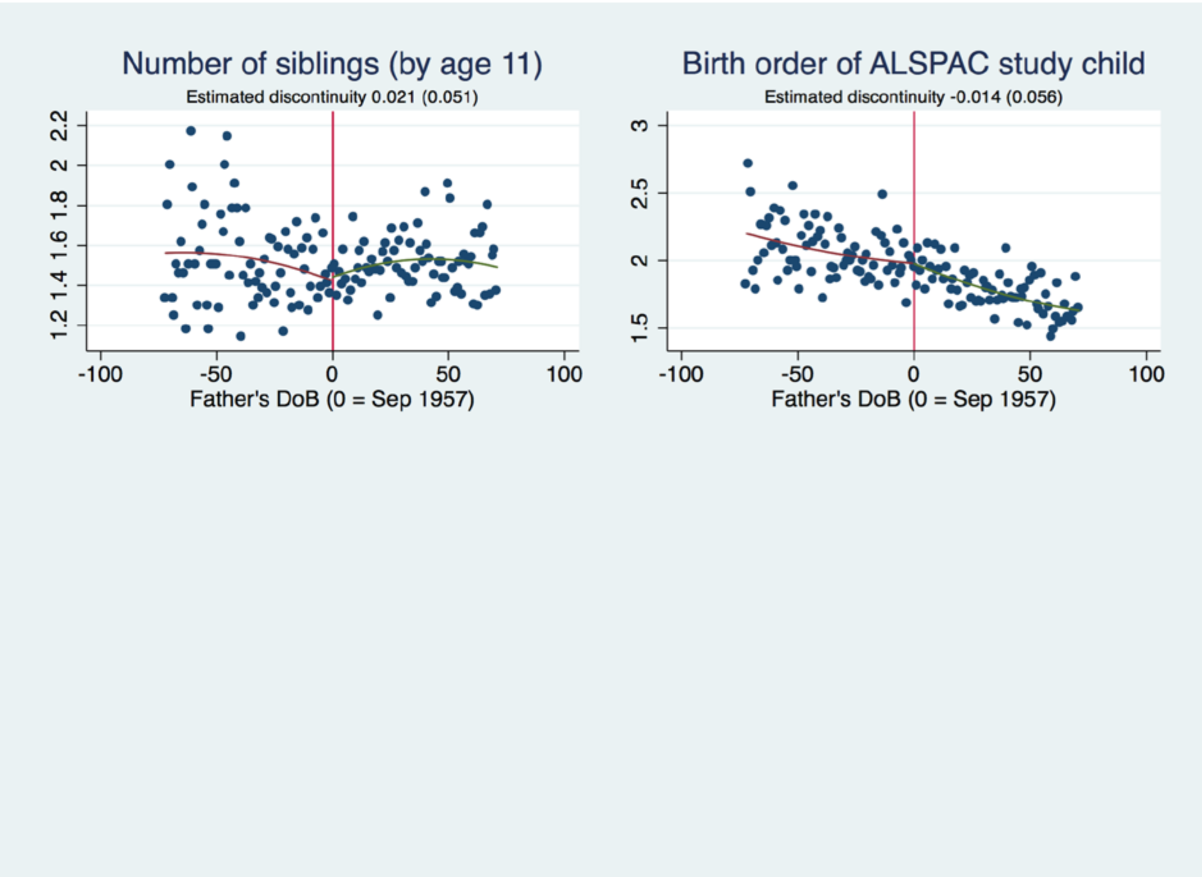
**Appendix Fig. A1:** Age of parent at child's birth and mapping to RoSLA treatment status, by parent



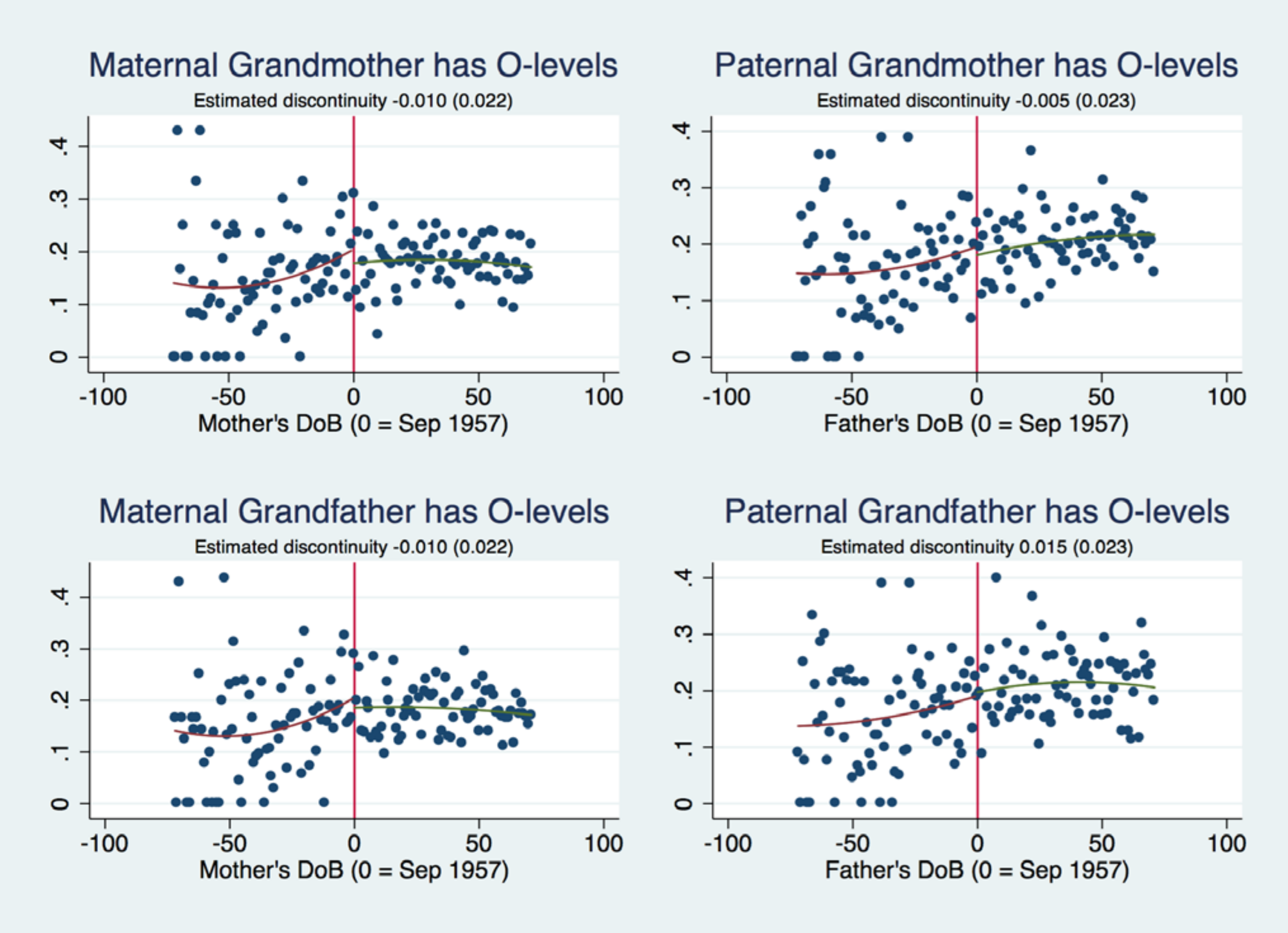
**Appendix Fig. A2:** Balancing Tests – Mother's fertility characteristics



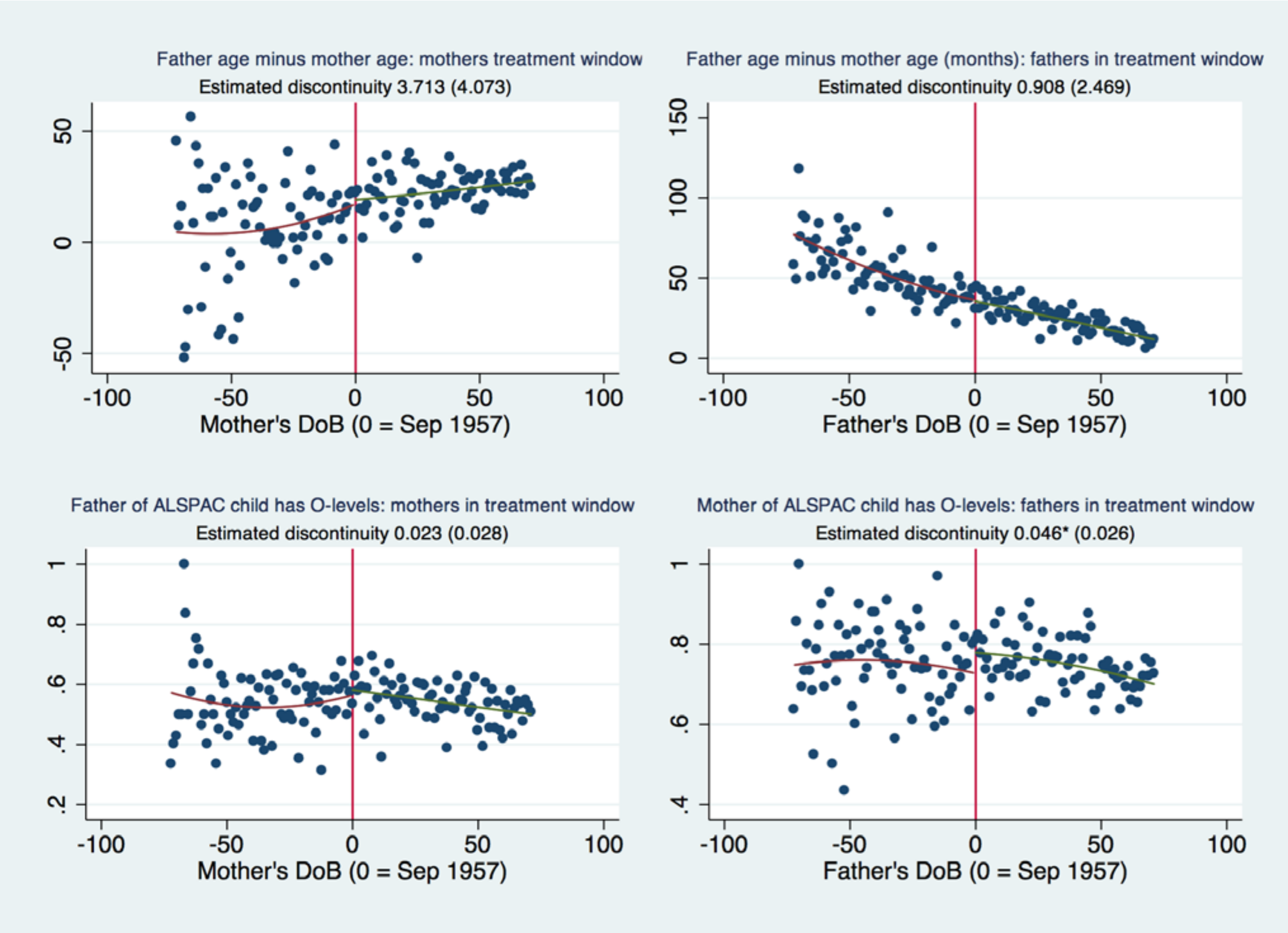

**Appendix Fig. A3:** Balancing Tests – Father's fertility characteristics



**Appendix Fig. A4:** Balancing Tests – Grandparent education




**Appendix Fig. A5:** Balancing Tests – parental relationship characteristics



**Appendix Fig. A6:** Balancing Tests – parental relationship characteristics and information availability

## Early, Late or Never –
## When Does Parental Education Impact Child Outcomes?
### Data Description

**ALSPAC**

We have used data from the Avon Longitudinal Study of Parents and Children (ALSPAC), which consists of children who were expected to be born between 1st April 1991 and 31st December 1992 in the Avon area, an area including and surrounding Bristol in the UK. All mothers with children due during this period in this area were invited to join the study, resulting in 14,062 live born children, 13,971 of whom were alive at 12 months, representing 13,801 mothers.

Additionally eligible children who were found in external education data but who were not in the core ALSPAC sample were added to the datasets. In total we have 19,966 observations including 14,663 children from the core sample and 5,303 eligible children added later, excluding triplets and quadruplets as the external data is unavailable for these children due to confidentiality concerns.

The data from the study includes information from survey questionnaires completed by the mothers, the mothers' partners and the study children. Further to the questionnaires there were several "clinics" during which children completed various types of tests and questionnaires on more sensitive topics; these occurred at ages 7, 8, 9, 10, 11, 12, 15 and 17. Data from other sources has also been linked in, including Annual School Censuses, at school and pupil level and children's school test results for all Key Stages and Entry Assessment.

**Variables Used: Parental Date of Birth**

The treatment of the study children is determined by whether their parents were affected by the "Raising of the School Leaving Age" that affected those turning 15 on or after 1 September 1972, i.e. those born on or after 1 September 1957. To determine treatment status requires parents' date of birth which is not directly recorded in ALSPAC. However, we were able to use answers to other questions to determine parents' year and month of birth. First we calculated a "benchmark" estimate from the good quality, clean data available and then used further information to construct more estimates to compare with the benchmark. If the majority of available further estimates were within a month of the benchmark we considered the benchmark validated. The process was slightly different for maternal and paternal estimates.

**Maternal Date of Birth:** For the benchmark we use mothers' age in months at their child's delivery. This was available for 15,995 observations, while study child's month and year of delivery is available for all study children. Therefore we could precisely calculate mothers' month and year of birth for all observations and determine whether they were treated or not by RoSLA. There are 3,108 observations with only a benchmark estimate, 12,792 observations with a validated benchmark estimate and 95 observations with a benchmark estimate that was not successfully validated, so the benchmark was used for 15,900 observations, while the date of birth was considered "missing" for the 95 observations with an invalid benchmark; the date of birth was considered missing also for all observations without a benchmark estimate.

**Paternal Date of Birth:** A reported month and year of birth was included in a questionnaire completed by, or on behalf of, the mothers' partners when the study child was approximately 8 months old. A reported month of birth was also included in questionnaires completed during pregnancy and when the child was 8 weeks old. Where the reported month of birth was the same in the majority of these three datasets, it was used along with the reported year of birth to calculate fathers' date of birth (month and year). This estimate was available for 6,510 observations, of which 6,304 were validated and a further 17 observations had no other available estimates. Like for maternal date of birth, the benchmark was used as the final estimate for all observations where the benchmark was valid or the only available estimate. However since there were many observations where there was no benchmark estimate, for these observations and observations where the benchmark was not validated, we found the median estimate (excluding the benchmark case) and used the same validation process on the median estimate as we had on the benchmark. This gave us a validated estimate for 53 of the invalid-benchmark observations and 2,455 observations with no benchmark estimate.

To see which estimates are used for each parent, see the table below:

**Table 1: Type of Date of Birth Estimate**

| Father | Mother | | Total |
|---|---|---|---|
| | Benchmark Estimate | Estimate Missing | |
| Benchmark Estimate | 6,300 | 21 | 6,321 |
| Median Estimate | 2,601 | 21 | 2,622 |
| Estimate Missing | 6,999 | 4,024 | 11,023 |
| Total | 15,900 | 4,066 | 19,966 |

### Variables Used: Treatment

The parents' treatment group is determined by three conditions:

*Date of Birth:* A sample window of ± 3 years, ± 6 years or ± 1 year is chosen and based on that, parents are treated, untreated or ineligible for treatment. If their date of birth is outside the sample window, i.e. either more than 3 years, 6 years or 1 year (depending on chosen window) away from the date of birth corresponding with RoSLA (1 September 1957) then the parent is ineligible for treatment. If they are born in the window before September 1957 they are untreated and if they are in the window on/after 1 September 1957 they are treated.

*Foreign Education:* RoSLA only affected those in the English and Welsh teaching systems so we have tried to identify parents who may have been in foreign education systems. In the child-based questionnaires at ages 4 years 9 months, 5 years 9 months and 6 years 9 months there is information on whether English is the only main language of the mother and their partner. If at any of these ages it is reported that English is not their main language or not their only main language then we believe they may have been educated abroad and so we consider them ineligible for treatment.[26]

*Parental relationship conditions (fathers only):* Since for the most part the date of birth estimate for fathers (i.e. mothers' partners) is taken early, we want to make sure that this partner is the child's main father figure and has spent most of the child's life in the same household. The mother is asked about the length of her marriage when the child is approximately 10 years old and the length of her cohabiting relationship when the child is approximately 12 years old. Using the resulting variables we can identify cases where the current partner is not the same as when the child was 8 months old (when the benchmark estimate is reported) and so we can make these fathers ineligible for treatment.[27]

The combined treatment variable is the number of treated parents, after considering all three conditions. If neither parent is eligible for treatment then the variable has no value, if both parents are untreated or if one is untreated and the other is ineligible then the treatment value is zero; if one is treated and the other is untreated or ineligible the treatment value is one; if both parents are treated then the treatment value is two.

### Variables Used: Parent and Child Education Outcomes

#### Parents

In our first stage regressions we use three dummy variables to measure parents' educational attainment, as reported by the study child's mother. These variables are for whether the parent has any qualifications, has any O Levels and has any A levels. Qualifications included in "Any Qualifications" include CSE, vocational and skill qualifications, apprenticeships, intermediate, full and final City & Guilds, State Enrolled Nurse, State Registered Nurse, teaching qualifications, degrees, O and A levels. Unfortunately there was no information on number of each type of qualification or grades. The information is taken from the mothers' questionnaire during pregnancy (at approximately 32 weeks gestation).

[26] In a robustness check for parents where both are missing information on main language we drop any observations for which either the child or household are reported as having a main language that is not English. The child's language data is teacher-reported in the Pupil Level Annual School Census; the household data is from child-based questionnaires at 3 years 2 months, 4 years 9 months, 5 years 9 months and 6 years 9 months.

[27] In robustness checks we make fathers ineligible if the mother has not been in the same relationship since the child was under a year old. In the "relaxed" robustness test, relationships must last until the child is at least 10 years old; in the "strict" test the relationship must have lasted until the child was at least 12 years old.

**Children:**

*IQ:* This is taken from the Focus 8+ Clinic, to which all ALSPAC study children were invited at around 8 years of age. The children were measured using the Wechsler Intelligence Scale for Children, specifically the WISC-III $^{UK}$, which was the most up-to-date at the time of the clinic. We use the total score, a sum of 10 subscales (split into verbal and performance categories) which are age-adjusted. The verbal subscales are: information, similarities, arithmetic, vocabulary and comprehension. The performance subscales are picture completion, coding, picture arrangement, block design and object assembly.

*Early Development:* We have mother-reported measures of child development in several areas from the early child-based questionnaires. We use Gross and Fine Motor Skills scores and Communication scores. The Gross and Fine motor skills scores are averages of scores taken from questionnaires when the child is aged 18 and 30 months, scaled between 0 and 100. Communication scores are available for ages 15, 18, 24 and 38 months[28], however the score at 18 months is much less detailed. We rescale these scores so they also range from 0 to 100, and create a mean Early Communication score using the more detailed measures at 15, 24 and 38 months. We do not adjust the scores for age but we do include age when measured in regressions as controls when using these dependent variables.

*Entry Assessment:* These measures are teacher-assessed in the child's first term of Reception (age 4 to 5 years), generally in late October/early November. These were not compulsory nationally at the time the ALSPAC children were being assessed, but the same system was used in about 80% of schools in the Avon area at the time. The Entry Assessments included both cognitive and behavioural measures, all measured on a scale from 2 to 7. We have constructed a total (prorated) from the results for Reading, Writing, Language and Maths, and have also looked at Maths and Literacy individually, using the mean of Reading and Writing for our Literacy measure[29]. Unfortunately there is no data for Entry Assessments for children who were not in the LEAS of Bristol, South Gloucestershire, Bath and North East Somerset, but the dataset from Bristol LEA included eligible children who were not already in the ALSPAC sample.

*Key Stage 1:* Key Stage 1 testing occurs when the children are aged 6 to 7 years and at the time the ALSPAC children were being assessed it included components measured by standardised national

[28] For the more detailed Communication measures, the score has the following subscales:

15 months: nonverbal communication, vocabulary, understanding.

24 months: vocabulary, grammar, past tense, plurals.

38 months: vocabulary, combining words, past tense, plurals.

We use the raw sum of these subscales, and then rescale for our final score.

[29] Where only one measure of Reading and Writing was available, that was used for Literacy, i.e. the Literacy score is the mean of the available scores for Reading and Writing.

tests and also teacher assessment. The teacher assessment results were not available for all ALSPAC school years so only the standardised test results are available. These cover Reading, Writing and Maths. As with Entry Assessment we combine the Reading and Writing results to create a Literacy measure, and also create a prorated total score. The results reported are Levels that are dictated by the Department for Children, Schools and Families and are used for Assessment at Key Stages 1 to 3. The table below indicates how the levels should be understood in terms of child development.

**Table 2: Key Stage Levels**[30]

| **Key Stage** | **Range of levels within which most children will work** | **Target that most children reach by the end of the key stage** |
|---|---|---|
| 1 | 1 – 3 | 2 |
| 2 | 2 – 5 | 4 |
| 3 | 3 – 7 | 5-6 |

The results in ALSPAC include a breakdown of level 2, to sublevels 2A, 2B and 2C, where 2A is the highest achievement and 2C is the lowest. Some children reach level 4 in assessment but this is not available to all children because it requires testing with Key Stage 2 materials and is only attained by a few, so the data combines these children with those reaching Level 3. Thus the data is coded:

**Table 3: Key Stage 1 Variables**

| **Key Stage Level** | **Value** |
|---|---|
| Working towards Level 1 | 0 |
| Level 1 | 1 |
| Level 2C | 2 |
| Level 2B | 3 |
| Level 2A | 4 |
| Level 3 or Higher | 5 |

*Key Stage 2:* Key Stage 2 assessment occurs at ages 10 to 11 and again results are in terms of levels, which are coded as follows:

**Table 4: Key Stage 1 Variables**[31]

| **Key Stage Level** | **Value** |
|---|---|
| Working towards Level of Test | 15 |
| Not Award A Test Level | 15 |
| Level 2 | 15 |

[30] Source: ALSPAC dataset documentation, originally taken from Department for Children, Schools and Families (DCSF) website.

