How Children Affect Mother's Labor Market Outcomes:

Evidence Based on Pregnancy Failures

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Abstract:

In this study I use data from the National Survey of Family Growth to estimate the impact of children on mothers' labor supply and earnings. Because it is highly likely that some factors that are both associated with a woman's labor market outcome and her fertility outcome (such as if she has children or not) are not included in the data, in a regression analysis of the data, a fertility outcome variable will be endogenous. To address this issue, I use a variable indicating if a woman's first pregnancy ended in a miscarriage or not as the instrumental variable and use the instrumental variable estimation technique to estimate the coefficient of the fertility outcome variable in the labor market outcome regression. I argue that the variable I use as the instrument is a valid one because evidence shows that the occurrence of a miscarriage is closely related with a woman's fertility outcome, and miscarriage largely happens randomly according to relevant medical studies. The estimation result shows that there is a negative and modest impact of children on mothers' labor supply and earnings. The magnitude of my estimates is comparable with that in the studies that estimate the impact of children with instrumental variables based on other natural experiments during a woman's reproductive history.

JEL Classifications: J13, J22

Keywords: Female Labor Supply, Fertility, Instrumental Variable, Natural Experiment

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1. Introduction

In this study I estimate the impact of children on women's labor market outcomes. In studies on female labor supply since Mincer (1962), children have always been an important factor to consider and model. An important reason for the interest in children's effect on women's labor supply and earnings is the persistent gender gap in wages; for example, O'Neill (2003) shows that the significant gap in labor force participation status between women who have young children and who do not – while there is no such gap among men – is likely to be a key reason for the overall gender difference in earnings.

A difficulty often encountered in estimating how children affect mother's labor supply is the identification problem: it is likely that the data do not include information on the characteristics that are associated with both fertility outcomes (such as the number of children a woman has) and labor market outcomes. In this case a simple ordinary least squares estimate will provide misleading conclusions.

In the literature, a solution to the identification problem is to use instrumental variable estimation. Rosenzweig and Wolpin (1980) is the first study to use twin births as an instrumental variable for fertility in the context of female labor supply. Studies that follow this idea include Bronars and Grogger (1994), Gangadharan and Rosenbloom (1996) and Jacobsen, Pearce and Rosenbloom (1999). Another instrument, proposed by Angrist and Evans (1998), is based on the sexes of the first two children. Iacovou (2001) uses both multiple births and children's sex mix as instruments using British data.[1] A third instrument is the outcome of fertility treatment for women who had sought help in conceiving in Cristia (2008).

In this study, I use the outcome of the first pregnancy of women who have had at least one pregnancy as the basis of the instrument. More specifically, whether or not the first pregnancy ended in a miscarriage is considered the result of a natural experiment. Medical literature suggests that miscarriages occur usually for unknown reasons and

[1] I thank Professor T. Paul Schultz for this reference.

the risk of a miscarriage (particularly the early miscarriages) is unrelated to human behaviors.[2] On the other hand, the first pregnancy ending in a miscarriage is strongly associated with fewer numbers of children that a woman will eventually have. Thus whether or not a woman's first pregnancy ended in a miscarriage can be used as the basis for the instrument in estimating the impact of fertility outcome.

Previous studies have utilized miscarriages in helping identify causal effect. Hotz, McElroy and Sanders (1999) use data from NLSY79 and investigate the impact of teenage motherhood. Miller (2008) studied the impact of motherhood timing on career path, also using the NLSY79 data. In this study I use data from the National Survey of Family Growth (NSFG). NSFG is a series of surveys directed by the Centers for Disease Control and Prevention (CDC) that interview a nationally representative sample of women in the U.S. and collect women's reproductive health related information. Data from NSFG are more detailed regarding a woman's pregnancy history. The sample is also of more matured age than the sample of NLSY79.

An advantage of my instrumental variable estimation strategy is that it allows one to estimate the effect of having any children versus childlessness. O'Neill (2003) suggests that the employment gap between women and men as they become parents is closely related to the persistent gender wage gap that has been witnessed in the past few decades. Using twins or sexes of the first two children as basis of instruments is not able to perform this task. Using the outcome of fertility treatment for women seeking fertility help can provide result for the impact of a first child. However the result will come from a more special sample of women than the sample I use in my study.

My results show that there is a modest negative impact of children on mother's labor supply and income. OLS estimates are consistently larger in magnitude than IV estimates, thus suggest the importance fertility outcome is indeed likely to be endogenous in female labor supply models.

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[2] As abortions are legal in the U.S., a significant percentage of pregnancies ended in abortions. In subsequent sections I will provide evidence in from the medical literature that vast majority of miscarriages occur at an early stage of the pregnancy which is before the woman is able to decide if she wants to end the pregnancy or not.

My results are highly comparable to the results in Bronars and Grogger (1994) and Angrist and Evans (1998). My estimate of impact of children is somewhat smaller than the estimated impact of a first child in Cristia (2008). As the estimate based on different instrumental variables will measure the average effect of children for different groups of women, my result contributes to the understanding of the effect of children on mother's labor supply for the general population by providing estimates for yet another group of women.

The rest of the paper is organized as the following. In Section 2 I briefly introduce the data I use. In Section 3 I present the statistical model and discuss the endogeneity problem and the identification of the parameter of interest. In Section 4 I present the case for using the random event of miscarriage as the basis of creating an instrumental variable. In Section 5 I describe how the sample for regression analysis is constructed and present the sample's summary statistics. In Section 6 I present the main results and compare them with results in related studies. Section 7 concludes.

2. Data

The data I use are from the National Survey of Family Growth (NSFG) series conducted under the direction of the Center for Disease Control and Prevention of the United States. The individuals interviewed make a sample that is representative of all the women between 15 and 44 years old in continental U.S. Six waves of surveys have been conducted in 1973, 1976, 1982, 1988, 1995 and 2002.[3] Survey questions include woman's childhood background, marriage and cohabitation history, sexual activities, contraceptive use, family planning and infertility service use, history of pregnancies and births, and employment and earnings. In this study, I will use data from the 1988, 1995 and 2002 waves of the survey.

3. Statistical Model

[3] Before 1982 the survey was only for married women or women who had children, while after 1982 women of all marital status were included. In 2002, men are included too and constitute half of the sample.

The focus of this study is to estimate the causal effect of the presence and/or number of children on mother's labor supply and earnings. The causal effect of children on the woman's labor market outcomes can be justified in a standard labor supply decision model, where more children will increase the opportunity cost of working outside home, thus affect her decision and outcome.

To empirically estimate the impact of children on women's labor market outcomes, a statistical model is specified as the following. First, I specify that a woman's labor market outcome is determined according to the following equation:

$$y_i = \beta C_i + x_i \alpha + u_i \qquad (1)$$

y_i is a measure of her labor market outcome, such as her labor force participation status, weekly hours worked or her annual labor income. C_i is her fertility outcome, which can be alternatively defined as either the number of children she had, or a dummy variable indicating if she had ever had a child. x_i is a vector of demographic variables such as the woman's age, race, education, marital status, etc. u_i is a random term with zero mean, and α and β are coefficients.

The second part of the statistical model is the specification that a woman's fertility outcome is determined according to the following equation:

$$C_i = \gamma z_i + x_i \phi + v_i \qquad (2)$$

C_i and x_i are fertility outcome and control variables as before. z_i is defined based on the outcome of the woman's first pregnancy; specifically, it is defined as a dummy variable indicating if the woman's first pregnancy ended in a miscarriage or not. v_i is the error term, and ϕ and γ are coefficients. It is assumed that v_i is *i.i.d.* with mean zero and variance one.

β is the coefficient of the most interest in this study. Considering the complicated process that determines one's labor supply and fertility outcomes, I conclude it is likely that all factors associated with the determination of labor supply and fertility outcomes are not included in the data. This implies a likely correlation between the error terms in Equation (1) and (2), which means an ordinary least squares (OLS) estimate of β will be biased.

z_i can be used as an instrumental variable and makes identification of β possible if two conditions are satisfied. First γ is non-zero. Second, z_i is not correlated with u_i. The empirical content of these two conditions are, first, the first pregnancy ending in a miscarriage affects the woman's fertility outcome. Second, miscarriage risk does not vary with any factors associated with the determination of a woman's labor market outcome except her fertility outcome.

In order to evaluate the previous two statements, and then to judge if z_i can be used as an instrumental variable to estimate β, in the next section I draw on results from medical studies on miscarriages and show that overall the strategy of IV estimation based on occurrence of miscarriage is valid.

4. Impact and Causes of Miscarriage

4.1 Why is miscarriage associated with fertility outcome?

There are two important mechanisms that lead to a correlation between miscarriage and fertility outcome.

First, there is limited amount of time in a woman's lifetime to bear children. A miscarriage incurs both direct time cost and perhaps often also psychological cost – time needed to recover from loss before trying to conceive again. In the appendix table, I show the average ages of women's pregnancies and births in their lifetime. For women who have had miscarriages but who later have successful pregnancies, the table shows that their motherhood is significantly delayed.[4]

The second channel responsible for the correlation between miscarriage and fertility outcome is the fact that a certain percentage of women in the population have physiological problems such that they have difficulty carrying the pregnancy to term. Specifically, some women tend to experience recurrent pregnancy losses, defined as having three or more consecutive miscarriages. Recurrent miscarriages severely affect the chance that the woman will ever have a child. For example, my data show that among women who have had at least two pregnancies, those whose first two pregnancies ended in miscarriages had 36 percent lower chance to have children than other women.[5]

4.2 Can miscarriage be associated with labor market outcome through channels besides fertility outcome?

As discussed before, the variable based on miscarriage is a valid instrumental variable only if its association with a woman's labor market outcome is only through its impact on her fertility outcome.

There are at least two situations where this condition may be violated. First, is it possible that having a miscarriage affects a woman's mentality such that she changes her life priority, including her labor market choices? On the other hand, does a miscarriage affect a woman's physical or psychological health which leads to changes in her employment or income?

Theoretically both are possible. However, from books and research literatures in public health and medicine that I have read, I have not found sufficient evidence to show that the impact of miscarriage on a woman's physical and

[4] For example, my data show that among women who had at least one birth, the miscarriage delayed the time of the first birth by 2.3 years: the age at the first birth is 21.7 for women whose first pregnancy ended in a live birth; it is 24.0 for women whose first pregnancy ended in a miscarriage.

[5] For women whose first two pregnancies ended in miscarriage, about 62 percent of them have children; for other women, it is 98 percent. The sample is from 1988 data, restricted to women who have had at least two pregnancies.

mental health is strong enough to alter her life course. For an example of the narrative accounts by women who have experienced pregnancy losses, see Friedman and Gradstein (1982).

The second possibility that undermines the validity of an instrumental variable based on miscarriage is that not all factors that are associated with both the woman's miscarriage risk and employment and income are covered by survey's questions and thus their information not contained in the data. For example, stress level is likely to be a part of the error term in Equation (1) because it is likely to be associated with one's labor market success but is not reported in the survey. If this is the case, the miscarriage status variable is an invalid instrument if stress is also associated with higher risk for miscarriage.

In the following, I will draw on evidence from the medical and epidemiological literature on causes of miscarriages, and the factors and behaviors that may affect miscarriage risk. In particular, I will look for factors and behaviors that are likely to be also associated with a woman's employment.

A. Background information about miscarriage

Most of the statistics and findings in this section are drawn from Isabel Stabile, Gedis Grudzinskas, and Tim Chard (Ed.) *Spontaneous Abortions: Diagnosis and Treatment* (1992). I provide a longer and more detailed summary of related background knowledge in Appendix 1 for interested readers. Spontaneous pregnancy losses (or interchangeably spontaneous abortion, early pregnancy failure, or simply pregnancy loss) are defined to be the expulsion of a fetus without signs of viability before a certain time during the pregnancy (e.g., 28 weeks of a pregnancy in the U.K.).[6] The main form of an early pregnancy failure is a miscarriage (the other much rarer form is an ectopic pregnancy).[7]

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[6] By this definition, a stillbirth is not a form of early pregnancy failures.
[7] In medical terms, a spontaneous abortion is more of a process rather than a one time event. Only some threatened abortions (painless vaginal bleeding) eventually become inevitable abortions, i.e., resulting in the expulsion of the fetus.

The statistics about the rate of miscarriage vary across studies depending on the detection technology of the pregnancies and the type of studies (hospital records, survey recollections, or prospective studies). There are five milestones in a pregnancy: conception, implantation, clinical recognition (such as via ultrasound), fetal stage, and live birth. Studies that use more sensitive detection technology recognize pregnancies in an earlier stage and report higher rate of pregnancy losses. Once the pregnancy is clinically established, most studies show the rate of loss is between 11 to 16 percent.

Why does a miscarriage occur? Even though there have been extensive studies in medicine on this important subject, the answer is still that it is unknown in most cases. Studies show that the percentage of miscarriages that are due to chromosomal aberrance is probably 40 percent or higher, depending on the gestational stage. The characteristics of the fetus that are related to miscarriage risk include: the sex of the fetus, multiple pregnancy, and parity (the order of the pregnancy).

B. Woman's characteristics and behaviors that may be related to miscarriage risk

In this section, I present evidence from the medical literature regarding the factors that are shown to be related to miscarriage risk, in particular, those that may also be related to a woman's work status and earnings.

- Maternal age and health status

Evidence shows that miscarriage risk and maternal age are associated nonlinearly: the percentage of miscarriage is higher for very young women (in teens) and for women in their late thirties or older. Certain medical conditions such as fever are related to miscarriage risk.

In estimation, I controlled for the age at which the woman had the pregnancy.[8] I do not control for conditions such as fever because it is unlikely to be significantly associated with the woman's work related outcomes.

- Use of IUD at the time of the conception

Evidence shows that the risk of miscarriage increases if the woman used an IUD (intra-uterus device) at the time of the conception. But given the prevalent use of IUD in the U.S., this is unlikely to be associated with a woman's work status or earnings.

- Smoking and substance use

Some studies show that smoking and use of alcohol during the pregnancy increase the risk of miscarriage 9as well as development of the fetus). This is consistent with popular beliefs that most people hold. However, the findings in the literature are not always consistent. For example, the study by Kline et al. (1989) showed that there is an increase in the risk of the fetal loss due to smoking during the pregnancy, but only for the group of women who were economically disadvantaged and were not treated privately; otherwise there is no significant increase in risks.

In some but not all years of survey, I have information about whether the woman smokes or not (and alcohol use). I will control for them whenever the information is available.[9]

- Environmental hazard

Studies show that exposure to certain environmental hazards such as anesthetic gas and irradiation increases the risk of miscarriage. The chance of being exposed to such hazard certainly is related to one's work status,

[8] The age at which the woman becomes pregnant is certainly subject to her (and her partner's) choice to a large extent, hence not exogenous in my model. I temporarily do not address this issue here. For interesting reference regarding dealing with endogenous motherhood timing, see Miller (2008).
[9] A more serious issue with the findings on the association between miscarriage risk and smoking is that smoking may be systematically correlated with one's employment status. I do not address this issue here.

particularly one’s occupation and industry if one works. However such jobs account for extremely small percentage of all jobs, therefore I do not consider this to be a serious issue that threatens the instrument’s validity.

Overall, evidence from medical studies suggests that the vast majority of miscarriages occur randomly, and the association of miscarriage risk with various identifiable characteristics or behaviors is weak. This provides support for validity of the IV estimation strategy based on a miscarriage status variable.

5. Sample Construction, Variables and Summary Statistics

The source of exogenous shock to fertility outcome comes from the possibility of a woman’s pregnancy ends in a miscarriage. Therefore the sample has to be restricted to those women who have had at least one completed pregnancy at the time of the survey.

Two alternative fertility outcome variables are used: one is a dummy variable indicating if the woman has any child (more precisely, if the woman has had a live birth or not), the other one is the number of children the woman has by the time of the survey.

The instrumental variable is defined to be a dummy variable, where it equals to 1 if the first pregnancy the woman ever had ended in a miscarriage, and 0 otherwise. If the first pregnancy ended in a miscarriage, it eliminates the possibility of having a live birth after the first pregnancy. Data show that many women continue to have successful pregnancies that provide them with children. However, statistically the miscarriage variable that is my instrumental variable will be negatively correlated with the fertility outcome variable (for either of the alternative fertility outcome variables). γ in Equation (2) thus is expected to be negative.

β in Equation (1) measures the impact of any children versus no child on the labor market outcome when the fertility variable is defined to be a dummy variable for any child versus no child. If the number of children is used alternatively, β measures the average impact of one child on mother's labor market outcome.

Note that an IV estimate of β measures a *local average treatment effect* (LATE) as defined in Imbens and Angrist (1994) under certain circumstances. Specifically, when C_i in Equation (1) is empirically defined to be the childlessness status dummy variable, IV estimate of β measures the impact of having any children on those whose first pregnancy ended in a miscarriage and who do not have children but who would have had a child if the first pregnancy had not ended in a miscarriage. The previous statement is true if the following statement is believed to hold: if a woman chose to have an abortion after the first pregnancy occurred and did not end in a miscarriage and do not have children (at the time of the survey), she would not have any children if the first pregnancy had ended in a miscarriage – that is she would not have continued to have more pregnancies and at least one of them would end in a live birth. In summary, this is the monotonicity condition in Imbens and Angrist (1994) that is required for the identification of a local average treatment effect. On the other hand, when C_i in Equation (1) is empirically defined to be the number of children the woman has, β simply measures the impact of one child for an average woman.

The means and standard deviations of various variables used in the regression analysis are presented in Table 1. The statistics are presented for each survey year separately because a few variables have missing values in one or two years of data.

On average, women in the sample are about 33 years old, 15 percent of them are black, and they receive almost 13 years of education. About 65 percent of them are married, and the spouse of those married receives 13.5 years of education. The average family income in 1995 dollar is 33000 dollars to 42000 dollars. Among women interviewed in 1988 and 1995, 15 percent of them are in poverty, while the poverty rate is 23 percent among those in the sample who were interviewed in 2002.

At the time of the survey, about 90 percent of the women in the sample have given birth to at least one child, and the average number of children is a bit smaller than 2. The average age the woman had her first pregnancy is about 22 years old. Between 11 to 13 percent of the first pregnancies ended in a miscarriage for the women in the sample.

Between 67 to 72 percent of women in the sample works for pay. On average women work between 24 to 26 hours (those who do not work are accounted as working zero hour). The average yearly earnings are between 13000 to 15000 dollars in 1995 dollar (those who do not work and have no labor income are counted as having zero earnings).

I also divide the sample into two groups, those whose first pregnancies ended in a miscarriage and those not, and examine how they compare to each other. If the two groups differ in various observed ways in a systematic manner, it will cast doubt on the randomness of miscarriage which is critical for my study. In Table 2, I provide the means and standard deviations of the two groups' age at the first pregnancy, education, mother's education, white dummy, and smoking dummy. In the last column I also provide the p-values of the t-tests for the equalities of the variables' means between the two groups.

The results in Table 2 suggest that those women whose first pregnancy ended in a miscarriage were older at the time of the pregnancy, more educated, and more likely to be white than women whose first pregnancies did not end in a miscarriage. On the other hand, the two groups are similar in terms of the educational levels of mothers, and the smoker status (i.e. if the woman has ever smoked 100 cigarettes or not). These seem to provide some indirect evidence that the two groups of women do not differ in a systematic manner.

6. Impact of Children on Women's Labor Market Outcomes

6.1 Impact of miscarriage on a woman's fertility outcome

The numbers in the second column in Table 3 are the ordinary least squares estimates of the various explanatory variables in Equation (2). They indicate that, older women, black women and those whose spouses are more educated if they are married on average have more children. On the other hand, more educated and smokers – defined by having smoked 100 cigarettes or more – on average have fewer children. In particular, those whose first pregnancy ended in a miscarriage are 19.4 percent less likely to have at least one child (by the time of the survey) than those women otherwise.[10] In addition, in Panel A of Table 4, it shows that a first pregnancy ending in a miscarriage reduces the number of children the woman would have by the time of the survey by 0.48. Therefore it is clear that the failure of the first pregnancy in the form of a miscarriage significantly affects a woman's fertility outcome.

6.2 Effect of children on women's labor market outcomes

The last four columns in Table 3 report the ordinary least squares estimates of effects of various variables on mothers' labor market outcomes. In general, older women, married women and more educated women tend to work more and earn more. On the other hand, married women whose spouses are more educated tend to work and earn less.

In Panel B of Table 4, the IV estimates suggest that children have a negative and modest effect on mother's labor supply. