High Birth Weight and Socio-Economic Status

Rachel Webb

University of Canterbury

ABSTRACT

The positive effect of socio-economic status on a wide range of health outcomes is widely acknowledged. In the context of infant health, socio-economic status has been shown repeatedly to lower the risk of low birth weight. The effect of socio-economic status on high birth weight, however, has not received much attention from health economists. In this paper, I propose a model where actions to prevent low birth weight increase the risks of high birth weight which leads to socio-economic status having a positive relationship with high birth weight. I then test my predictions empirically using two different datasets of birth outcomes in the United States.

ACKNOWLEDGEMENTS

I would like to thank the PRAMS Working Group and the Centers for Disease Control and Prevention for allowing me to use their data. I would also thank my thesis supervisor, Dr. Andrea Menclova for a great deal of help and guidance with this paper.

INTRODUCTION

Socio-economic status is highly positively correlated with a number of good health outcomes. Grossman's seminal paper, 'On the concept of health capital and the demand for health, (1972)' modelled education as increasing health outcomes as educated people are more informed about health inputs and also use them more effectively[1]. As health inputs such as preventative medical care are generally considered to be normal goods, as income increases, people increase their consumption of health inputs leading to better health outcomes. Marital status is also linked to better health outcomes, arguably because married people have more incentive and ability to invest in health inputs. Although the causality from socio-economic status indicators to generally positive health outcomes may be debateable, the correlation is irrefutable. This correlation can be seen clearly when it comes to the likelihood of giving birth to a low birth weight baby. Numerous studies in the health economics literature have found a strong negative relationship between socio-economic status and incidence of low birth weight as discussed in the next section. This relationship holds even when controlling for confounding factors such as age, ethnicity, and parity.

In recent times, the issue of high birth weight has become increasingly apparent. Recent research suggests giving birth to babies over 4,500g carries significant risks to both the infant and the mother. An increased risk of shoulder dystocia has been identified by a number of studies to be associated with high birth weight ([2];[3];[4]). Other foetal afflictions such as still birth, Erb's palsy, neonatal jaundice, and respiratory distress have been found to be more common in high birth weight babies than normal weight ones [5]. High birth weight is also associated with an increased risk of infant mortality [6, 7]. Delivering a high birth weight baby also leads to maternal complications such as vaginal, perineal and cervical tears [8].There also appears to be a higher prevalence of obesity later in life for high birth weight babies [9, 10]. The propensity of high socio-economic status people to avoid negative health outcomes could also demonstrate itself in a lower incidence of high birth weight births. However, the available evidence does not support this conjecture.

The medical literature has largely ignored the effect of socio-economic status on the likelihood of giving birth to a high birth weight baby. To my knowledge, no studies have addressed the effect of income or wealth on the risk of high birth weight. The effects of education and marital status on high birth weight have been addressed by some studies and have been found to be positively correlated with high birth weight as discussed in the next section.

To my knowledge, Cesur and Kelly (2010) is the only health economics study examining high birth weight[11]. The authors examine the effect of high birth weight on cognitive outcomes during childhood. To rule out omitted variable bias, they examine the relationship between high birth weight and socio-economic status. They find that although socio-economic status is highly correlated with low birth weight it is not correlated with high birth weight, with or without controlling for confounding factors.

This paper endeavours to explore the relationship (or lack thereof) between high birth weight and socio-economic status and to find the magnitude and robustness of any relationship to additional controls. I first propose a model where the probabilities of giving birth to a baby with low, normal or high birth weight is a monotonic function of inherited maternal characteristics and purposeful actions undertaken by the mother (e.g. stress avoidance, quitting smoking, eating adequately, etc.). Under reasonable assumptions about the effect of wealth, education, and marital status on the demand for actions, I show that increasing socio-economic status increases the amount of actions undertaken by the mother which in turn can either decrease or increase the likelihood of having a high birth weight baby. I introduce these outcomes as two competing hypotheses about the effect of socio-economic status on high birth weight.

My empirical analysis uses data from the Pregnancy Risk Assessment Monitoring System (PRAMS) and the Natality Detail File (NDF). PRAMS is a survey run by the US Center for Disease Control and Prevention (CDC) annually from 1988 to 2008 over 44 states sampling between 1,300 and 3,400 women within each cohort. The NDF covers all births in the United States and includes information on education and marital status. I use data from 2003 to 2009 (substantial revisions to the way data was collected were undertaken in 2003 and 2009 is the last year of data available).

In the empirical section below, I first examine descriptive statistics to determine whether major socio-economic indicators such as income, education and marital status appear to be correlated with the prevalence of high birth weight. I then attempt to replicate the findings of Cesur and Kelly(2010) and proceed to test the robustness of any relationship found to additional controls and explore what factors seem to be driving the relationship.

Descriptive statistics indicate that income, education and being married are positively correlated with the incidence of high birth weight. Attempting to estimate Cesur and Kelly’s (2010) regressions on a different dataset yields some discrepancies with their results. Contrary to their findings (but consistent with my theoretical model), my results seem to indicate that socio-economic status is negatively correlated with high birth weight risk.

BACKGROUND LITERATURE

Socioeconomic status and health

The relationship between socio-economic status and general health outcomes has been studied extensively by health economists. Generally, high socio-economic status in the form of higher education, higher income and being married rather than single leads to better health outcomes.

The notion that health and education are positively correlated is well supported; however, the mechanism underlying this relationship is unclear. Poor health may impede learning, therefore lowering education, education may increase health outcomes if education increases awareness about health in general, or a third factor may be related to both health and education. Grossman (1972) described a mechanism for how education may be causally related to health. If educated people are better informed about health inputs they will both use more health inputs and use them more effectively, increasing health outcomes. This hypothesis is supported by evidence from the US[12] and UK[13] using changes in compulsory schooling law as an instrument. Fuchs (1982) proposes another hypothesis that time preferences may be a third factor driving the relationship; since education and health outcomes both require substantial investment and delayed payoffs, individuals with high discount rates will have lower investment in both health and education and vice versa.

Income or wealth are generally agreed to be correlated with good health outcomes[14]. However, similar to education, the relationship is not necessarily a straight causal one from income to health. Higher incomes of course allow for greater spending on health inputs, but it may also be the case that poor health interferes with one's earning capacity.

Vast evidence in the health literature supports the notion that being married improves health outcomes. Coombs (1991) reviews the literature on the effect of marital status and well-being and finds that available evidence strongly suggests that married people tend to have a lower incidence of illness and greater longevity. This relationship is suggested by some to arise due to selection, sickly people are less likely to marry, but Coombs also finds extensive support for a causal explanation, where protection and support from the spouse improves health outcomes[15].

Many studies in the health literature provide evidence that low socio-economic status is strongly related to a higher likelihood of giving birth to a low birth weight baby. Jonas, Roder, and Chan (1992) examined 12,047 births in Adelaide and found that women residing in low socio-economic areas had a higher chance of having a low birth weight baby and general poor pregnancy outcomes[16]. Pattenden, Dolk and Vrijheid (1999) examined births in England and Wales and found that 30% of low birth weight incidence can be described by socio-economic status. They conclude that: "If the 'experience of the currently most healthy groups' with respect to low birth weight could be achieved by all, then up to 30% of low birth weights might be avoided"[17]. Other research shows that higher education[18], income[19] and being married[20] are associated with a lower risk of low birth weight.

SES and High birth weight

Few studies examine the effect of socio-economic status factors on the likelihood of giving birth to a macrosomic infant. To my knowledge, no studies have addressed the effect of income or wealth on the risk of high birth weight. The effect of education and marital status has received limited attention. Frank, Frisbee & Pullum (2000) found women with less than 12 years of education were about 20% less likely to have a high birth weight infant than women with more than 12 years[21]. Ourskou et. al. (2003) found women with 10 or more years of education and women who were living with a partner had higher risks of high birth weight[22]. Boulet et al (2003) also found higher rates of educational attainment and marriage for women who delivered babies weighing over 4,000g compared to women who delivered normal weight babies[6] but no multivariate analyses were used to determine if this higher proportion remained after controlling for other factors such as ethnicity.

Cesur & Kelly (2010) examined the effect of high birth weight on cognitive outcomes at a later age. To my knowledge, this is the only study on high birth weight in the health economics literature. By using mother's pregnancy weight gain, gestational age, and mother's age as instrumental variables, they found that high birth weight had a negative effect on cognitive outcomes. They addressed the possibility of socio-economic status being an omitted variable that could influence both birth weight and cognitive outcomes but found that socio-economic status was a poor predictor of high birth weight (unlike low birth weight) so concluded it was unlikely to bias their results. This is a surprising result, due to the large influence socio-economic status has on most health outcomes and, in particular, low birth weight.

Potential Confounders with socioeconomic status and birth outcomes

There are two potential avenues that socio-economic status could affect birth weight; through the effect on characteristics and behaviours. Socio-economic status may be related (causally or not) to inherent characteristics of the mother at the time of conception and/or socio-economic status may influence the behaviours undertaken during pregnancy.

High socio-economic status women could plausibly differ in their characteristics that may also influence birth weight. For example, maternal characteristics that could potentially differ with socio-economic status include ethnicity, age, birth order, and weight. Maternal pre-pregnancy Body Mass Index (BMI) has been found to be associated with the incidence of high birth weight in a number of studies[23];[2];[21] and maternal age[24];[21];[6], parity [21], and ethnicity [2] are also important predictors.

Another potential confounder is the gender of the infant. Male infants tend to be larger and evidence shows that this extends to having a higher risk of high birth weight [21];[2]. If left unaccounted for, this could conflate our results as according to Trivers and Willard (1973), the sex ratio can be increased by factors that enhance reproductive success. Since females tend to marry men of higher socio-economic status than themselves being born of high socio-economic status will have less effect on their ability to find a partner than it does for males. Therefore, a higher socioeconomic status at birth improves the reproductive success for males by a greater factor than females, consequently we would expect to see a positive relationship between socio-economic status and the sex ratio [25]. Almond and Edlund (2007) find evidence to support this so-called

“Trivers-Willard Hypothesis”; analysing all births to white mothers between 1983-2002, they find higher education and being married both correlate with a higher likelihood of having a male infant[26].

Birth weight can also be affected by behaviours undertaken during pregnancy. Weight gain during pregnancy is commonly found to be associated with high birth weight[27]. Vitamin intake may increase the likelihood of giving birth to a high birth weight baby; in particular, iron supplementation is recommended for foetal growth and a number of studies have shown a positive correlation between iron supplementation and birth weight [28];[29];[30]. Non-smoking has been associated with an increased incidence of high birth weight [24];[6];[2]. Other factors such as stress avoidance and pre-natal care could also plausibly influence birth weight.

MODEL

Birth weight can be sorted into three categories; low birth weight, normal birth weight and high birth weight. Birth weight cannot be perfectly controlled but the actions taken by the mother can influence the probabilities of having a baby in each of the three categories. Certain actions can be undertaken by the mother to reduce the probability of low birth weight, such as quitting smoking, consuming more calories, taking prenatal-vitamins etc. However, these actions may also have the effect of increasing the probability of high birth weight. Recognising that low, normal and high birth weight are mutually exclusive categories that encompass all outcomes, we can state:

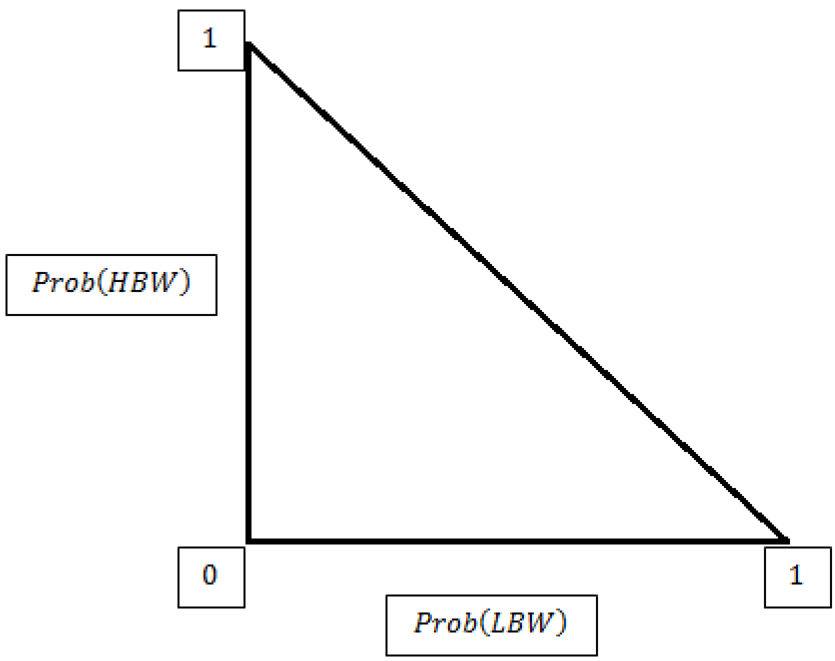
$$Prob(LBW) + Prob(NBW) + Prob(HBW) = 1$$

I define the infant's health function as:

$$H_{Infant} = Prob_{LBW} \times H_{Infant}^{LBW} + Prob_{NBW} \times H_{Infant}^{NBW} + Prob_{HBW} \times H_{Infant}^{HBW}$$

Where H_{Infant}^{LBW}, H_{Infant}^{NBW}, and H_{Infant}^{HBW} are constants representing the effect of low, normal, and high birth weight on infant health, respectively. As there are three different mutually excludable outcomes with different associated probabilities, we can model the infant's health function using a Marschak triangle[31]. The Marschak triangle demonstrates the range of all possible probabilities of the three outcomes by assigning the probabilities of two of the outcomes on the axes with a line drawn between the two axes at the probability=1 for either possible outcome. I have assigned the probability of high and low birth weight to the two axes, so the probability of having normal birth weight can be calculated by:

$$Prob(NBW) = 1 - Prob(LBW) - Prob(HBW)$$



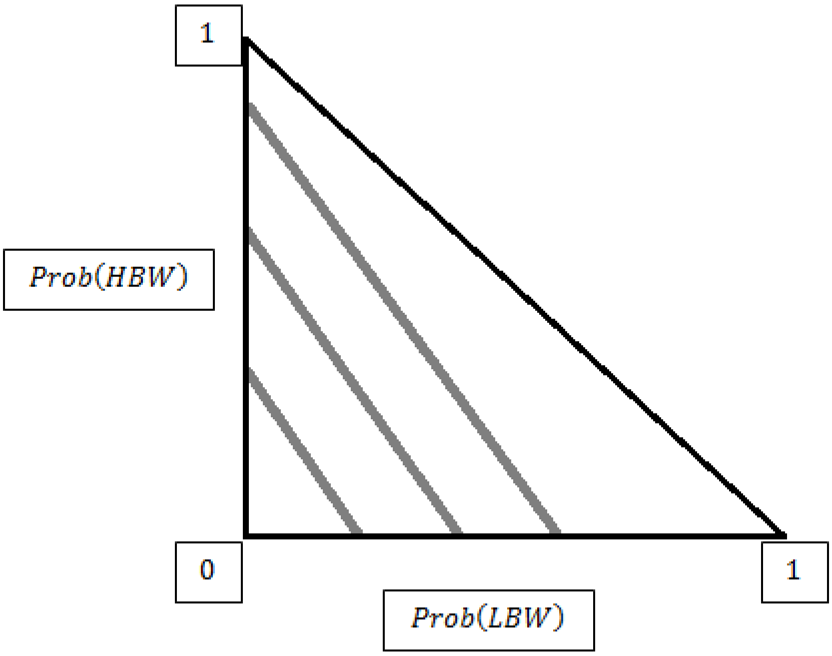
The slope of the indifference curves is given by:

$$\frac{\partial Prob(HBW)}{\partial Prob(LBW)} = -\frac{\frac{\partial H_{Infant}}{\partial Prob(LBW)}}{\frac{\partial H_{Infant}}{\partial Prob(HBW)}} = -\frac{H_{Infant}^{LBW} - H_{Infant}^{NBW}}{H_{Infant}^{HBW} - H_{Infant}^{NBW}}$$

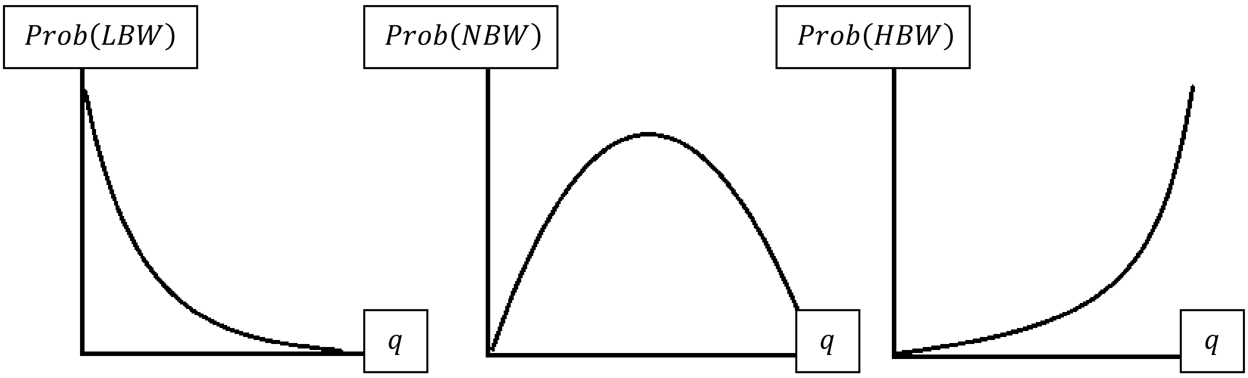
Assuming that low birth weight has a more detrimental effect on health than high birth weight, then:

$$\left|H_{Infant}^{LBW} - H_{Infant}^{NBW}\right| > \left|H_{Infant}^{HBW} - H_{Infant}^{NBW}\right|$$

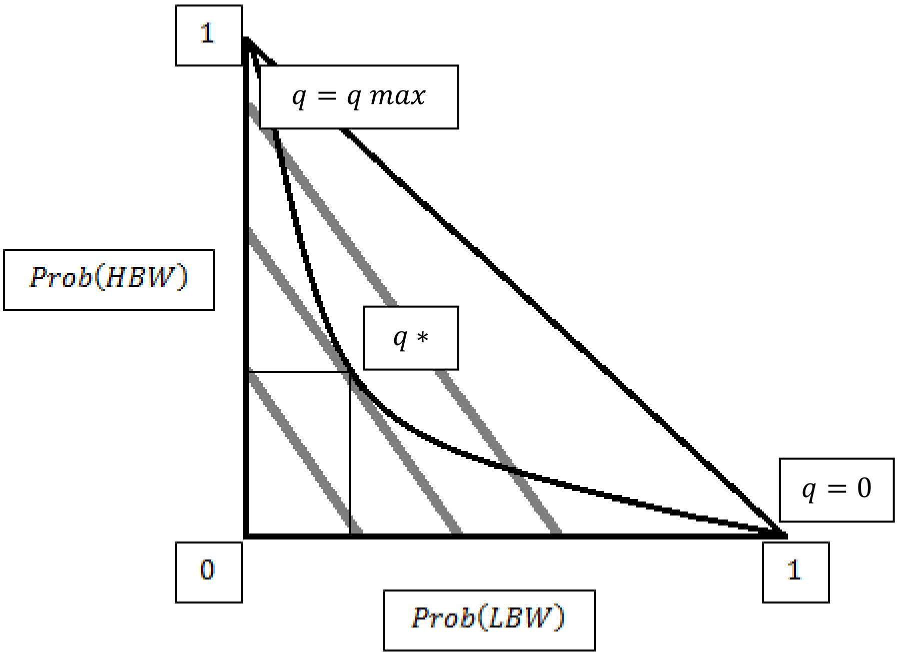
Therefore, the slope of the indifference curves must be steeper than the hypotenuse. We can draw some indifference curves on the Marschak triangle:



If we assume that actions have a diminishing effect on the probability of low birth weight we can model the effect of actions (q) on the birth weight probabilities:

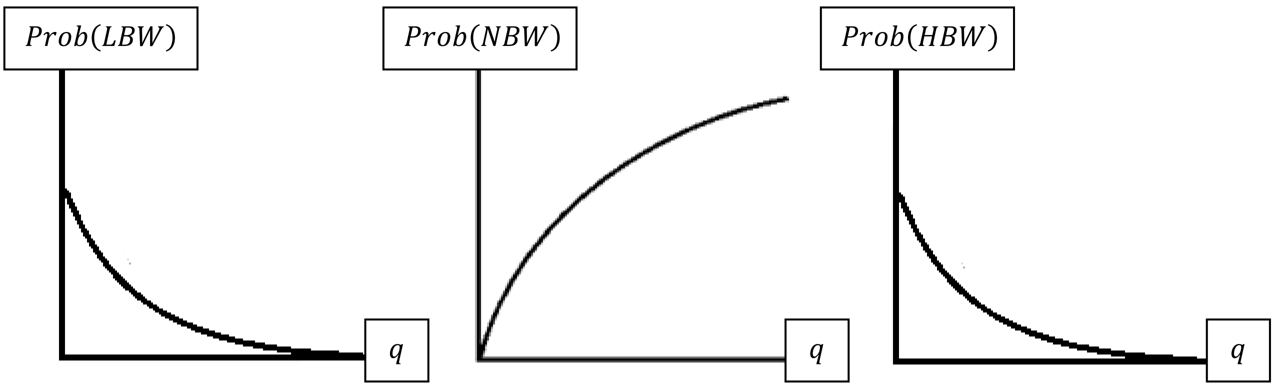


This can be shown as a path of q on the Marschak triangle which allows us to find the optimal level of q, given no constraints:

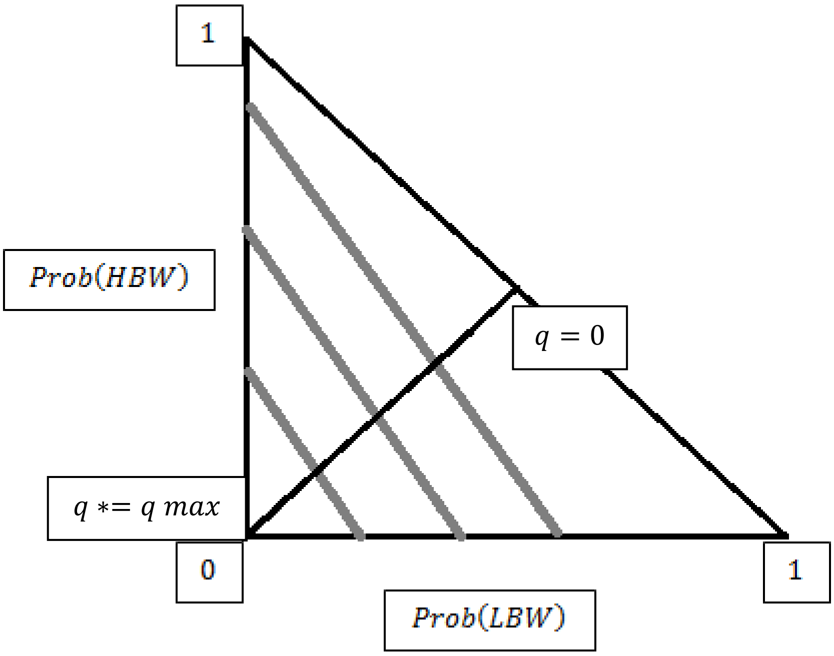


Here we can see that if actions are costless, mothers will choose a level of action that gives a higher probability of high birth weight than low birth weight.

An alternative possibility is that actions such as using pre-natal care, eating healthier etc. may reduce both the probability of low and high birth weight, and by induction increase the probability of normal birth weight.



On the Marschak triangle this gives a different optimal outcome:



With this assumption, the optimal amount of actions is the maximum actions that can be taken to bring about certainty of normal birth weight.

This analysis is missing a vital component: the constraints. Actions would not be costless, and mothers would have to decide on the best allocation of their resources across actions and general consumption to maximise their own utility.

Building on the static version of Grossman's demand for health and health capital model[1], I assume that utility of the mother is a function of the mother's own health, her infant's health and other consumption. This allows me to define an optimisation model:

$$\max_{q,Z} U = U\left(H_{Infant}, H_{Mother}, Z\right)$$

$$s.t.\ H_{Infant} = Prob_{LBW} \times H_{Infant}^{LBW} + Prob_{NBW} \times H_{Infant}^{NBW} + Prob_{HBW} \times H_{Infant}^{HBW}$$

$$Prob_{LBW,NBW,HBW} = f(q,x)$$

$$M \geq Pq + Z$$

Where:

$$H_{Infant} = \begin{cases} H_{Infant}^{LBW}\ if\ LBW = 1 \\ H_{Infant}^{NBW}\ if\ NBW = 1 \\ H_{Infant}^{HBW}\ if\ HBW = 1 \end{cases}$$

$$LBW = \begin{cases} 1\ if\ b < 2500 \\ 0\ if\ b \geq 2500 \end{cases}$$

$$NBW = \begin{cases} 1\ if\ 2500 \leq b > 4500 \\ 0\ if\ b \geq 4500\ or\ b < 2500 \end{cases}$$

$$HBW = \begin{cases} 1\ if\ b \geq 4500 \\ 0\ if\ b < 4500 \end{cases}$$

In this series of equations , H_{Infant} denotes the health stock of the infant, H_{Mother} denotes the health stock of the mother, Z denotes a composite good representing all other consumption, $Prob_i$ represents the probability of giving birth to a baby of low (LBW), normal (NBW), or high (HBW) birth weight, the vector $\boldsymbol{x}$ denotes exogenous characteristics of the infant and the mother that affect birth weight such as ethnicity, region, age, parity etc., q denotes actions undertaken by the mother to influence birth weight (e.g., eating, quitting smoking, stress avoidance), M is income and P the cost of actions (q). We assume H_{Mother} is a constant.

Given that the three birth weight outcomes account for all possible outcomes and are mutually exclusive, we can rewrite the infant health function:

$$H_{Infant} = Prob_{LBW} \times H_{Infant}^{LBW} + (1 - Prob_{LBW} - Prob_{HBW}) \times H_{Infant}^{NBW} + Prob_{HBW} \times H_{Infant}^{HBW}$$

$$H_{Infant} = Prob_{LBW} \times \left(H_{Infant}^{LBW} - H_{Infant}^{NBW}\right) + H_{Infant}^{NBW} + Prob_{HBW} \times \left(H_{Infant}^{HBW} - H_{Infant}^{NBW}\right)$$

The marginal utility of actions can be described as:

$$\frac{\partial U}{\partial q} = \frac{\partial U}{\partial H_{Infant}} \cdot \frac{\partial H_{Infant}}{\partial Prob_{LBW}} \cdot \frac{\partial Prob_{LBW}}{\partial q} + \frac{\partial U}{\partial H_{Infant}} \cdot \frac{\partial H_{Infant}}{\partial Prob_{HBW}} \cdot \frac{\partial Prob_{HBW}}{\partial q}$$

$$\frac{\partial U}{\partial q} = \frac{\partial U}{\partial H_{Infant}} \cdot (H_{Infant}^{LBW} - H_{Infant}^{NBW}) \cdot \frac{\partial Prob_{LBW}}{\partial q} + \frac{\partial U}{\partial H_{Infant}} \cdot (H_{Infant}^{HBW} - H_{Infant}^{NBW}) \cdot \frac{\partial Prob_{HBW}}{\partial q}$$

The tangency condition states that:

$$\frac{\partial U}{\partial q} = P \times \frac{\partial U}{\partial Z}$$

Hence $\frac{\partial U}{\partial q}$ must be strictly positive. Since low birth weight and high birth weight have negative health consequences we can say that:

$$(H_{Infant}^{LBW} - H_{Infant}^{NBW}) < 0$$

$$(H_{Infant}^{HBW} - H_{Infant}^{NBW}) < 0$$

Since q decreases the likelihood of low birth weight $\frac{\partial Prob_{LBW}}{\partial q}$ must be negative, therefore:

$$\frac{\partial U}{\partial H_{Infant}} \cdot \frac{\partial H_{Infant}}{\partial Prob_{LBW}} \cdot \frac{\partial Prob_{LBW}}{\partial q} > 0$$

If we assume actions decrease the risk of high birth weight $\frac{\partial Prob_{HBW}}{\partial q}$ must also be negative, therefore:

$$\frac{\partial U}{\partial H_{Infant}} \cdot \frac{\partial H_{Infant}}{\partial Prob_{HBW}} \cdot \frac{\partial Prob_{HBW}}{\partial q} > 0$$

In this scenario the level of q chosen will be chosen simply where the utility from foregone consumption is equal to the utility gained from the marginal increase in infant health. Assuming both q and Z are normal goods, increasing income will increase $\tilde{q}$ and therefore decrease the risk of high birth weight. If we assume, like Grossman (1972), that education helps people to use health inputs more effectively, we could model this as P being a decreasing function of education. Hence, with higher education, the cost of undertaking actions is lower. For instance, educated women may have less difficulty researching how to improve birth weight, and therefore the initial search cost is lower. It follows that $\tilde{q}$ would increase with education and therefore decrease the risk of high birth weight. The effect of marital status could be explained by a higher $\frac{\partial U}{\partial H_{Infant}}$. If we assume that pregnancies of married women are more likely to be planned and on average would have a higher 'wantedness' then it is not unreasonable to assume in general the utility gained from a healthy infant would be higher for married women. Therefore being married would increase $\tilde{q}$, lowering high birth weight risk. Therefore, with the assumption that actions decrease high birth weight risk, we find that socio-economic status should decrease the incidence of high birth weight.

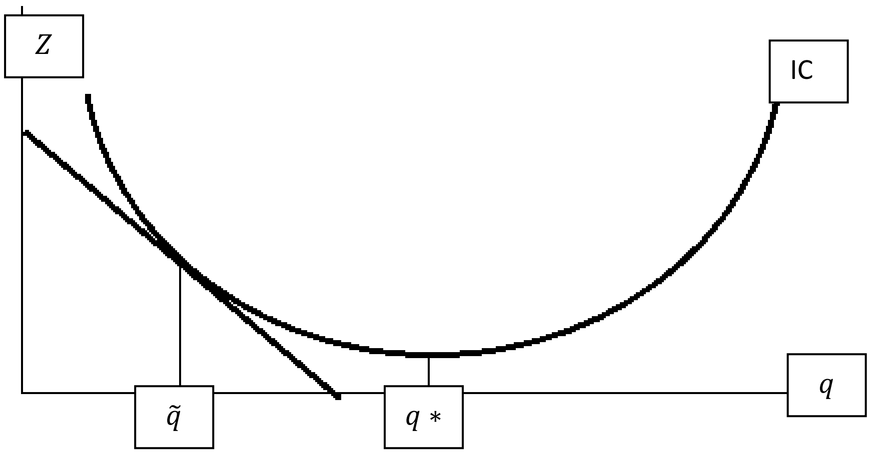
If however actions increase high birth weight risk then:

$$\frac{\partial U}{\partial H_{Infant}} \cdot \frac{\partial H_{Infant}}{\partial Prob_{HBW}} \cdot \frac{\partial Prob_{HBW}}{\partial q} < 0$$

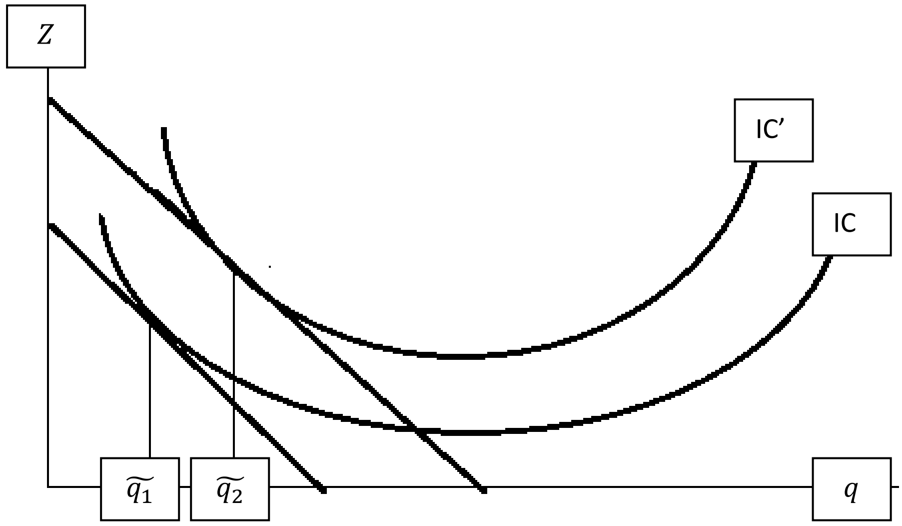
Given that the tangency condition tells us that the marginal utility from actions must be strictly positive we can conclude that:

$$\left| \frac{\partial U}{\partial H_{Infant}} \cdot \frac{\partial H_{Infant}}{\partial Prob_{LBW}} \cdot \frac{\partial Prob_{LBW}}{\partial q} \right| > \left| \frac{\partial U}{\partial H_{Infant}} \cdot \frac{\partial H_{Infant}}{\partial Prob_{HBW}} \cdot \frac{\partial Prob_{HBW}}{\partial q} \right|$$

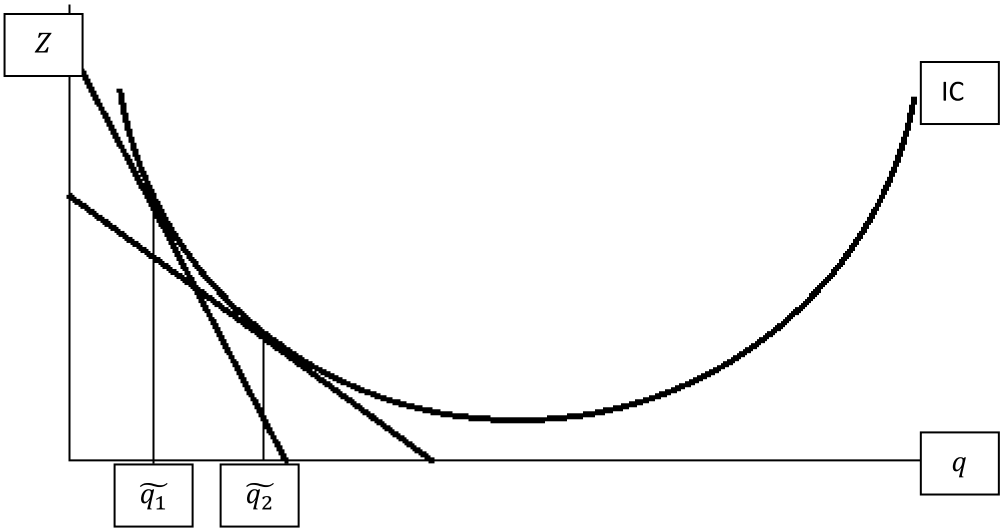
Therefore, the level of q chosen by the mother, $\tilde{q}$, will be lower than the level of q which would offset the negative consequences of low birth weight and hence maximise H_{Infant}. This can be shown with a U-shaped indifference curve, where the lowest point represents the level of actions needed to maximise H_{Infant}:



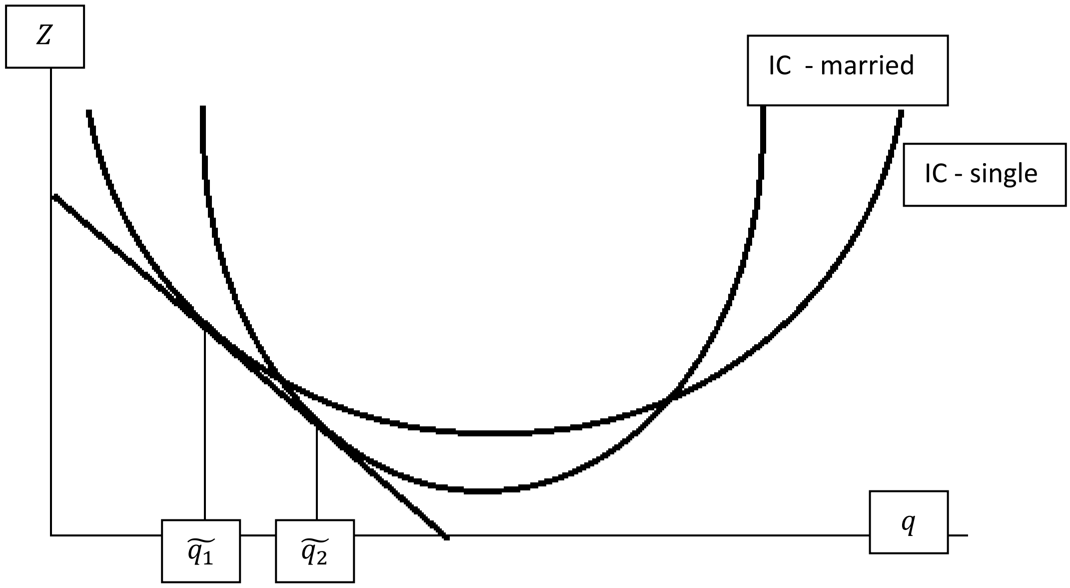
Assuming both q and Z are normal goods, increasing income will increase $\tilde{q}$:



Assuming, as explained above, that education reduces the price of actions we can demonstrate that increasing education will increase the level of actions chosen. This is shown below with the Hicksian substitution effect for a change in the price of q:



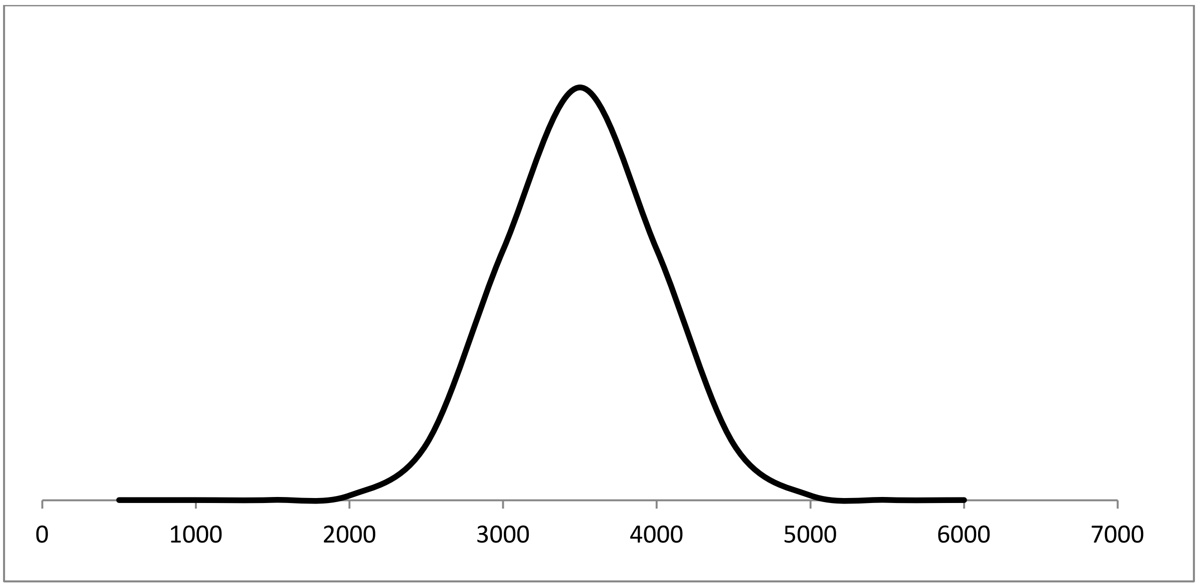
Assuming married women have a higher $\frac{\partial U}{\partial H_{Infant}}$ would produce a narrower indifference curve:



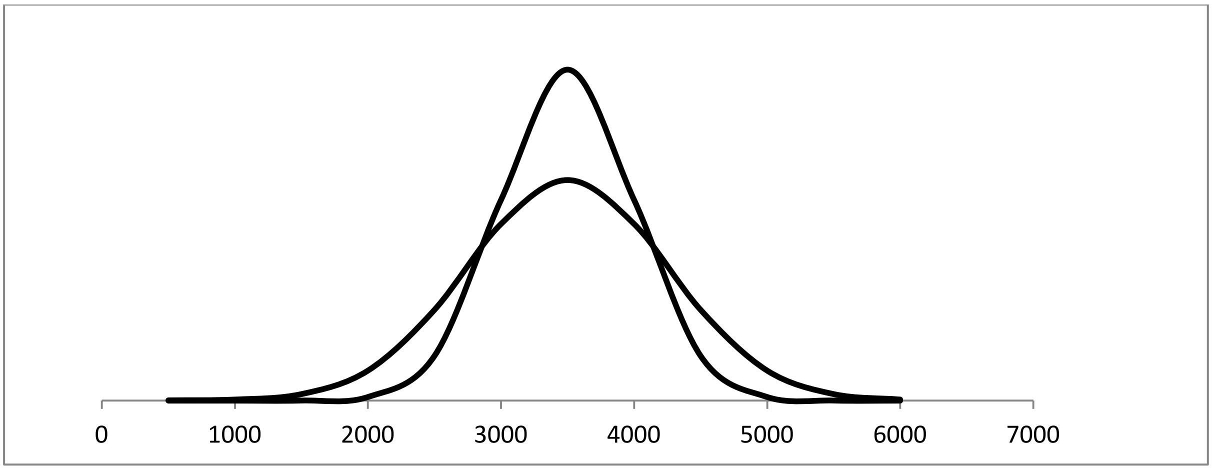
Similarly to the effect of education, being married would increase the level of actions chosen.

Under either assumption about the effect of actions on high birth weight risk, we get the conclusion that socio-economic status will increase the level of actions chosen. Therefore the effect of socio-economic status on high birth weight risk could be either negative or positive. Either way we would expect high socio-economic status women to have a lower risk of low birth weight and a higher likelihood of normal birth weight.

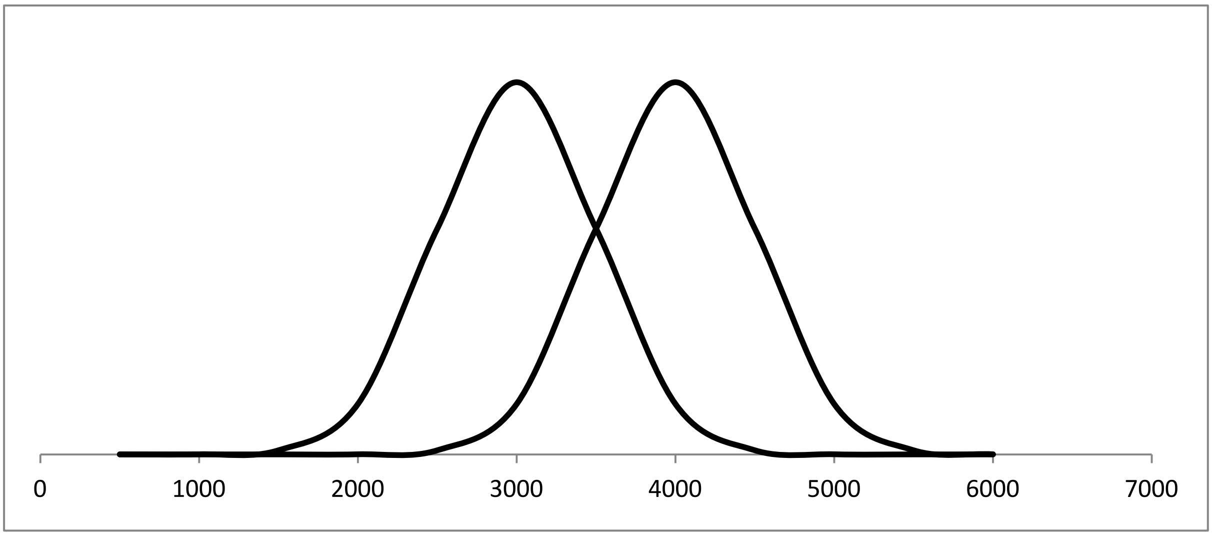
We can show the effect of socio-economic status on birth weight predicted by this model by showing the distributional shifts. Starting with a normal distribution of birth weight:



If actions reduce the risk of high birth weight, the effect of increasing socio-economic status can be shown as a tightening of the distribution, or a decrease in the variance:



Under the assumption of actions increasing high birth weight risk, my model predicts that socio-economic status increases birth weight, hence this could be shown as a shift in the distribution of birth weight:



This leaves us with two competing hypotheses:

> Hypothesis 1: High socio-economic people are better able to avoid negative health outcomes and therefore will have a lower incidence of high birth weight
> Hypothesis 2: High socio-economic people have higher birth weight over all levels as they are better able to avoid low birth weight but this translates into a higher incidence of high birth weight

DATA

NDF

The Natality Detail File (NDF) is a dataset that covers all live births in the United States dating back to 1968 and available up to 2009. In 2003, substantial revisions to the way data was collected were undertaken so I am only using data from 2003 onwards.

The large population of the USA and the high coverage of the data allow for an enormous sample; roughly 4 million births a year over 7 years of data provide me with about 28 million potential data points. In addition to information on birth weight, maternal pre-pregnancy weight and weight gain during pregnancy, the dataset also contains important demographic and socio-economic status variables such as ethnicity, marital status and education. Unfortunately, no information is available on income/wealth, height, or region of residence for the majority of the data set.

PRAMS

The Pregnancy Risk Assessment Monitoring System (PRAMS) is a survey run by the US Centre for Disease Control and Prevention (CDC) annually from 1988 to 2008 over 44 states which each sample between 1,300 and 3,400 women. The dataset does not represent a balanced panel as there are substantial gaps in state/year groups; most years cover fewer than 30 states. The sample draws from the NDF so only covers live births. The major benefit of this dataset is that it includes information unavailable in the NDF; most importantly, it includes a measure of household income which allows for a more thorough examination of the effect of socio-economic status on high birth weight risk.

In this analysis, I focus exclusively on singleton births. Multiple births present unique pregnancy and birth issues and also tend to produce much smaller babies, so the likelihood of babies in a multiple birth being of high birth weight is very low.

To measure socio-economic status, I create a dummy variable to indicate whether the woman was married and a set of dummy variables to indicate her education level. The categories for education are elementary only, high school dropout, high school completion, some college, and a college degree holder. In both data sets, I also create variables to indicate ethnicity, infant gender, mother's age, and whether the mother smoked during pregnancy. Ethnicity is defined with five different categories: white, black, Asian/Pacific Islander, American Indian/Alaskan native, and Hispanic. NDF recode the ethnicity variables to aggregate ethnicities from a more specific categorisation into the first four categories, and separately ask for the Hispanic origin of the mother. I use the four categories but when any Hispanic origin was indicated, I classify that to be the ethnicity. I follow the same procedure with the PRAMS data.

With the NDF, I also create variables for parity, pre-pregnancy weight, and weight gain during pregnancy. Parity is expressed with a set of dummy variables indicating if this was the first birth, second birth, etc. up to a parity of eight; higher parities are included in the highest category. A set of dummy variables are used to allow for a nonlinear effect (for instance, the effect of increasing parity from one to two may be different than the effect of going from three to four).

With the PRAMS data, I can create a set of dummy variables indicating the state of residence. With these, I also create a set of dummy variables indicating the census region of residence, (South, West, Northeast, and Midwest) and the census sub-regions (Mountain, Pacific, Southwest Central, Southeast Central, South Atlantic, Northwest Central, Northeast Central, Middle Atlantic, New England). Parity cannot be identified in the PRAMS data but first births can so I create a dummy variable indicating if this birth was the first for the mother. Mother's age is reported in the following groups: 17 or younger, 18-19, 20-24, 25-29, 30-34, 35-39, and 40 or older. The PRAMS data set has a measure of mother's height and weight so a BMI measure can be calculated and women classified into categories as underweight (BMI<20), normal weight (BMI 20-25), overweight (BMI>25), obese (BMI>30) and morbidly obese (BMI>35). The PRAMS data set collects household income information from respondents for the year preceding the birth. Unfortunately, the specific question asked differs across states, so aggregating the information into common variables proved difficult. To get the closest fit for the largest possible number of states, I create five categories of annual income: <$10,000, $10,000-$20,000, $20,000-$30,000, $30,000-$40,000, >$40,000. Some states had ranges that did not match these categories. In those cases, I rounded to the nearest category. Some states refused permission to income data and individuals within states were given the option to not answer the question.

For all variables where there is missing data, I create a dummy variable indicating that the information is missing.

METHOD

Initial analysis

I first examine the descriptive relationship between socio-economic status factors and birth weight. Using both data sets separately, I compare the percentages of married women among those who had a low birth weight baby (<2,500g), a high birth weight baby (>4,500g), and a normal birth weight baby. I repeat this for each category of education, and, for the PRAMS data, income categories as well. I also report the percentage of low and high birth weight for women in each education, income, and marital status category. As I wish for the counterfactual to be normal birth weight, from this point forward, all low birth weight babies are excluded from analysis.

Replicating Cesur and Kelly (2010)

My next step is replicating Cesur and Kelly's (2010) regressions that led them to conclude there was no correlation between socio-economic status and high birth weight. Cesur and Kelly (2010) use two data sets; the National Longitudinal Survey of Youth and the Early Childhood Longitudinal Study Kindergarten Cohort for their regression analysis, and run separate regressions with each data set. The data sets contain similar variables but information may be more precise in one data set. For example, their first data set contains information on the socio-economic status factors income, education, and marital status, whereas the other data set only includes a composite measure of socio-economic status. For my analysis, I will attempt to replicate the more precise measure from either data set they have used.

I use the same dependent variable as Cesur and Kelly (2010) which is a binary variable indicating whether had a birth weight greater than 4500g. I have been able to match the socio-economic status explanatory variables used in their analysis with some minor discrepancies. For marital status, their categories include single, married, and divorced. The PRAMS data set does identify divorcees but only for a fraction of the data set, so is therefore unreliable and I only include married and single as categories for marital status. For income, they have actual numbers whereas I only have grouped values. For education, our measures are identical.

Cesur and Kelly (2010) include the same set of controls in these regressions as they do for their main regressions. As Cesur and Kelly (2010) were not mainly focused on the effect of socio-economic status - they were instead addressing the effect of high birth weight on cognitive outcomes - some of these controls are inappropriate to include in a regression addressing the effect of socio-economic status on high birth weight risk and I exclude these from analysis. These variables are current age, whether the child was breast fed, child's current height and weight, current number of children to the mother, children books at home, and the highest qualification the child expects to obtain. Clearly, as these factors do not manifest until after birth there is no plausible way that they could influence birth weight and therefore are not relevant for inclusion in my regression analysis.

The only other discrepancies with their variable set is that in the PRAMS data, mother's age is in ranges and only an indication of whether the baby is firstborn is available; Cesur and Kelly (2010) have the mother's age in years and a variable indicating birth order. Cesur and Kelly (2010) include a variable for mother's BMI. I also include BMI using the PRAMS data set and I add its square to allow for a non-linear effect.

Cesur and Kelly (2010) report constants from Ordinary Least Squares (OLS) regression analysis in their paper. However, they also repeat their analysis using marginal effects from probit, results of which are unreported but I received through correspondence. I continue to use marginal effects from probit for consistency and as it is the more appropriate measure when using binary dependent variables. As the imperative aim in replicating Cesur and Kelly's (2010) regressions is to see if I also find the variables to be insignificant as opposed to comparing magnitudes, the choice of regression methods is less crucial.

The general form of the models I estimate using NDF and PRAMS (respectively) is as follows:

$$\begin{aligned} High\ Birth\ Weight &= \beta_0 + \beta_1 marital\ status + \beta_2 education + \beta_3 infant\ gender \\ &+ \beta_4 mother's\ weight\ + \beta_5 parity + \beta_6 ethnicity + \beta_7 mother's\ age \\ &+ \beta_8 mother's\ age\ squared + \beta_9 year + e \end{aligned}$$

$$\begin{aligned} High\ Birth\ Weight &= \beta_0 + \beta_1 marital\ status + \beta_2 education + \beta_3 income + \beta_4 infant\ gender \\ &+ \beta_5 mother's\ bmi + \beta_6 mother's\ bmi\ squared + \beta_7 first\ birth + \beta_8 ethnicity \\ &+ \beta_9 mother's\ age + \beta_{10} mother's\ age\ squared + \beta_{11} region\ of\ residence \\ &+ \beta_{12} year + e \end{aligned}$$

Further Analysis

After replicating Cesur and Kelly's (2010) regression, I subject the general form for the PRAMS data set to a number of robustness checks such as: altering the regions of residence used to census sub-regions and states, changing the dependent variable to indicate 'very high birth weight' (>5,000g), 'somewhat high birth weight' (>4,000g), and 'large for gestational age' (birth weight in the 90^{th} percentile or higher for the infant's gestation length),restricting the sample to only prime-age mothers between 20 and 35 years of age, using dummy variables for mother's BMI to indicate if she was underweight (BMI<20), overweight (BMI>25), obese (BMI>30), or morbidly obese(BMI>35) , and controlling for the number of people dependent on the household income.

With the NDF data set I also perform the robustness checks of changing the dependent variable to 'very high birth weight' and 'somewhat high birth weight', and restricting the sample to only prime-age mothers.

RESULTS

Preliminary Analysis

PRAMS

Table 1. Percentage of mothers in socio-economic categories by birth weight; PRAMS

	Low Birth Weight	Normal Birth Weight	High Birth Weight
Elementary education	4.70***	4.43	4.20
High school drop out	21.04***	14.44	9.18***
High school	35.44***	31.50	31.27
Some college	20.75***	22.90	24.07
College degree	18.06***	26.73	31.28***
Married	51.01***	65.78	76.28***
Household income <$10000	28.62***	19.47	13.09***
Household income $10,000-$20,000	20.40***	17.29	14.38***
Household income $20,000-$30,000	10.46	10.68	11.53
Household income $30,000-$40,000	9.88***	10.80	12.80**
Household income >40000	30.64***	41.76	48.20***

*Where *, **, *** indicate significance from the Normal Birth Weight percentage at the 10%, 5%, and 1% level, respectively.*

Table 1 shows that, in general, women who have high birth weight babies are concentrated in higher education, higher income and married categories (compared to those with infants of normal birth weight), whereas women who have low birth weight babies are concentrated in lower education and lower income categories.

Table2. Percentage of high birth weight babies by education level; PRAMS

Education	Elementary	High school drop out	High school	Some college	College degree
High Birth Weight	1.33	0.87	1.39	1.49	1.68

Table 3. Percentage of high birth weight babies by household income level; PRAMS

Household Income	<$10,000	$10,000-$20,000	$20,000-$30,000	$30,000-$40,000	>$40,000
High Birth Weight	0.94	1.18	1.54	1.70	1.67

Table 4. Percentage of high birth weight babies by marital status; PRAMS

Marital status	Married	Not married
High Birth Weight	1.65	0.95

Aside from the lowest category of education, there appears to be a clear trend of a higher risk of high birth weight with increasing education. Similarly the incidence of high birth weight increases with household income with a slight drop off at the highest category. Married women have a markedly higher incidence of high birth weight. This is largely consistent with hypothesis 2, that high birth weight risk increases with socio-economic status.

NDF

Table 5. Percentage of mothers in socio-economic categories by birth weight; NDF

	Low Birth Weight	Normal Birth Weight	High Birth Weight
Elementary education	2.85***	3.30	3.40***
High school drop-out	10.28***	8.24	5.84***
High school	18.70***	17.10	15.84***
Some college	12.08***	12.39	13.43***
College degree	11.14***	16.16	18.50***
Married	48.86***	62.26	71.10***

*Where *, **, *** indicate significance from the Normal Birth Weight percentage at the 10%, 5%, and 1% level, respectively.*

Table 5 shows that women who had high birth weight babies were more likely to have a high level of education and to be married than women who had normal or low birth weight babies. They were also less likely to have just a high school education or be a high school drop-out, but interestingly, were more likely to have no high school education. Aside from the lowest level of education this seems to support hypothesis 2; that high birth weight risk increases with socio-economic status.

Replicating Cesur and Kelly (2010)

PRAMS

Table 6. Cesur and Kelly (2010) replication; PRAMS

High Birth Weight	Marginal Effect
Married	0.0010 (0.0008)
High school drop out	-0.0032* (0.0016)
High school	-0.0021 (0.0017)
Some college	-0.0025 (0.0017)
College degree	-0.0015 (0.0018)
Household income $10,000-$20,000	0.0006 (0.0011)

Household income $20,000-$30,000	0.0031** (0.0015)
Household income $30,000-$40,000	0.0033** (0.0015)
Household income >$40,000	0.0022* (0.0012)
Male infant	0.0091*** (0.0006)
Mother's BMI	0.0023*** (0.0003)
Mother's BMI squared	-0.00002*** (0.0000)
First birth	-0.0029*** (0.0006)
Black	-0.0069*** (0.0006)
Asian	-0.0064*** (0.0007)
Hispanic	-0.0040*** (0.0008)
Native American	0.0060*** (0.0018)
Mother's age 18-19	0.0008 (0.0025)
Mother's age 20-24	0.0022 (0.0023)
Mother's age 25-29	0.0034 (0.0024)
Mother's age 30-34	0.0057** (0.0027)
Mother's age 35-39	0.0082** (0.0052)
Mother's age 40+	0.0149*** (0 .0034)

*Where *,**,*** indicates significance at the 10%, 5%, and 1% level, respectively. Standard errors given in parentheses.*

My results (Table 7) seem to provide some support for Cesur and Kelly's conclusion; education variables are not significant, so we have no evidence that education increases high birth weight risk once other factors have been controlled for. However, my results do provide some evidence that increasing income increases high birth weight risk at least at relatively low levels of income. This is in contrast to Cesur and Kelly's findings which found an insignificant relationship. My results indicate that going from an income between $10,000 and $20,000 to an income between $20,000 and $30,000 increases the risk of high birth weight by 0.25 percentage points or 17% from the baseline risk. Being married was not considered as a socio-economic status variable in Cesur and Kelly's paper but here it is statistically insignificant.

The marginal effect of BMI is as expected, a higher body mass poses a higher risk of high birth weight, with a diminishing effect implied by the negative marginal effect of BMI squared. The coefficient implies that a one point increase in body mass index number, the risk of high birth weight increases by roughly 0.1 percentage points or 7% from the baseline risk across conceivable BMI ranges. Male infants also have a higher risk of high birth weight as expected. The coefficient implies that a male infant has a 0.9 percentage point or 60% higher risk of high birth weight than female infants. As expected, first births are significantly less likely to have high birth weight. All ethnicity categories are highly significant, the marginal effects imply that native babies are largest, followed by White, Hispanic, Black, and Asian babies are the smallest. The age groups also live up to expectations where higher age groups present higher risks of high birth weight.

NDF

Table 8. Replicating Cesur and Kelly; NDF

High Birth Weight	Marginal Effect
Married	0.0011*** (0.0001)
High school drop out	-0.0018*** (0.0001)
High school	-0.0004*** (0.0001)
Some college	0.0002 (0.0001)
College degree	-0.0007*** (0.0001)
Parity 2	0.0018*** (0.0001)
Parity 3	0.0030*** (0.0001)
Parity 4	0.0043*** (0.0001)
Parity 5	0.006*** (0.0002)
Parity 6	0.008*** (0.0003)
Parity 7	0.011*** (0.0004)
Parity 8 plus	0.017*** (0.0005)
Male infant	0.0075*** (0.0000)
Mother's age	0.0008*** (0.0000)
Mother's age squared	-0.000007*** (0.0000)
Hispanic	-0.0020*** (0.0001)
Asian	-0.0060***

	(0.0001)
Black	-0.0048*** (0.0001)
Native	0.0059*** (0.0002)
Underweight	-0.0060*** (0.0002)
Overweight	0.0090*** (0.0002)
Obese	0.0170*** (0.0003)
Morbidly Obese	0.0306*** (0.0004)

*Where *,**,*** indicates significance at the 10%, 5%, and 1% level, respectively. Standard errors given in parentheses.*

The NDF marginal effects can be much more precisely estimated due to the much larger sample size. With these results it appears that being married does increase high birth weight risk by roughly 0.1 percentage points or 7% from the baseline risk. Education variables with the exception of 'some college' exhibit significance but the relationship is inconsistent. High birth weight risk decreases from only elementary education to high school drop-out, then increases from high school drop-out to high school completion, and decreases for a college degree.

Further Analysis

Tables 9 show the results of robustness checks on the main regression for the PRAMS data set. In general, it seems that changes to the functional form have only minor effects on the results. For most of the checks, marriage and education effects are still statistically insignificant, but income does seem to have an initially positive effect on high birth weight risk, reversing at higher levels of income. Two of the regressions, however, suggest that education and marriage do have a positive effect on high birth weight risk. When the dependent variable is either somewhat high birth weight (birth weight >4,000g) or large for gestational age, the marginal effect of marriage is positive and significant, and for both regressions, the highest level of education is positive and significant. However, when looking at very high birth weight, it appears education and marital status have a negative effect on High birth weight risk and income is no longer significant.

Table 10 shows the results of robustness checks on the NDF data set. Here the effect of education and marital status on the risk of very high birth weight is clearly negative, whereas the effect on the risk of somewhat high birth weight is clearly positive.

These results generally are more supportive of hypothesis 1 than hypothesis 2. If hypothesis 2 were correct we would expect to see a positive relationship with high birth weight at any threshold, however at a threshold of 5000g the relationship is clearly negative. The positive relationship with socio-economic status and high birth weight at a lower threshold of 4000g is not necessarily inconsistent with hypothesis 1, if complications associated with high birth weight do not arise at this threshold of birth weight then 4000g would be within the normal range and hence we would expect to see high socio-economic status being more likely to have this birth weight. Another possibility is that this could imply a combination of my two hypotheses is occurring, where socio-economic status is shifting the birth weight distribution but decreasing the variance as well, leading to higher birth weights in general but not at the extreme end where health risks are present.

Table 9. Model Specification Changes PRAMS

	Census sub-region fixed effects added	State fixed effects added	Very high birth weight (>5,000g) as dependent variable	Somewhat high birth weight (>4,000g) as dependent variable	Large for gestational age as dependent variable	BMI categories added	Sample restricted to mothers aged 20-35	Number of dependents in household variable added
Married	0.0012 (0.0008)	0.0012 (0.0007)	-0.0004* (0.0002)	0.0087*** (0.0021)	0.011*** (0.0022)	0.001 (0.0008)	0.0015* (0.0009)	0.001 (0.0008)
High school drop out	-0.003* (0.0016)	-0.003* (0.0016)	-0.0004 (0.0003)	-0.0196*** (0.0046)	-0.0092* (0.0052)	-0.004*** (0.0014)	-0.0008 (0.0025)	-0.0032* (0.0016)
High school	-0.002 (0.0017)	-0.002 (0.0017)	-0.0006* (0.0003)	-0.0026 (0.0049)	0.0059 (0.0053)	-0.0026* (0.0015)	-0.0003 (0.0024)	-0.0021 (0.0017)
Some college	-0.0024 (0.0017)	-0.0023 (0.0017)	-0.0006* (0.0003)	0.0026 (0.0052)	0.0124** (0.0056)	-0.003** (0.0015)	-0.0006 (0.0025)	-0.0024 (0.0017)
College degree	-0.0013 (0.0018)	-0.0012 (0.0018)	-0.0006* (0.0003)	0.0115** (0.0054)	0.0191*** (0.0058)	-0.0023 (0.0016)	0.0002 (0.0026)	-0.0014 (0.0018)
Household income $10,000-$20,000	0.0005 (0.0011)	0.0005 (0.0011)	0.0001 (0.0002)	0.0083*** (0.0031)	0.0071** (0.0032)	0.0009 (0.0011)	-0.0002 (0.0012)	0.0005 (0.0011)
Household income $20,000-$30,000	0.0028* (0.0015)	0.0028* (0.0015)	0.0007 (0.0005)	0.013*** (0.0037)	0.0115*** (0.0039)	0.002* (0.0015)	0.0022 (0.0016)	0.0031** (0.0015)
Household income $30,000-$40,000	0.0032** (0.0015)	0.0033** (0.0015)	0.0002 (0.0003)	0.0114*** (0.0037)	0.0126*** (0.0039)	0.0032** (0.0015)	0.0024 (0.0016)	0.0032** (0.0015)
Household income >$40,000	0.0021* (0.0012)	0.0021* (0.0012)	0.0001 (0.0003)	0.014*** (0.0031)	0.018*** (0.0032)	0.002* (0.0012)	0.0015 (0.0013)	0.0021* (0.0012)

*Where *,**,*** indicates significance at the 10%, 5%, and 1% level, respectively. Standard errors given in parentheses.*

Table 10. Model Specification Changes NDF

	Very high birth weight (>5,000g) as dependent variable	Somewhat high birth weight (>4,000g) as dependent variable	Sample restricted to mothers aged 20-35
Married	-0.0002*** (0.0000)	0.0113*** (0.0001)	0.0009*** (0.0001)
High school drop out	-0.0004*** (0.0001)	-0.0098*** (0.0003)	-0.0017*** (0.0002)
High school	-0.0004*** (0.0000)	-0.0004 (0.0003)	-0.0006*** (0.0002)
Some college	-0.0004*** (0.0000)	0.0053*** (0.0004)	0.000007 (0.0002)
College degree	-0.0007*** (0.0000)	0.0054*** (0.0004)	-0.001*** (0.0001)

*Where *,**,*** indicates significance at the 10%, 5%, and 1% level, respectively. Standard errors given in parentheses.*

DISCUSSION

This paper shows through a theoretical model that socio-economic status should have an effect on high birth weight risk and provides evidence of a relationship with empirical results. This contradicts the findings of Cesur and Kelly (2010) which found no relationship between high birth weight and socio-economic status. Even though preliminary analysis shows that high socio-economic status women tend to have a higher incidence of high birth weight, when controlling for inherent characteristics of the mother and child, the results refute hypothesis 2, that socio-economic status is unambiguously positively related to high birth weight risk.

The results tend to lend support to hypothesis 1, that socio-economic status increases positive health outcomes, therefore reducing high birth weight risk. However, it is still possible that a combination of the two hypotheses is occurring, where socio-economic status reduces the probability of the most extreme outcomes whilst increasing birth weight in general.

BIBLIOGRAPHY

1. Grossman, M., *On the Concept of Health Capital and the Demand for Health.* Journal of Political Economy, 1972. **80**(2): p. 223-255.
2. Ju, H., et al., *Fetal macrosomia and pregnancy outcomes.* Australian and New Zealand Journal of Obstetrics and Gynaecology, 2009. **49**: p. 504-509.
3. Berard, J., et al., *Fetal macrosomia: risk factors and outcome a study of the outcome concerning 100 cases >4500g.* European Journal of Obstetrics & Gynecology and Reproductive Biology, 1998. **77**: p. 51-59.
4. Sinclair, B.A., J.A. Rowan, and O.T. Hainsworth, *Macrosomic infants are not all equal.* Australian and New Zealand Journal of Obstetrics and Gynaecology, 2007. **47**: p. 101-105.
5. Srofenyoh, E.K. and S.J. D, *Prenatal, labor and delivery characteristics of mothers with macrosomic babies.* International Journal of Gynecology and Obstetrics, 2006. **93**: p. 49-50.
6. Boulet, S.L., et al., *Macrosomic births in the United States: Determinants, outcomes, and proposed grades of risk.* American Journal of Obstetrics and Gynecology, 2003. **188**(5): p. 1327-8.
7. Mathew, M., et al., *Fetal macrosomia: Risk factors and outcome.* Saudi medical journal, 2005. **26**(1): p. 96-100.
8. Diani, F., et al., *Fetal macrosomia and management of delivery.* Clinical and Experimental Obstetrics and Gynecology, 1997. **24**(4): p. 212-214.
9. Seidman, D.S., et al., *A longitudinal study of birth weight and being overweight in late adolescence.* American Journal of Diseases of Children, 1991. **145**(7): p. 782-785.
10. Curhan, G.C., et al., *Birth Weight and Adult Hypertension and Obesity in Women.* Circulation, 1996. **94**(6): p. 1310-1315.
11. Cesur, R. and I.R. Kelly, *From Cradle to Classroom: High Birth Weight and Cognitive Outcomes.* Health Economics, 2010. **13**(2).
12. Lleras-Muney, A., *The Relationship Between Education and Adult Mortality in the United States.* The Review of Economic Studies, 2005. **72**(1): p. 189-221.
13. Silles, M.A., *The causal effect of education on health: Evidence from the United Kingdom.* Economics of Education Review, 2009. **28**(1): p. 122-128.
14. Attanasio, O.P. and C. Emmerson, *Mortality, Health Status, and Wealth.* Journal of the European Economic Association, 2003. **1**(4): p. 821-850.
15. Coombs, R.H., *Marital Status and Personal Well-Being: A Literature Review.* Family Relations, 1991. **40**(1): p. 97-102.
16. Jonas, O., D. Roder, and A. Chan, *The Association of Low Socio-Economic Status in Metropolitan Adelaide with Maternal Demographic and Obstetric Characteristics and Pregnancy Outcome.* European Journal of Epidemiology, 1992. **8**(5): p. 708-714.
17. Pattenden, S., H. Dolk, and M. Vrijheid, *Inequalities in Low Birth Weight: Parental Social Class, Area Deprivation, and "Lone Mother" Status.* Journal of Epidemiology and Community Health (1979-), 1999. **53**(6): p. 355-358.
18. Taylor, C.A.L., *ASSOCIATIONS BETWEEN MEASURES OF SES AND LOW BIRTH WEIGHT AMONG BLACK MOTHERS AND WHITE MOTHERS IN MICHIGAN.* Michigan Sociological Review, 2010. **24**(ArticleType: research-article / Issue Title: RESEARCH ON POVERTY IN MICHIGAN / Full publication date: Fall 2010 / Copyright © 2010 Michigan Sociological Association): p. 56-73.
19. Dalton, C. and N.G. Bennett, *Birth Weight and Income: Interactions across Generations.* Journal of Health and Social Behavior, 2001. **42**(4): p. 450-465.
20. Phung, H., et al., *Risk Factors for Low Birth Weight in a Socio-Economically Disadvantaged Population: Parity, Marital Status, Ethnicity and Cigarette Smoking.* European Journal of Epidemiology, 2003. **18**(3): p. 235-243.

21. Frank, R., W.P. Frisbie, and S.G. Pullum, *Race/ethnic differentials in heavy weight and cesarean births.* Population Research and Policy Review, 2000. **19**: p. 459-475.
22. Ourskou, J., et al., *Maternal Characteristics and Lifestyle Factors and the Risk of Delivering High Birth Weight Infants.* Obstetrics & Gynecology, 2003. **102**(1): p. 115-120.
23. Srofenyoh, E. and J.D. Seffah, *Prenatal, labor and delivery characteristics of mothers with macrosomic babies.* International Journal of Gynecology and Obstetrics, 2006. **93**: p. 49-50.
24. Wojcicki, J.M., et al., *Risk factors for macrosomia in infants born to Latina women.* Journal of Perinatology, 2008: p. 743-749.
25. Trivers, R.L. and D.E. Willard, *Natural Selection of Parental Ability to Vary the Sex Ratio of Offspring.* Science, 1973. **179**(4068): p. 90-92.
26. Almond, D. and L. Edlund, *Trivers-Willard at Birth and One Year: Evidence from US Natality Data 1983-2001.* Proceedings: Biological Sciences, 2007. **274**(1624): p. 2491-2496.
27. Deruelle, P., et al., *Maternal and fetal consequences of gestationnal weight gain in women of normal prepregnant weight.* Gynecologie Obstetrique & Fertilite, 2004. **32**: p. 398-403.
28. Siega-Riz, A.M., et al., *The effects of prophylactic iron gidven in prenatal supplements on iron status and birth outcomes: a randomized controlled trial.* American Journal of Obstetrics & Gynecology, 2006. **194**(2): p. 512-519.
29. Aranda, N., et al., *Pre-pregnancy iron reserves, iron supplementation during pregnancy, and birth weight.* Early Human Development, 2011.
30. Watson, P.E. and B.W. McDonald, *The association of maternal diet and dietary supplement intake in pregnant New Zealand women with infant birthweight.* European Journal of Clinical Nutrition, 2010. **64**: p. 184-193.
31. Marschak, J., *Rational Behavior, Uncertain Prospects, and Measurable Utility.* Econometrica, 1950. **18**(2): p. 111-141.