[31] http://www.bris.ac.uk/cmpo/plug/support-docs/ks2userguide2011.pdf [Accessed 6 November 2011]

| | |
|---|---|
| Level 3 | 21 |
| Level 4 | 27 |
| Level 5 | 33 |

English, Maths and Science are assessed using standardised tests, and we construct a prorated total from the results for these.

*Key Stage 3:* At age 13 to 14, children face Key Stage 3 assessments using standardised national tests. English is scored out of 100; Maths and Science are both scored out of 150. A prorated Total is constructed from the total supplied in the dataset (used in the value-added calculations) and the reported number of subjects included. In the data this Total ranges from 0 to 141.

*Key Stage 4:* Assessments occur age 15 to 16, including GCSEs as well as other vocational qualifications, which are designed to be graded equivalently to GCSEs. The following table explains the grading system for GCSEs and their equivalents.

**Table 5: GCSE Points Scores**[32]

| Grade | Points |
|---|---|
| A* | 58 |
| A | 52 |
| B | 46 |
| C | 40 |
| D | 34 |
| E | 28 |
| F | 22 |
| G | 16 |

The measures we consider are total Key Stage 4 points (the sum of all GCSE-equivalent points for all Key Stage 4 qualifications, the total points for GCSEs, the total points for traditional academic GCSEs[33], the score for Maths GCSE and the score for English Language GCSE (as a measure of literacy).

**Variables Used: Controls**

*Parent education:* While being used dependent variables in the "first stage" of the analysis, parental education is also used as a control. There is a pair of dummy variables for each parent, one dummy for

[32] Table 4.1 in Washbrook, 2010, ***Early Environments and Child Outcomes:*** *An Analysis Commission for the Independent Review on Poverty and Life Chances*, University of Bristol

[33] Included GCSEs: Maths, English Language, English Literature, Geography, History, French, German, Italian, Russian, Spanish, Single/Double award Science, Biology, Chemistry, Physics.

whether the parent has A levels, equivalent or more[34] and a second dummy for whether their education information is missing.

*Foreign Education:* As outlined in the Treatment section above, RoSLA only affected those in the English and Welsh teaching systems. We have control dummies containing the information in the method above, plus dummies recording whether there is no available information for each parent, which are used as controls so we pick up any effects when one parent is eligible for treatment but the other is believed to have a high probability of a foreign education.

*Siblings:* Based on information from a child-based questionnaire at age 11 years 8 months we have a set of dummies for the child's siblings: no siblings (i.e. only child), one sibling, more than one sibling, missing information. At this age this constitutes the mother's lifetime fertility for most children. The siblings include all siblings living in the home of the study child, and do not need to be full siblings.

*Child demographics:* We use child's sex and month of birth (from the Sample Definition dataset which uses information from hospital records) and child's GCSE cohort (taken from the Key Stage 4 dataset), except for the early development dependent variables, when age at questionnaire completion is used instead of month of birth and GCSE cohort.

*Date of Birth groups:* For each parent we include a set of dummies for whether they were born before the treatment window, after the treatment window, or if they have missing Date of Birth information. These are used to control for these effects where one parent was eligible for treatment (whether treated or untreated) but the other was not because they were not known to be born in the sample window.

*Age at child's birth:* For each parent there are three main age-at-birth variables, all with the parent's age of birth in whole years, constructed using the parent's date of birth estimate and the child's month and year of birth (from the Sample Definition dataset). The variables are conditional on the parent's date of birth, specifically whether they are born before, during or after the sample window. The values of the variables are zero if the parent was not born in the relevant time period, and is the parent's age at the study child's birth if they were born in the time period. In the main regressions both the mother's and the father's age are included as controls.[35]

[34] This is based on the National Qualifications Framework, where A levels are Level 3 qualifications. The dummy captures whether parents have A levels, degrees, full City & Guild qualifications, teaching qualifications or are a State Enrolled or State Registered Nurse.

[35] We also test for sensitivity to the imposed linearity by including the parent's age-at-birth squared.

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