

Mother's education and birth weight

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Abstract:

Birth weight has been identified as a predictor of child health and development. Low birth weight has considerable short and long term effects and thus potentially high costs to the individual and society even in a developed economy. Maternal education may affect birth weight through its positive affects on maternal health, prenatal behaviours or family circumstances during pregnancy.

Using OLS on a sample of first time mothers, maternal education has significant and positive effects on infant birth weight. However, the effect of maternal education may be due to unobservable characteristics affecting both her educational choice and her health investment. Whilst changes in compulsory school leaving age have been previously used as instrument, we refine their use by demonstrating that they affected pupils differently according to their social background. Additionally, the number of siblings and birth order of the mother provide exogenous changes in maternal education and are used to identify the causal effect of maternal education. We find small effect of maternal education – maybe due to the lack of medical information available to the mother for this cohort.

Key words : Returns to education, health

JEL: I12, I29

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1. Introduction:

Low birth weight is a consequence of a poor foetal environment which may permanently leave the body more “susceptible to adverse environmental influence” (Watson et al., 1995) and/or program the body to the onset of certain diseases (Barker, 1997). Exposure to ill health at such a crucial stage in the physical development of a person has thus serious short- and long-term effects in terms of infant mortality, child development and increased costs during childhood (Lewitt et al., 1995) but also adult health, educational attainment and labour market attainment (Currie and Stabile, 1999). The general wisdom is that policies increasing birth weight have substantial returns in the long run. This is true in the developing world as well as in more advanced economics. The US department of Health has, for example, fixed a target of 5% low birth weight (birth weight lower than 2,500g or 5lb 8oz) in its Healthy People 2010 agenda.

In the developing world, improving maternal education has been the medium to improve children’s health (World Bank, 1993) suggesting that one possible route to improving birth weight could be to invest in maternal education. Currie and Moretti (2003) also demonstrate that such a relationship is not specific to the developing world with substantial effect of maternal education on birth weight being also found in California. However, despite dramatic improvement in medical knowledge and technology, as well as ever increasing maternal education, low birth weight has remained stubbornly persistent in the Western world in the last three decades¹ (National Centre for Health Statistics, 2003). This paper assesses the potential for increasing maternal education in the context of a cohort of British babies born in

¹ Medical progress and maternal education have conflicting results on the average birth weight of children born. Following Currie and Moretti (2003) the positive trend in maternal education observed in the last three decades should have resulted in an increase average birth weight and a reduction of the probability of low birth weight babies. However, medical progress has lead to an dramatic improvement in the survival of premature babies (really low birth weight have increased from 1.2% to 1.4% over the period 1970 2003), so that on average the probability of having a low birth weight baby is identical, at 7.9% in 2003 and in 1970 in England, National Centre for Health Statistics (2003). Also the increase in education has been associated with women having their first child at a later age, which may also increase the risk of low birth weight.

the Fifties and also relates to the literatures on social return to education and on intergenerational transmission of inequality².

Like for other health components, the effect of education on birth weight stem from various components. Maternal education affects birth weight by improving the choice and/or productivity of prenatal care and other health behaviours, the financial situation directly and indirectly since educated mothers marry more educated (wealthier) men and modify the timing and number of birth (quantity/quality trade off). The main agenda of this paper is not to assess which of these channels is responsible for the effect but to confirm that the effect of education on birth weigh is causal and not due to an unobserved third factor such as the mother's discount rate affecting both her educational attainment, her health and subsequently the health of her child (Fuchs, 1982), in which case the relation between maternal education and birth weight would be spurious and the estimate biased upwards.

To identify a causal effect of maternal education on birth weight, Currie and Moretti (2003), rely on the proximity to a newly opened college when the mother was a teenager as an exogenous shock to her education. The rational is that the opening of a college reduces the cost of higher education in a way that is uncorrelated with the unobservable term correlating both education and health. This identification allows them to conclude that that higher maternal education has a causal effect on the use of prenatal care, marriage prospects of the mother and ultimately improves the health of the child. Contrary to the omitted variable bias expectations, the IV estimate doubles compared to OLS.

In this paper, we also rely on an exogenous shock to identify the causal effect of maternal education on her children's birth weight. The identification stems from two distinct processes. First, a legislative change created a so called "natural experiment"; in 1948, the minimum school leaving age was increased from 14 to 15, thus generating an increase in maternal education independent of the mother's unobservable characteristics. Moreover, the

² See Grossman (2005) for a recent review of the non financial returns to education and Currie and Moretti (2005) for evidence of birth weight on intergeneration inequality.

change in legislation affected children differently depending on their social background, with children from lower social class gaining the most. Moreover, we exploit information on the mother's birth order and number of siblings, which have been shown to impact on educational attainment (Black et al., 2005b) but have no direct effect on birth weight.

The effect of maternal education is identified for a group of mothers at the lower end of the educational attainment; our estimates thus complement Currie and Moretti (2003) and are important to inform policy makers. Assuming decreasing returns to education, we expect the returns to lower level of maternal education on birth weight to be larger than at university level. Maternal education increases the average birth weight by 70 grams and reduces the probability of low birth weight by 1.5 percentage point as in Currie and Moretti (2003). However, this reduction is not statistically significant. Using quantile regression, we do not find evidence that maternal education has a greater impact for children more at risk. Based on the mean effects, we calculate that a policy increasing maternal education has small social returns but these estimates may be considered as lower bounds.

The paper has the following structure: Section 2 describes the general birth weight literature. Section 3 examines the birth weight production function and Section 4 explores various estimation issues. The results are presented in Section 5 and Section 6 concludes with further remarks.

2. Birth weight, health and education

Low birth weight has costs to the individual and family but also to society. These costs are observed in the short and long run. Infant mortality rates among low birth weight infants being over five times that of their normal weight counterparts (ONS, 2003)³ and three

³ Post neonatal death rates are a non-linear function of birth weight, with the highest risk being observed for babies born at a weight between 1,500 and 1,999 grams (1.04%) and the lowest for babies weighting more than

quarters of infant deaths relate to the infant being too small and/or premature (Paneth, 1995). Additionally, Lewitt et al. (1995) estimate that 35% of all health care spending on new born children is related to low birth weight children who make up just under 8% of new born children, with each additional gram costing an additional \$6 to \$10 (Joyce, 1999).

In the longer run, low birth weight has profound effects on health, cognitive deficit and behavioural problems (Aylward et al. 1989) as well as subnormal growth and developmental disorders (Abel, 1980, Hack et al., 1995, Naeye, 1981, Hediger et al., 2002). Low birth weight also impacts on educational attainment and leads to delayed entry to kindergarten (Corman, 1995), repeat years at school (Corman & Chaikind, 1998) and an increased probability of attending special education (National Education Goals Panel, 1997). Finally, Currie and Hyson (1999) find that low birth weight has significant long term effects on self-reported health status, educational attainment and labour market outcomes.

Birth weight may be the cause of these outcomes or might simply reflect low investments by the mother not just in her own health whilst pregnant, but also in the child post-natal environment, health and human capital, leading to the adverse outcomes aforementioned. Alternatively, Wilcox and Russell (1983) and Wilcox (2001) argue that the correlation between low birth weight and bad health is due to (unobservable) biological processes that affect both weight and health or that “infants at biological risk may be more susceptible to adverse environmental risk than are normal babies” (Watson et al., 1996)

The question of causality of low birth weight on these outcomes is currently a debated topic with Currie and Hyson (1999) finding that the effect remains even accounting for the endogeneity of birth weight, whilst Almond et al. (2005) dispute the causality of low birth weight on health cost and infant mortality by comparing these outcomes for twins and thus differencing out any genetic and family effects. Black et al. (2005 a) also using a large sample

3,500 grams (0.11%). Death rates for infants are remarkably similar at 1.14% for the first category and 0.12% for the heaviest babies (ONS, 2003).

of twins find evidence that low birth weight has limited impact in the short run but larger one on height, IQ, education and wage (see also Harmon et al. 2005).

Whilst the debate on the causality of birth weight on these outcomes is clearly of importance to design the appropriate policies, the objective of this paper is to concentrate on the causes of low birth weight rather than its consequences. The main cause of low birth weight is a shorter than normal gestation periods and slow foetal growth but disentangling these two effects is difficult (Institute of Medicine, 1985). However, the medical research has identified certain risk factors which affect the gestation period and/or the foetal growth; these include nutrition during pregnancy especially smoking, consumption of alcohol or coffee, time elapsed before prenatal medical care, frequency of visits during pregnancy, and physical and emotional stress during pregnancy. Since all these factors are within the control of the mothers, policies to improve birth weight have concentrated on affecting maternal decisions during pregnancy and typically maternal education will affect these decisions.

First, more educated mothers face a more favourable budget constraint either directly through increased earnings or indirectly through assortative mating. Additionally, education may modify the budget constraints by its effect on fertility decision and more educated mothers have their first child at a later age and have less children, and would thus have more resources per child. Hence, maternal education may simply proxy for an income effect.

Second, maternal education affects maternal health, which determines her reproductive capacity and her ability to physically cope with pregnancy. The causal effect of education on health may be through productive efficiency (Grossman, 1975) i.e. more educated people are more efficient producers of health. For example, educated individuals have better success rates with “less easy” forms of contraception (Rosenzweig and Schultz, 1989), are better able to manage chronic illness (Goldman & Lakdawalla, 2001), particularly those involving complex treatments such as diabetes and AIDS (Goldman & Smith, 2001). Concomitantly, Welch (1970) and Michael (1973) posited the notion of allocative efficiency

where education increases the ability to process and use “medical” information. This leads to a better input-mix as it increases the willingness and ability of an individual change their preventive health behaviour (Kenkel, 1991), seek out advice and information, and greater openness to newer technology (Lleras-Muney & Lichtenberg, 2002).

However the relationship between education and health may be spurious. Fuchs (1982) for example, argue that since both education and health can be seen as component of the individual’s capital, they will both be affected by the individual’s discount rate, so that an individual with a high discount rate will invest less in his education and his own health. Farrell and Fuchs (1982), Becker and Murphy (1988) and Chaloupka (1991) argue similarly and Munashinge and Sicherman (2000) have shown a link between high discount rates and unhealthy behaviour such as smoking. However one could argue that education has a positive feed back on discount rate, so that the relationship between education and health may, to some degree, still be causal (Leigh, 1986 and Becker & Mulligan, 1997).

While many papers include education in either the birth weight equation or in the prenatal input equation as a control, not much attention has been paid to estimating the causal effects of education. Currie and Moretti (2003) is one of the few papers to investigate the causal link between child health and maternal education, other examples being Desai and Alva (1998) and Thomas, Strauss and Henriques (1991) although both of these studies used data from developing countries. Using a sample of birth in California in the early Nineties, Currie and Moretti (2003) use proximity to college as an instrument for maternal education. They find that maternal education reduces the probability of low birth weight by 1 percentage point, the probability of premature birth by 1 percentage point. These outcomes could be due to changes in the following behaviour: maternal education reduce smoking during pregnancy (-6 percentage points), pre-natal care (+2.5), and increase partnership (+1.3). The authors thus conclude that education improves infant health through a number of different pathways.

3. The demand for health inputs and infant health production:

The traditional approach to modelling infant health production is to use a system of equations as in Rosenzweig & Schultz (1982, 1983).

$$(1) \quad B=f(O, X, PNC, H, E, Q,)$$

$$(2) \quad PNC=f(E, H, D, Y, X)$$

Equation (1) represents the infant health production function. O contains obstetrical information such as whether or not the child is male, parity and plurality of the birth. X includes demographic information such as the age of the mother and region. PNC refers to the use of prenatal care inputs which will be dealt with in equation (2). H is the health endowment of the mother and ideally contains long term measure of health status. Q represents prenatal health behaviours which affect the health of the child. These usually also affect the health of the mother. A common choice for empirical work, partly due to the availability of data, is to examine smoking during pregnancy. These terms (H and Q) are problematic as maternal health is potentially correlated with her education. Moreover, the knowledge of her own health endowment will affect the pregnancy behaviour of the mother thus generating endogenous prenatal inputs⁴.

It is debateable as to whether education (E) enters the birth weight production function directly or indirectly through the prenatal care equation. For instance, Rosenzweig and Schultz (1983) argue that parental education affects the choice of health inputs but has no direct effect on birth weight. Contrary to this, Joyce (1990) finds that education belongs in both the input demand function and the birth weight production function. Education belongs to the

⁴ Additionally, there are some problems of selection if mothers in bad health do not have children. These problems are neglected here.

birth weight production function if productive or allocative efficiency exist or, in the absence of a complete measure of maternal health, as a proxy for maternal health.

Equation (2) represents the prenatal care equation. One could imagine this to be a function of the mother's education level if allocative efficiency exists. Her level of health endowment would also be a factor although it is not clear in which direction this would affect prenatal care use. The maternal discount factor (D) would also determine prenatal care use. Again this is typically unobserved and another reason to include smoking behaviour is to use it as a proxy for discount rate. Under certain health care systems income levels (Y) might also play a role. The difficulty is that most covariates can be assumed to be also correlated with educational achievement.

4. Estimation issues:

Estimation of the model throws in many difficulties. The major problem is that of endogeneity. Simply estimating equations (1) and (2) by treating maternal education as exogenous is unsatisfactory. As discussed above, maternal education, the main variable of interest, is affected by unobservables characteristics also correlated with the use of prenatal inputs and infant health. Under OLS the estimate of the effect of education will thus be biased. To alleviate the problems of endogeneity, the model is estimated by instrumental variable where the exogenous component of education is isolated to estimate its effect on birth weight.

The problem of endogeneity arises also in relation to prenatal care, as the researcher does not have full information about the mother's health endowment. There will always be unobservable characteristics representing health endowment of the mother and these unobservable elements may affect both the choice of prenatal care as well as the infant health (Rosenzweig and Schultz, 1982, 1983). The problem can be viewed as that of an omitted variable problem. It may be the case that those with worse health seek prenatal care earlier and/or more often than others - the adverse selection, as found in Rosenzweig and Schultz

(1983), leading to underestimating the effect of prenatal care on birth weight. Alternatively favourable selection may exist: healthier people use more prenatal inputs (as using prenatal care is but one form of healthy behaviour). For instance Grossman and Joyce (1990) find that healthier women start pre-natal care earlier. Favourable selection results in overestimating the effect of prenatal care on birth weight - e.g. Joyce (1990).

Furthermore there is a potential endogeneity problem in relation to prenatal health behaviours such as smoking. For example mothers who smoke (observed in this dataset) may also drink (not observed in this data set) which may affect infant health. Evans and Ringel (1999) use variation in cigarette taxes as an instrument and find that smoking reduces birth weight by 367g.

In this study, due to the potential endogeneity of prenatal care and health behaviours and lack of a plausible instrument for these, prenatal inputs are omitted from the birth weight equation for much of the analysis, and only a reduced form model is estimated which identify the total effect of maternal education on birth weight. Furthermore, information on previous birth history such as previous still-births, premature births or low birth weight is not included for most of the analysis as these too may be endogenous. An unobserved fixed factor which affected the outcome of a previous birth may affect the outcome of the birth observed in the 1958 cohort. Tables 8 & 9 show results when controlling for these potentially endogenous variables.

As in Currie and Moretti (2003), the OLS and IV estimates of the effect of education on different infant health outcomes and inputs for first time mothers are generated. The bulk of the analysis adopts a parsimonious model similar to theirs.

$$(3) \quad \text{Outcome} = \beta E + \beta O + \beta H + \beta Z + \epsilon$$

$$(4) \quad E = \beta \text{Instruments} + f(H, Z) + \epsilon$$

Where the outcome in equation (3) is either infant health (e.g. birth weight, gestational period, etc) or prenatal inputs (behaviours such as smoking or use of prenatal care).

Again, E represents maternal education, O , represents obstetrical information, H represents the mother's health endowment (includes weight and stature), Z represents demographic controls and ϵ and η are error terms. Equation (4) is the maternal education equation. The function $f(Z)$ uses demographic information such as region and mother's date of birth to control for smooth trends in school leaving so that the *RoSLA* dummy variables only pick up the effects of the reform and not overall trends in educational attainment.

The analysis is based on the 1958 National Child Development Survey (NCDS). This is a longitudinal study of the universe of babies born in Great Britain between 3rd and 9th of March 1958. The 1958 perinatal mortality survey has been followed by 6 subsequent waves (NCDS 1–6) at age 7, 11, 16, 23, 33 and the most recent, at ages 41-42. Here attention is restricted to the perinatal mortality survey. Mothers born outside of Great Britain were excluded as we do not know when they entered Britain or where they were educated. Also excluded are individuals reporting leaving school at a lower age than the minimum school leaving age. Including them in the sample (regardless of whether or not they are recoded) does not change the overall picture generated by the results. Only mothers aged 16 and above are kept so that we observe their educational attainment (at least past minimum schooling age).

Pregnancy resolution and the use of live births only in the sample create selection issues. The econometrician only observes the birth weight of those foetus who survived till birth but not for those who died from miscarriage or whose mother choose to terminate the pregnancy; this is a classic example of a sample selection problem (Heckman, 1979). Liu (1998) finds negative foetal selection, where unobserved factors increasing the probability of giving birth tend to reduce birth weight (negative foetal selection) whilst Rous, Jewell and Brown (2004) or Grossman and Joyce (1990) find positive foetal selection. The later also concludes that pregnancy resolution selection is less important than selection in prenatal care inputs.

The data available to us only contains live births, which preclude any correction for selection. However, since abortion was not legalized in Great Britain until 1967 (nine years after the NCDS cohort were born) the selection would solely be due to illegal abortion, miscarriage and stillbirth. It is difficult to find reliable, non-partisan estimates of the level of illegal abortions taking place prior to 1967. From the national statistics, around 10% of pregnancy ends in miscarriage. Regan (2001) report that 50% of all miscarriage are due to random foetal misformation and that the majority of non random miscarriages are due to health conditions of the mother that are independent of her behaviour during pregnancy. Therefore the magnitude of selection and its possible effects on the estimates presented here are unknown but for this pre-legal abortion cohort are likely to be relative small.

Birth weight is affected by birth order and since education affects the timing and number of birth, we focus the analysis on a sample of first time mothers (as in Currie and Moretti, 2003), which leaves us with a sample of 3,025 mothers. In this cohort the first born children are about 150g lighter than subsequent children (see Figure 1). Focusing on first born children creates additional selection problem, since older mothers are disproportionately less likely to be giving birth to their first child (Figure 2)⁵. We also exclude mothers with missing data on the relevant variables (see Appendix).

Table 1 reports descriptive statistics for all mothers and for first time mothers only. The variables are divided into 5 groups – birth outcomes, prenatal care and behaviours, maternal health and stature, maternal demographic background and finally, obstetrical information. First born children are 145g smaller and have been in the womb for an extra 1.5 day, they are only half as likely to weight greater than 4kg but otherwise do not differ from all babies born. First time mothers are obviously younger and 20 percentage points more likely to have faced a compulsory school leaving age of 15 rather than 14, which results in them having 0.30 years more education than the average mother. Despite being more likely to smoke prior

⁵ From a medical point of view, mothers aged outside the 17-35 bracket are at risk of poor infant health outcomes.

to the pregnancy, they appear to be in better health and have more favourable pre-natal care behaviour.

A graph of maternal education levels (Figures 6) against average birth weight reveals that, unconditional on other factors, higher education groups (left education at ages 16 and over) have higher average birth weights. The exception being the group who left aged 19 or 20. These are a very small group of under a hundred observations, thus the mean birth weight has a relatively large confidence interval.

To identify a causal effect of maternal education on birth weight, we rely on an instrumental variable strategy. First, we rely on a legislative change which creates a natural experiment as in Currie and Moretti (2003). In 1948, the Education Act of 1947 was (partially) implemented, increasing the legal minimum school leaving age to 15 as opposed to 14 for previous cohorts⁶. This policy had been legislated during the Second World War as part of wide ranging educational reforms (e.g. free for-all secondary education, expansion in the numbers of teachers and free milk and meals) but did not get implemented before 1948. Although the original plan had been to raise the school leaving age to 16 (this was delayed until 1973), this reform had a huge impact on the numbers attending school. The Education Act of 1947 measures affected pupils born after 1933 and created an important discontinuity in education attainment which has been used to instrument education in the context of various outcomes; see Harmon and Walker (1995) for an early example. In Figure 3, we report a detrended series of educational attainment, also controlling for region that clearly shows the discontinuity happening for mothers born after 1933 for whom schooling increases by 9 months.

This reform only has a time element and its impact on education may not be distinguished from other time specific events. The concern here is that the education of some

⁶ There were some regional variation in the implementation of the reform with Scotland's legislation being altered 2 years later and Northern Ireland enacting it only in 1957. The Northern Irish population is a relatively small group and arguably very different from the rest of the UK and is not surveyed in the NCDS.

individuals would have been disturbed by the Second World War (Ichino and Winter-Ebmer, 2003)⁷. The reform reduced the cost of post compulsory schooling and thus had a larger impact on the most financially constrained pupils. Moreover, Galindo-Rueda's (2003) analysis of the aggregate figures shows that the increase was concentrated in schools without ability entry requirements, and thus affected the most pupils who were on a non-academic track. We thus posit that the effect of the 1947 Education Act on educational attainment is larger for pupils from a lower social background. Pre-reform, children from better background were more likely to remain in education past the age of 14 than their poorer peers, hence they are less affected by the reform than children from lower background. To capture this variation, the reform dummy is interacted with the socio-economic group of the maternal grandfather. Individuals from an unskilled manual background have almost three years less education than those born in a professional family. The reform reduced this gap, as it was designed for, with the children from the lower two social class gaining almost a full year of education while children from the top three social class see no change in their behaviour (see Figure 4).

Hence contrary to Currie and Moretti (2003), the exogenous shock in education affects individuals with potentially low level of education⁸. The instruments are thus capturing more than the time dimension and within a cohort will vary by social class. Note also that since the bulk of pupils left school at the minimum school leaving age (see Table 1) the reform affected a large proportion of a cohort.

The second set of variables that can be used by instrument relates to the family characteristics of the mother mainly the number of siblings and her birth order, since both have been found to affect educational achievement (Black et al., 2005b). None of these variables is likely to have a direct effect on birth weight whilst all have been found to affect maternal

⁷ Being of school age during the second world war is not a valid instrument as the war affected education but also potentially nutrition, which during puberty could affect the capacity of future mothers to have healthy children.

⁸ The 1973 school leaving age reform was shown to have no indirect effect on the educational attainment of the pupils not directly affected (Chevalier et al. 2004).

education, and can thus be seen as valid instruments⁹. In Figure 5 we report the mean years of education of mothers according to their number of siblings. There is a clear gradient of educational attainment with lone children having almost a year more education than children with more than 4 siblings. Similarly, birth order (conditional on family size) also affects education. They are thus also used as instruments.

5. Results

Amongst the sample of first time mothers, various outcomes of interest are reported in Table 2 separately for different levels of schooling. Generally more educated mothers have more favourable outcomes. For example, mothers who attended higher education (left 21, 22) have babies weighting 170g more, with a probability of low birth weight 50% lower than those born out of mothers who left school at 14, These more educated mothers also are in better health, less likely to have been smoking throughout the pregnancy but surprisingly have a lower probability to have had adequate visits to doctors. Education is also associated with differences in the family environment with more educated more likely to be single and have had a short-gun wedding. However, their husbands have on average an extra 6 years of education and are 6 times more likely to be from the top two social classes; more educated mothers are thus in family with greater financial resources. Overall, education has ambiguous correlations with the environment and behaviour of mothers during pregnancy.

In Table 3, we report OLS estimates for various reduced form models. The outcome of interest is the birth weight of the child (other birth outcomes and prenatal behaviours are also reported in Tables 4 and 5). In the first column, we adopt a parcimonious specification which includes the gender of the baby (boys weigh 130g more than girls), the mother's social class when she was a child (insignificant), as well as a complete set of dummy for maternal year of birth and region of residence, since health care provision and ultimately health

⁹ First stage regressions are presented in Annex 1.

endowments may differ by area. The marginal effect of another year in school for the mother is to increase the birth weight of her child by 17g (the average birth weight of the sample is 3259g). The effect is statistically significant; assuming it is linear, each year of maternal education increases the weight of babies by 0.5%, but rather small.

In columns 2, 3 & 4 additional controls are added but without changing the significance or magnitude of the estimate. Model two adds indicators for maternal health proxied by her body mass^{10 11}. As expected, maternal BMI has a non linear effect on the child birth weight with both underweight and obese mothers giving birth to smaller children, whilst over-weight mothers give birth to heavier children. Model 3 adds an important determinant of birth weight: the gestation period. Each additional day of gestation increases birth weight by 17g, almost as much as a year of maternal education. Whilst, both coefficients can be biased due to the reasons explained above, it is likely that the effect of maternal education is marginal compared to the gestation period effect. Moreover, gestation period and maternal education appear orthogonal to each other since the education estimate remains similar in models with and without gestation. Finally, model 4 includes some health behaviour of the mother prior to pregnancy, mainly her smoking intensity as well as whether she had previous abortion – as a proxy for how much this child is desired. These variables have the expected impact on birth weight, with more smoking being associated with lower birth weight and abortion being marginally significant.

Results when accounting for the endogeneity of education are presented in Table 4. In the first panel, the dependent variable is the birth weight, measured in grams whilst in the bottom panel, the probability of being a low birth weight baby (less than 2,500g) is estimated using a linear probability model. Each column report results for models using the same

¹⁰ Whilst maternal height is reported continuously, maternal weight is only reported in category. We use the mid point of each category to approximate the bmi. As the effect of bmi on birth weight is likely to be non-linear we created dummies for under-weight, over-weight and obese.

¹¹ From the documentation, it is unclear when maternal weight was measured. Ideally one would like to have a measure of weight taken before the pregnancy, so as not to lead to reverse causality.

specification as the one presented in Table 3, so moving from the most to the least parsimonious model. For each model, the instruments are found to be valid in the first stage, and a F-test of their significance is always greater than the critical value recommended by Jaeger et al. (1995). However, the overidentification tests tend to reject that all instruments are valid – more is done in Table 8.

As in Currie and Moretti (2003) we find that instrumenting maternal education lead to a much larger estimate of its effect on birth weight which ranges from 57g to 70g or a 2% increase on the mean birth weight. The exogeneity of maternal education is rejected in the most parsimonious model.

In the second panel of this table, we estimate the probability of being a low birth weight baby, which is the typical objective of any policy of birth weight. Here, the OLS estimates are always 0 and whilst the 2SLS estimates are always negative, around 1.5 percentage point (or a 30% reduction in the probability of low birth weight), they are only marginally significant in the most parsimonious model. Surprisingly, the point estimates are almost identical to those found by Currie and Moretti (2003) in California in the Nineties. There are several differences between the two studies. Their identifying strategy is based on an educational reform affecting individuals at the higher end of the schooling distribution whilst here the affected population has rather low level of education. Assuming diminishing returns to education, we could have expected larger estimates in our case. Second, the periods of interest are rather different, the Nineties in their case and the late Fifties here, and dramatic medical knowledge had been gained. Since the medical communication to the general public, particularly the negative effects of maternal smoking during pregnancy, has changed drastically over this period, it is perfectly possible that maternal education had a less of a role to play in the Fifties. Finally, the institutions are rather different, with the health coverage being much more comprehensive and less unequal in the UK, and thus a reduced impact of maternal education could also be expected.

In similar vein to Currie and Moretti (2003) the effect of maternal education on a number of different outcomes is estimated in Table 5. Model 2 which includes maternal health is used throughout and both OLS and 2SLS are reported. The outcomes relate to birth outcomes, use of prenatal care, prenatal health behaviours and some environmental factors. For most factors, the impact of maternal education is greatly enhanced when estimated by 2SLS and the endogeneity of can be rejected for whether initial care was initiated on time, whether a short-gun wedding took place, the husband's year of education and social class. Maternal education is found to improve pre-natal care (allocative efficiency) with the probability that care has been initiated on time, and been followed through increased by almost 5 percentage points for each year of education. Whilst early initiation of care is important, many complications associated with low birth weight such as vaginal haemorrhaging and premature labour occur late on in pregnancy (Guttmacher, 1986). Frank et al. (1991) find that adequate care is more important than early initiation¹². Maternal education also improves the environmental factors as it reduces the probability of a short-gun wedding and is correlated with more educated husband from higher social classes, so that the effect of maternal education may be mostly due to an improvement in financial conditions.

These factors potentially affect birth weight directly and could indicate the route by which maternal education affects birth weight. In Table 6, we extend model 4 previously estimated with the variables presented in Table 5. These variables are all potentially endogenous as they are not independent of maternal education, as seen in Table 5. We divide them into three broad categories: pre-natal care, smoking behaviour and husband characteristics. The number of pre-natal visit, the maternal blood pressure and the number of gestation days all have a positive effect on birth weight, which are similar to those found in the rest of the literature. However, education only affects the number of pre-natal visits, so it is unclear that these variables are the routes by which maternal education increases birth weight.

¹² American College of Obstetrics and Gynaecology (1988)for example recommends 15 visits over a 40-week term.

After controlling for pre- pregnancy smoking intensity, mothers smoking whilst pregnant reduce the weight of their child by 85g, but maternal education has no significant effect on this probability¹³. Finally, only the marital position of the mother at birth – probably reflecting her income level, significantly affects birth weight, but once again education does not affect this variable directly. It is thus not surprising that the inclusion of these variables has no substantial effect on the estimates of the effect of maternal education on birth weight, so the effect of education on birth weight is mostly direct.

Further discussion of results:

In Table 7, we provide various robustness checks by first using our set of instruments separately (as suggested by the over-identification test) not all instruments are valid, but also various sample. All IV estimates are larger than the OLS, but not always significant. Using uniquely RoSLA seems to generate peculiar results, but this is a weak instrument on its own. The other combinations of instruments lead to results that are more in the same ball park. As explained previously, the RoSLA reform affects mostly children from modest background born after 1933. Focusing on the cohort born 5 years before and after the reform, we find that the instruments are valid only for the subpopulation of pupils originating from lower social background. Similarly, mothers who have more than 16 years of education were not affected by the reform (no rippling effect) and we confirm that the first stage is only significant for the cohort of individuals with lower educational attainment. The estimates of education on the population for which the instrument is precisely defined tend to be larger than those estimated for the full population.

Finally in Tables 8 and 9, we test the non-linearity of the calculated estimates. Mothers leaving school at the 17 and 18/19 categories are rather atypical since since ages do

¹³ Smoking has also been identified as a major a major risk factor in terms of low birth weight. Evans and Ringel (1997) generate OLS estimates, which show a negative effect of smoking on birth weight by between 238g and 253g. Using data where mothers who smoked prior to pregnancy were randomly assigned counselling, Sexton and Hebel (1984) found a negative effect of roughly 92g on birth weight.

not match with any qualification. They are thus only a few individuals in these two categories. Omitting them, there is some weak evidence supporting that the positive effect of education on birth weight are larger at lower level of education. For example, an additional year of education for mothers who left school at 14 would result in a birth weight gain of 50 grams, whilst the increase for an additional 3 years of education between 18 and 21 is only 60 grams or 20 grams per year. These results support decreasing returns to maternal education and policies should be targeted at lower achiever. However, in the second column of Table 8, we do not find that increasing education, even at the lowest level has any impact on the probability of giving birth to a low weight baby. However, these results all assume the exogeneity of maternal education and can be considered as under estimates.

In Table 9, we assess whether the positive impact of having a more educated mothers differs by the weight of the baby. Non-linearity in the effect of education could stem from the fact that medical information has greater returns for babies who are expected to be low birth weight. So if education improves the collection and use of information we could expect that it has a greater role for babies with the highest risk. We thus estimate a quantile regression using the same specification as in Model 2 and do not find evidence that babies more at risk benefit more from maternal education and reject the assumption that the use of information differ by babies risk at least for a cohort were information on babies risk of low birth weight was limited by the medical technology.

6. Conclusion:

Birth weight has been identified as a predictor of child health and development. The costs of low birth weight are considerable and its effects can reach well into adulthood (Currie & Hyson, 1999). Maternal education may affect infant health through its positive affects on maternal health, prenatal behaviours such as smoking and through use of prenatal care.

Using OLS on a sample of first time mothers in Fifties Britain, maternal education has significant, but small (17 grams) effects on infant birth weight. These effects remain controlling for gender of the baby as well as stature, age and region of origin of the mother. Relaxing the assumption of exogeneity of maternal education, each year of maternal education is estimated to increase the average birth weight by 60 to 70 grams (or 2%). The estimates on the probability of a low birth weight outcome are potentially large but insignificant.

Maternal education improves the production of health mostly through greater contact with doctors and improvement in the family situation and income. However, the inclusions of pre-natal factors do not change the conclusion, and the effect of maternal education whilst causal cannot be explained by these factors.

The gains of increasing the birth weight are multiple and can be observed from infancy to adulthood. To calculate the benefit of a policy increasing birth weight, we focus on two of these benefits. Joyce (1999) estimates these costs between \$6 and \$10 per grams in 1990 or £4 to £7 in today's price. Hence a policy increasing maternal education by one year would lead to a direct benefit of between £240 and £420. To these short-run gains, we add gains from improvement in earnings. Black et al. (2005) estimate an elasticity of earnings on birth weight of 0.1. Our favoured estimates are that one year of maternal education increases birth weight by 60g or roughly 2%, which will translate into a wage increase of 0.2%. The average gross earnings in 2005 was £24,000 (Social Trends, 36), which we assumed to be fixed from the age of 20 until 65. The present value (at age 0) of increasing maternal education would thus be a rather small £570. The total benefit of a policy increasing maternal education by one year would be £1,000 maximum per child. Assuming that each woman had two children (which is an under-estimate in 1958) and that the effects of maternal education are independent of birth order then the total benefit per treated child would be £2,000. This estimate has only envisaged two types of benefits and can be thus seen as an underestimate. Even in a developed

country with public provision of health and at a time when information on behaviour during maternity was limited, a substantial return to maternal education can be found.

Table 1: Probability 1958 pregnancy is the first and summary statistics

	Linear prob model	Summary statistics	
		Full sample	First birth only
Birth weight (in grams)		3396.89 (519.84)	3259.05 (485.17)
Age mother left education 14	Base category	56.02	25.03
Age mother left education: 15	0.026 (1.65)	24.76	50.29
Age mother left education: 16	0.068 (3.94)	10.71	14.01
Age mother left education: 17	0.071 (2.80)	3.82	4.75
Age mother left education: 18	0.093 (2.46)	1.73	2.37
Age mother left education: 19/20	0.129 (2.70)	1.01	1.35
Age mother left education: 21+	0.096 (2.69)	1.94	2.20
Maternal grand dad - social class I	Base category	2.14	2.23
Maternal grand dad - social class II	0.042 (1.14)	11.29	13.25
Maternal grand dad - social class, Non Manual III	0.021 (0.53)	5.22	5.98
Maternal grand dad – social class IV	-0.006 (0.17)	37.64	40.27
Maternal grand dad – social class V	-0.047 (1.27)	13.81	11.43
Maternal grand dad – social class VI	-0.043 (1.15)	12.24	10.43
Maternal grand dad – social class missing / no dad	-0.025 (0.69)	17.67	16.41
Mother underweight	0.012 (0.50)	0.042 (0.200)	0.052 (0.222)
Mother normal weight	Base category		
Mother overweight	-0.027 (2.14)	0.195 (0.396)	0.151 (0.358)
Mother obese	-0.067 (4.19)	0.099 (0.299)	0.065 (0.246)
Previous abortions	-0.017 (1.63)	0.129 (0.335)	0.073 (0.261)
Male	-0.008 (0.85)	0.518 (0.500)	0.503 (0.500)
Constant	0.135 (3.02)		
Observations	8835	5423	3412
R-squared	0.21		

Note: robust t-statistics in parentheses. The model also includes dummies for region of residence in 1958 and maternal year of birth

Table 2: Average outcomes by level of education

	Mother's age when left education						
	14	15	16	17	18	19/20	21+
Birth outcome							
Birth weight (g)	3231.2 (483.0)	3251.2 (479.3)	330301 (508.9)	3252.2 (481.9)	3346.4 (477.7)	3249.8 (525.1)	3402.4 (444.3)
Birth weight low (<2500g)	0.068 (0.25)	0.056 (0.23)	0.053 (0.22)	0.090 (0.287)	0.052 (0.224)	0.087 (0.28)	0.041 (0.20)
High birth weight (>4000g)	0.048 (0.213)	0.054 (0.225)	0.057 (0.23)	0.058 (0.23)	0.091 (0.29)	0.065 (0.25)	0.055 (0.23)
Pre-natal care and behaviour							
Abnormal pregnancy	0.274 (0.45)	0.272 (0.44)	0.257 (0.44)	0.235 (0.425)	0.234 (0.426)	0.174 (0.383)	0.253 (0.438)
Gestation period in days	280.8 (11.0)	280.8 (11.5)	281.0 (10.0)	281.5 (10.7)	280.2 (10.5)	281.0 (12.2)	281.4 (13.3)
Mother initiated care on time	0.847 (0.360)	0.763 (0.425)	0.754 (0.43)	0.844 (0.364)	0.788 (0.412)	0.848 (0.363)	0.764 (0.44)
Mother had adequate number of visits to doctor	0.757 (0.429)	0.686 (0.464)	0.740 (0.44)	0.765 (0.43)	0.778 (0.42)	0.739 (0.44)	0.693 (0.46)
Mother smoked during pregnancy	0.324 (0.47)	0.338 (0.47)	0.189 (0.39)	0.209 (0.41)	0.272 (0.45)	0.109 (0.31)	0.133 (0.34)
Mother had deficient haemoglobin levels	0.122 (0.33)	0.132 (0.34)	0.117 (0.322)	0.077 (0.27)	0.095 (0.30)	0.000 (0.00)	0.053 (0.23)
Mother's had acceptable blood pressure	0.570 (0.495)	0.630 (0.48)	0.627 (0.48)	0.669 (0.47)	0.557 (0.50)	0.585 (0.50)	0.606 (0.49)
Family characteristics							
Mother single at time of birth	0.024 (0.15)	0.043 (0.20)	0.048 (0.21)	0.031 (0.17)	0.062 (0.24)	0.044 (0.21)	0.067 (0.25)
Shotgun wedding	0.046 (0.21)	0.286 (0.45)	0.137 (0.34)	0.133 (0.34)	0.131 (0.34)	0.114 (0.32)	0.186 (0.39)
Husband age	30.50 (4.6)	25.02 (4.1)	27.87 (5.4)	27.67 (4.7)	28.28 (4.9)	29.07 (4.2)	29.67 (4.9)
Husband's age left education	14.48 (1.3)	14.95 (1.3)	15.77 (2.1)	16.4 (2.6)	17.31 (2.9)	18.80 (3.8)	20.36 (3.8)
Husband currently working	0.962 (0.192)	0.960 (0.196)	0.977 (0.15)	0.993 (0.081)	0.972 (0.165)	1.000 (0.00)	0.986 (0.12)
Husband social class I or II	0.132 (0.34)	0.093 (0.29)	0.319 (0.47)	0.442 (0.50)	0.541 (0.50)	0.721 (0.454)	0.768 (0.425)
Observations	819	1661	456	155	77	46	73

Table 3: Determinants of birth weight

	(1)	(2)	(3)	(4)
	Birth weight:	Birth weight:	Birth weight:	Birth weight:
Age mother left education:	17.33 (2.92)	18.30 (3.34)	18.49 (3.39)	17.23 (3.15)
Male:	133.22 (7.95)	135.09 (8.02)	148.10 (9.54)	147.65 (9.51)
Maternal grand dad - social class II	-62.44 (0.94)	-63.05 (0.95)	-37.04 (0.59)	-40.20 (0.64)
Maternal grand dad - social class, Non Manual III	-35.92 (0.51)	-33.04 (0.47)	-2.28 (0.03)	0.573 (0.01)
Maternal grand dad – social class IV	-49.09 (0.76)	-44.79 (0.70)	-27.60 (0.45)	-28.99 (0.47)
Maternal grand dad – social class V	-56.18 (0.82)	-48.58 (0.71)	-35.30 (0.54)	-34.21 (0.53)
Maternal grand dad – social class VI	-85.53 (1.23)	-79.23 (1.15)	-57.12 (0.87)	-53.46 (0.81)
Maternal grand dad – social class missing / no dad	-105.14 (1.57)	-96.85 (1.45)	-84.63 (1.34)	-84.86 (1.33)
Mother underweight		-130.24 (3.92)	-112.00 (3.57)	-102.07 (3.25)
Mother overweight		72.71 (3.05)	48.27 (2.18)	49.83 (2.26)
Mother obese		-16.83 (0.42)	5.60 (0.17)	11.22 (0.31)
Smoke 1-4 /day prior pregnancy				7.05 (0.21)
Smoke 5-9 /day prior pregnancy				-44.09 (2.01)
Smoke 10-14 /day prior pregnancy				-70.80 (2.91)
Smoke 15-19 /day prior pregnancy				-107.15 (2.36)
Smoke 20-24 /day prior pregnancy				-121.06 (2.09)
Smoke 25+/day prior pregnancy				-72.36 (0.65)
Days of gestation			16.70 (20.63)	16.63 (20.51)
Days of gestation missing			42.33 (1.62)	46.99 (1.79)
Previous abortions (dummy)				58.071 (1.63)
Constant	3043.85 (19.12)	3010.97 (18.91)	-1699.31 (6.26)	-1665.05 (6.15)
Dummies for year of mother's birth	Yes	Yes	Yes	Yes
Dummies for region of residence	Yes	Yes	Yes	Yes
N			3287	
R sq	0.033	0.040	0.186	0.192

Note: Linear regression of birth weight in grams. Omitted categories are maternal grand dad social class I, mother born in 1921 and the North West region, non smoker, no previous abortions. Robust standard errors are used to compute the reported t-statistics in parentheses.

Table 4: Maternal education effects on birth weight and low birth weight probability

	Model (1)	Model (2)	Model (3)	Model (4)
Panel A: Birth weight				
Age mother left education:				
OLS	17.33 (2.92)	18.30 (3.34)	18.49 (3.39)	17.32 (3.17)
IV	70.30 (2.59)	71.52 (2.64)	63.37 (2.52)	57.20 (2.24)
F test of significance of instruments				
F(25,3224)	21.20	21.11	20.89	20.20
Partial R ²	5.35	5.36	5.30	5.12
Test of exogeneity: $\chi^2(1)$	4.34	4.41	3.69	2.83
p	0.037	0.036	0.055	0.093
Test of overidentification: $\chi^2(24)$	40.24	40.97	37.22	36.42
p	0.020	0.017	0.042	0.050
Panel B: Low birth weight				
Age mother left education:				
Probit (marginal effects)	-0.0000 (0.17)	-0.0004 (0.19)	-0.0000 (0.15)	-0.0000 (0.00)
Instrumental variable	-0.023 (1.83)	-0.016 (1.56)	-0.015 (1.56)	-0.014 (1.40)
F test of significance of instruments				
F(25,3335)	18.25	18.24	18.12	17.59
Partial R ²	0.052	0.051	0.049	0.049
Test of exogeneity: $\chi^2(1)$	3.64	2.314	2.335	1.992
p	0.056	0.128	0.127	0.158
Test of overidentification: $\chi^2(24)$	25.77	23.63	22.53	22.15
p	0.363	0.483	0.548	0.570

Note: Observations in low birth weight model =3398. Robust t-statistics reported in parentheses. The models are based on the same specifications as those presented in Table 3.

Instruments are: RoSLA, RoSLA and interactions with grand father social class, maternal birth order and number of sibling.

Table 5: Effect of maternal education on other outcomes

Outcome	OLS	IV
High birth weight (>4000g)	0.002 (0.65)	0.007 (0.63)
Abnormal pregnancy	-0.006 (1.03)	0.023 (0.94)
Gestation period in days	0.071 (0.46)	0.415 (0.66)
Mother initiated care on time	-0.011 (2.28)	0.053 * (2.29)
Mother had adequate number of visits to doctor	-0.001 (0.22)	0.047 * (1.87)
Mother smoked during pregnancy ^A	-0.014 (2.85)	-0.019 (0.94)
Mother had deficient haemoglobin levels	-0.009 (1.87)	-0.037 (1.77)
Mother's had acceptable blood pressure	0.008 (1.16)	-0.000 (0.02)
Mother single at time of birth	0.004 (3.32)	-0.006 (0.77)
Shotgun wedding	0.010 (2.23)	-0.051 * (2.51)
Husband age	0.068 (1.15)	0.118 (0.54)
Husband years of education	0.687 (16.47)	0.884* (9.38)
Husband currently working	0.005 (1.93)	0.011 (1.38)
Husband social class I or II	0.062 (12.27)	0.132* (6.49)

Note: Specification uses model 2, * indicates that exogeneity of maternal education can be rejected. Robust t-statistics reported in parentheses.

^A this specification controls for smoking behaviour prior pregnancy.

Instruments are: RoSLA, RoSLA and interactions with grand father social class, maternal birth order and number of sibling.

Table 6: Effects of prenatal inputs and maternal education

	OLS	IV
Age mother left education:	17.076 (2.71)	58.689 (1.60)
Pre-natal care		
Previous abortions (dummy)	50.537 (1.42)	58.786 (1.61)
Mother initiated care on time	-9.903 (0.45)	-6.730 (0.30)
Mother had adequate number of visits to doctor	67.776 (3.72)	66.534 (3.66)
Mother had deficient haemoglobin levels	38.573 (1.21)	45.373 (1.40)
Mother's had acceptable blood pressure	40.402 (2.37)	43.160 (2.48)
Days of gestation	15.988 (19.41)	15.990 (19.43)
Smoking behaviour		
Smoke 1-4 /day prior pregnancy	56.492 (1.59)	53.347 (1.50)
Smoke 5-9 /day prior pregnancy	24.213 (0.81)	23.887 (0.80)
Smoke 10-14 /day prior pregnancy	8.906 (0.26)	10.119 (0.30)
Smoke 15-19 /day prior pregnancy	-32.398 (0.63)	-34.369 (0.66)
Smoke 20-24 /day prior pregnancy	-38.800 (0.62)	-34.087 (0.54)
Smoke 25-29/day prior pregnancy	55.224 (0.46)	45.842 (0.39)
Smoked during pregnancy	-91.041 (3.21)	-84.795 (2.93)
Husband characteristics		
Mother single at time of birth	-228.720 (1.91)	-261.299 (2.16)
Shotgun wedding	-1.567 (0.07)	-5.715 (0.23)
Husband currently working	86.060 (1.93)	82.549 (1.83)
Husband age	-3.350 (1.53)	-3.841 (1.72)
Husband years of education	-2.243 (0.45)	-14.647 (1.23)
Husband - social class II	-37.999 (0.90)	-39.012 (0.92)
Husband - social class, Non Manual III	-7.348 (0.16)	13.008 (0.27)
Husband – social class IV	-46.706 (1.11)	-24.701 (0.53)
Husband – social class V	-65.401 (1.35)	-41.256 (0.78)
Husband – social class VI	-48.131 (0.94)	-26.447 (0.48)
Husband – social class missing / no dad	-108.247 (1.57)	-76.762 (1.04)
Constant	-1,389.577 (4.56)	-1,878.420 (3.72)
R-squared	0.21	0.21

Note: Robust t-statistics in parentheses. Specification identical to model 4 plus additional dummies for missing values for pre-natal visits, haemoglobin level, blood pressure, husband currently working, husband's age, husband's years of education. Full set of instruments are used (see Table x for details). Observations: 3278.

Table 7: Robustness check: Estimate of maternal education on birth weight (in grams)

Instrument:	OLS	IV 1 RoSLA	IV 2 RoSLA & Interactions grand dad social class	IV 3 Maternal birth order & number of siblings	IV 4 All instruments	Obs.
Full sample	18.30 (3.09)	236.71 (1.23)	57.53 (1.13)	78.23 (2.52)	71.52 (2.64)	3287
F- first stage		6.11	36.30	11.57	17.52	
Born 1928-38, dad occ III non manual and below	23.09 (2.75)	104.02 (0.75)	131.16 (1.65)	69.88 (1.90)	80.56 (2.39)	2144
F- first stage		25.23	16.11	10.12	9.98	
Born 1928-38, dad occ III non manual and below	29.59 (3.31)	-536.05 (0.53)	365.38 (1.27)	95.78 (2.02)	100.92 (2.16)	557
F- first stage		0.28	6.37	4.03	6.87	
Mother left school at or before age 16	46.16 (2.85)	202.50 (1.24)	123.67 (1.26)	231.69 (2.45)	174.64 (2.59)	2936
		34.09	33.21	6.37	15.17	
Mom left school at or after age 16	7.11 (0.78)	-258.95 (0.92)	-141.96 (1.10)	207.06 (2.48)	125.22 (1.74)	807
		3.02	3.60	2.33	2.57	

Note: Estimates based on model (2) specification. Robust t-statistics reported in parentheses.

Table 8: Non linearity in the effect of mother's education on birth weight

Age mother left education	Birth weight (g)	Prob low birth weight
	48.47	-0.012
15	(1.53)	(0.84)
	85.45	-0.011
16	(2.69)	(0.81)
	36.35	0.022
17	(0.81)	(1.07)
	121.34	0.001
18	(2.02)	(0.05)
	25.93	0.024
19 or 20	(0.33)	(0.69)
	182.19	-0.021
21 or above	(3.29)	(0.92)

Note: Panel A - Regression based on Model 2, estimated by OLS. Robust t-statistics provided in parentheses .

Table 9: quantile regression, maternal education and birth weight

	Quantile estimate
	18.857
Q10	(1.31)
	14.976
Q20	(1.70)
	16.928
Q30	(2.20)
	20.541
Q40	(2.48)
	19.937
Q50	(2.45)
	19.552
Q60	(2.31)
	20.974
Q70	(2.62)
	17.029
Q80	(2.21)
	17.550
Q90	(1.48)

Note: Simultaneous quantile regression based on Model 2. The low birth weight model is estimated by linear probability model. T-statistics based on bootstrap (100 replications)

Figure 1: Birth order and birth weight

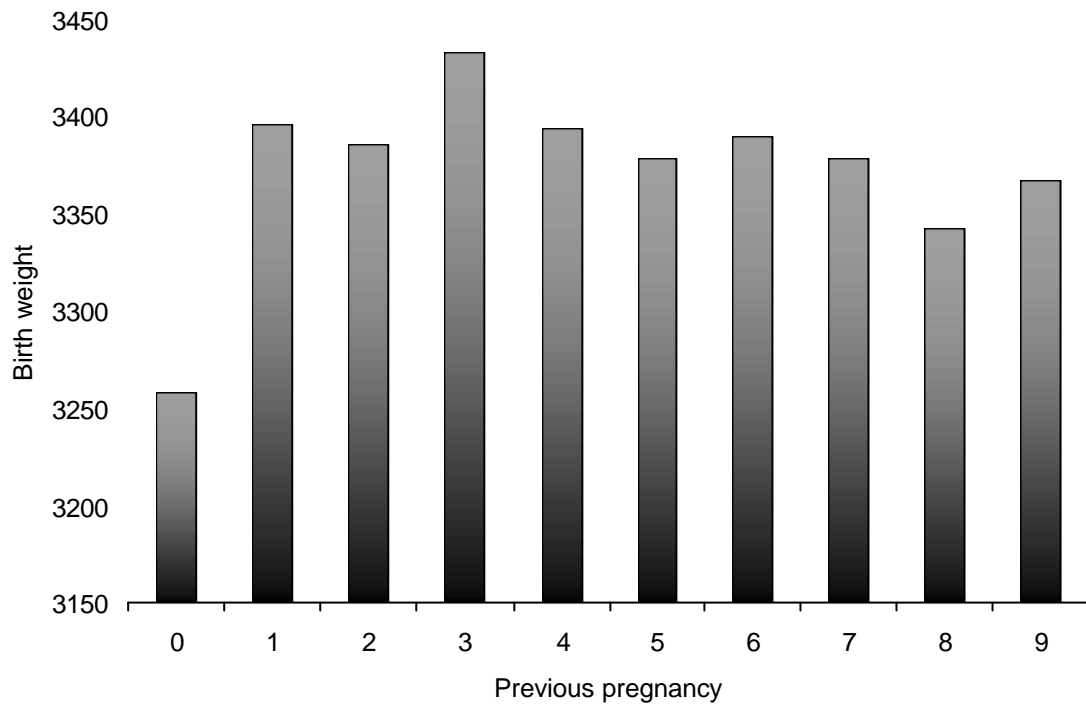


Figure 2: Probability of first birth in 1958 by year of maternal birth

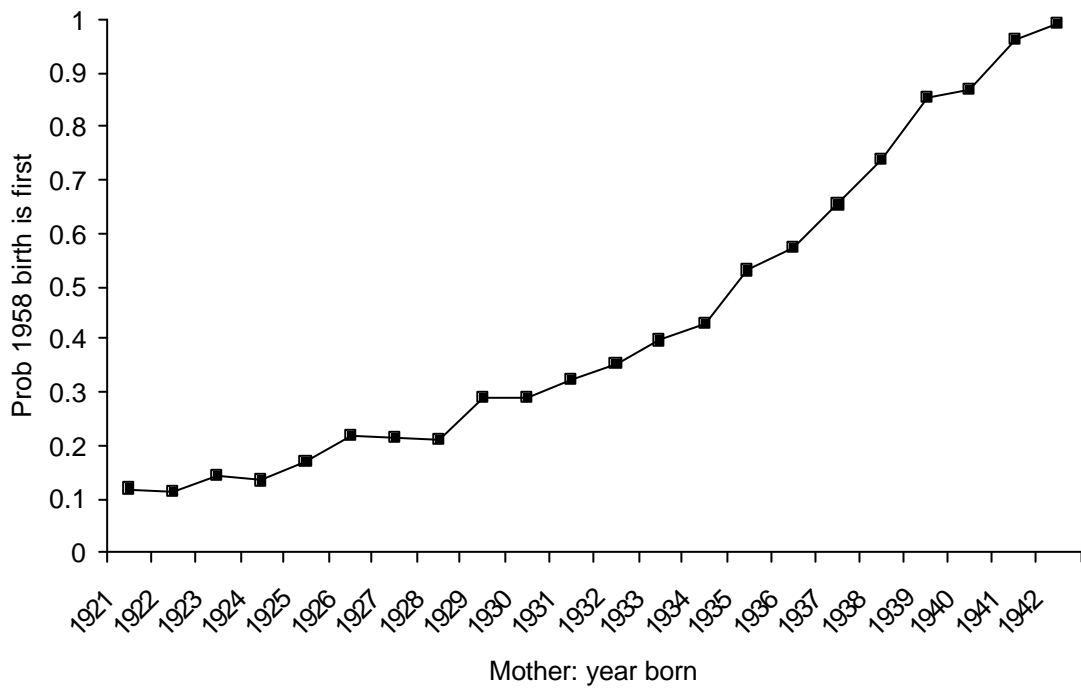


Figure 3: Average age mother left education by year of birth.



Note: Estimated coefficient from dummy variables on year born on years of education, including controls for region.

Figure 4: Effect of change in school leaving age by social class.

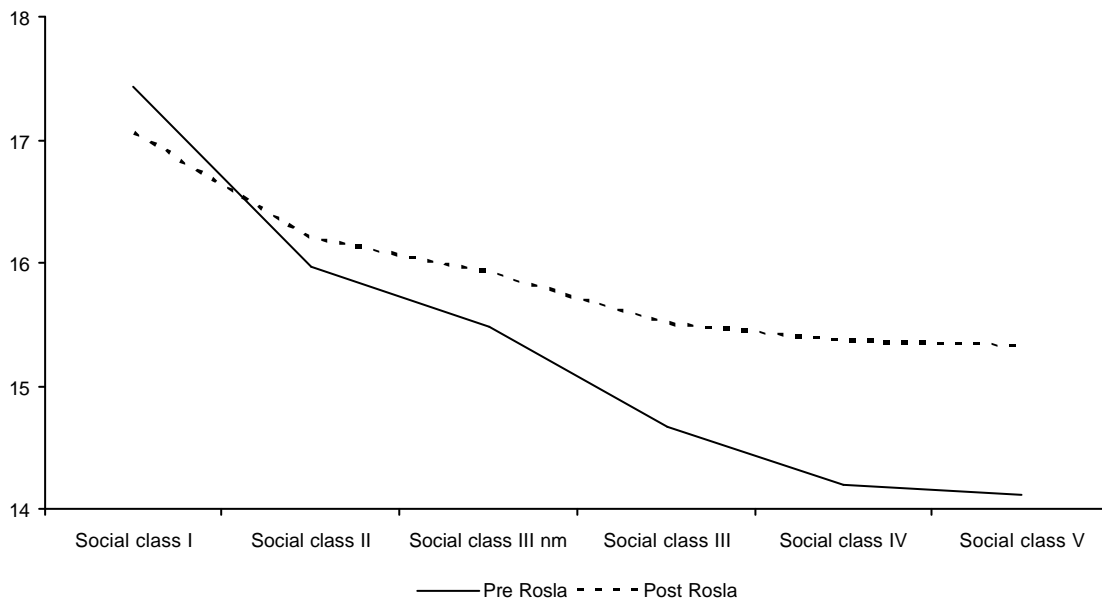


Figure 5: Number of siblings and educational attainment

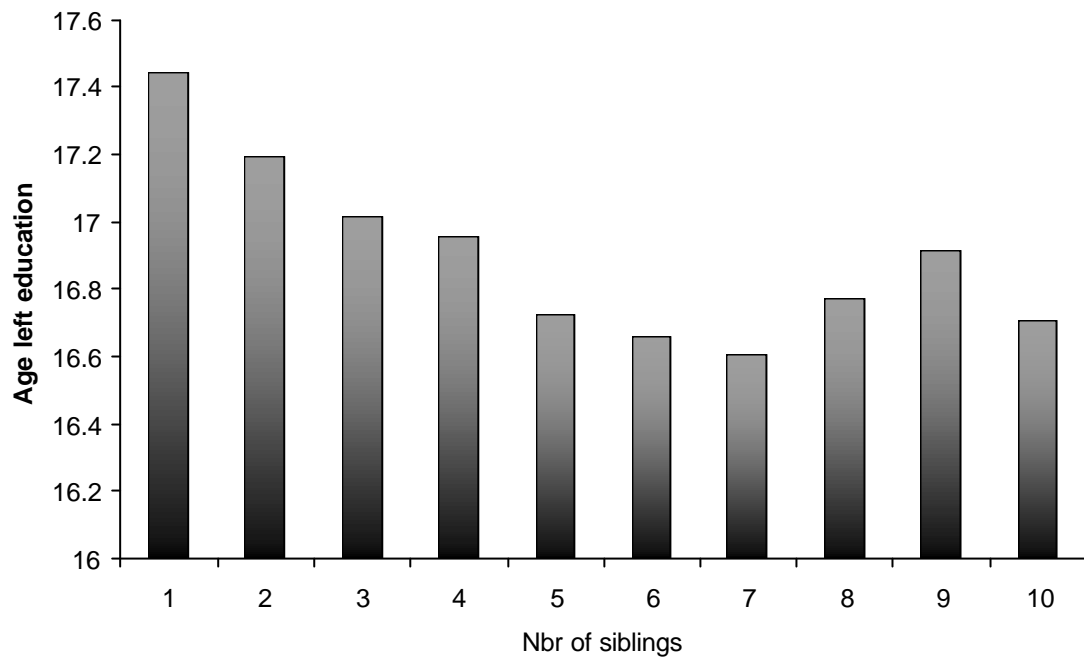


Figure 6a: Average birth weight by age mother left education –pre-RoSLA

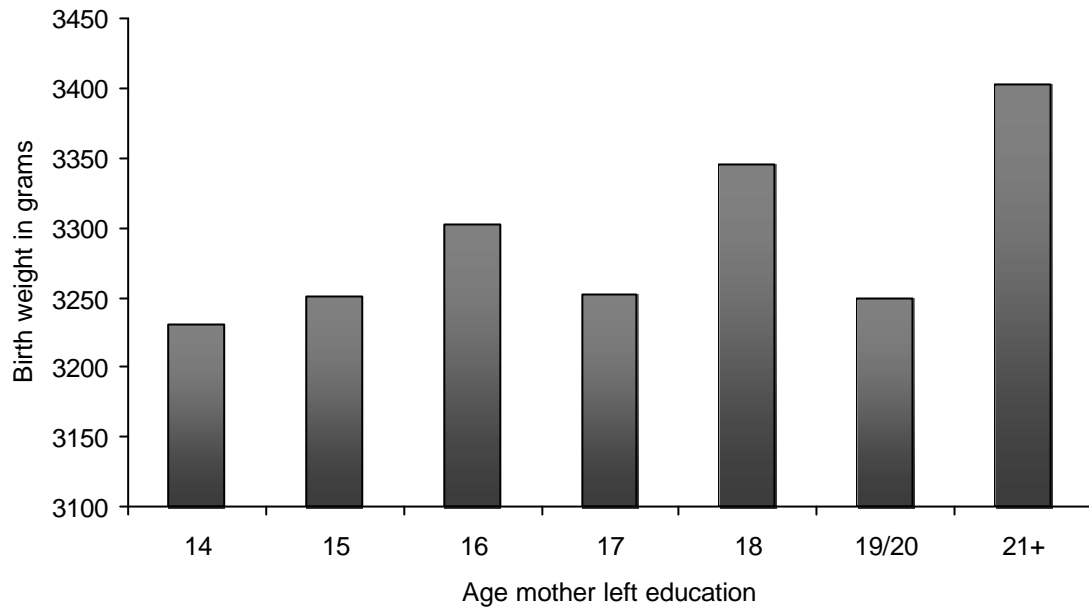
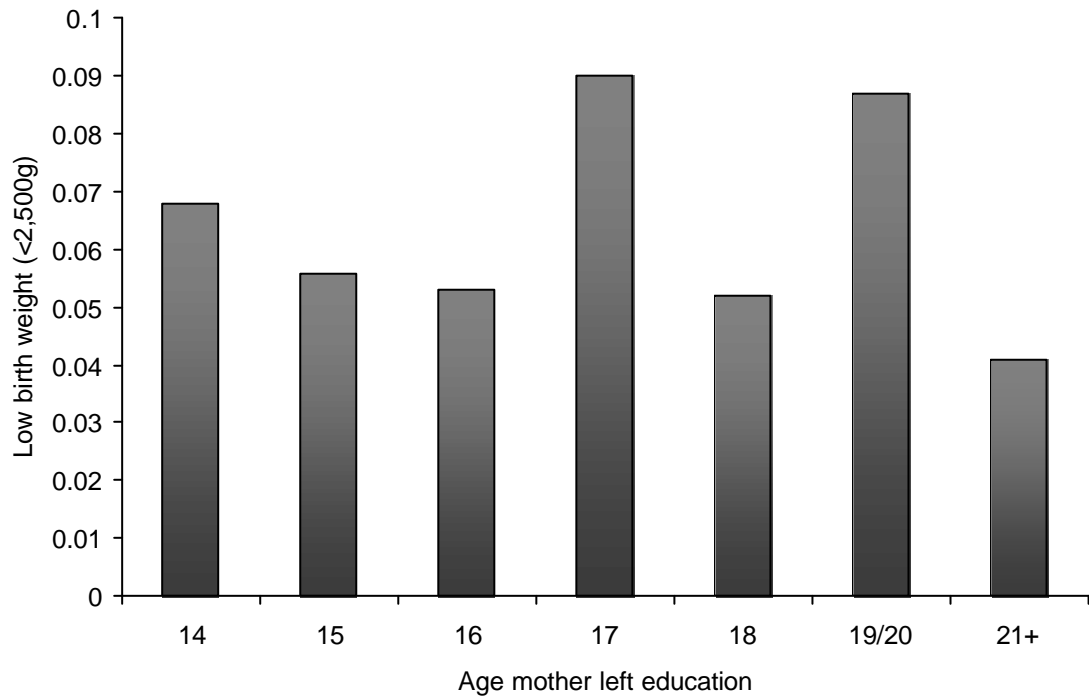


Figure 6b: Average birth weight by age mother left education –post RoSLA



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Annex 1: Sample selection

Table A1: Number of observations at selection stages

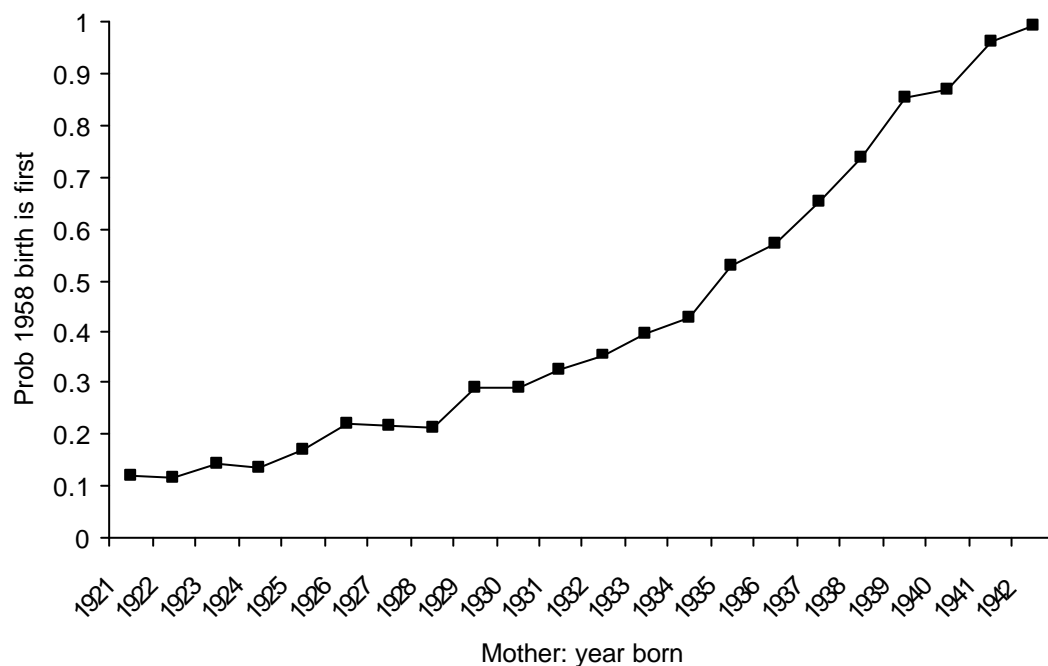
Selection criteria	Observations
NCDS Perinatal Mortality Survey	17,414
Maternal education missing	11,173
Mother born in UK	10,336
Mother year of birth missing	10,017
Mother defier on school reform ^a	9,610
Mother aged less than 16 or more than 39	9,122
Mother birth order missing	8,991
Twin birth ^b	8,835
First birth in 1958 only	3,412
Low birth weight missing ^c	3,398
Birth weight (in grams) missing	3,287

Note: ^a Mother claiming to have finished schooling at a lower age than minimum school leaving age.

^b The selection variable is independent of the control variables used in Model 2

^c Missing birth weight is proxied as being under or above 2,500g, so a dummy for low birth weight can be created even for observations with missing birth weight

Figure A1: Probability of 1958 being first by maternal year of birth



Note: Based on estimates from Table 1

Annex 1:

Table A1: First stage results with all instrument sets

Age mother left education	IV 1 RoSLA	IV 2 RoSLA & Interactions grand dad social class	IV 3 Maternal birth order & number of siblings	IV 4 All instruments
Maternal grand dad - social class II	-1.278 (4.26)	-1.469 (3.51)	-1.307 (4.42)	-1.463 (3.52)
Maternal grand dad - social class, Non Manual III	-1.692 (5.38)	-1.974 (4.42)	-1.711 (5.52)	-1.989 (4.48)
Maternal grand dad – social class IV	-2.291 (8.07)	-2.779 (7.07)	-2.268 (8.09)	-2.723 (6.97)
Maternal grand dad – social class V	-2.558 (8.97)	-3.259 (8.27)	-2.489 (8.83)	-3.137 (8.02)
Maternal grand dad – social class VI	-2.601 (9.16)	-3.323 (8.40)	-2.451 (8.71)	-3.144 (7.99)
Maternal grand dad – social class missing / no dad	-2.293 (7.95)	-2.750 (6.82)	-2.224 (7.80)	-2.668 (6.66)
Mother underweight	-0.014 (0.12)	-0.012 (0.11)	-0.043 (0.39)	-0.040 (0.36)
Mother overweight	-0.224 (3.38)	-0.226 (3.43)	-0.222 (3.41)	-0.224 (3.44)
Mother obese	-0.343 (4.90)	-0.324 (4.74)	-0.335 (4.79)	-0.327 (4.78)
Mother school leaving age 15	0.772 (2.47)	-0.298 (0.54)		-0.338 (0.63)
Maternal grand dad - social class II * SLA15		0.604 (1.08)		0.563 (1.01)
Maternal grand dad - social class, N. M. III * SLA15		0.838 (1.41)		0.860 (1.45)
Maternal grand dad – social class IV * SLA15		1.221 (2.30)		1.191 (2.26)
Maternal grand dad – social class V * SLA15		1.561 (2.94)		1.496 (2.83)
Maternal grand dad – social class VI * SLA15		1.585 (2.99)		1.552 (2.94)
Maternal grand dad – missing / no dad * SLA15		1.173 (2.18)		1.174 (2.19)
Mother’s birth order: 2			-0.153 (2.39)	-0.146 (2.28)
Mother’s birth order: 3			-0.033 (0.40)	-0.021 (0.26)
Mother’s birth order: 4			-0.080 (0.93)	-0.073 (0.87)
Mother’s birth order: 5			-0.083 (1.09)	-0.095 (1.26)
Mother’s birth order: 6			-0.032 (0.35)	-0.041 (0.44)
Mother’s birth order: 7			0.145 (0.87)	0.170 (1.03)
Mother’s birth order: 8			-0.244 (2.36)	-0.221 (2.15)
Mother’s birth order: 9			-0.511 (3.39)	-0.413 (2.60)
Mother’s birth order: 10			-0.220 (1.27)	-0.214 (1.23)
Mother’s number of siblings: 2			-0.245 (2.27)	-0.249 (2.31)
Mother’s number of siblings: 3			-0.423	-0.427

Mother's number of siblings: 4			(3.84)	(3.87)
			-0.481	-0.494
			(4.16)	(4.29)
Mother's number of siblings: 5			-0.717	-0.721
			(6.29)	(6.33)
Mother's number of siblings: 6			-0.783	-0.772
			(7.10)	(7.04)
Mother's number of siblings: 7			-0.833	-0.815
			(6.88)	(6.71)
Mother's number of siblings: 8			-0.669	-0.697
			(5.12)	(5.32)
Mother's number of siblings: 9			-0.531	-0.551
			(3.61)	(3.63)
Mother's number of siblings: 10			-0.738	-0.748
			(5.15)	(5.29)
Constant	16.924	17.331	17.441	17.826
	(54.30)	(43.73)	(53.53)	(43.78)
Observations	3287	3287	3287	3287
R-squared	0.15	0.17	0.18	0.20

Note: Linear regression of age mother left education. Omitted categories are Maternal grand dad social class I, mother born in 1921 and the North West region. The regression includes dummies for maternal year of birth and region of residence. Robust standard errors are used to compute the reported t-statistics in parentheses.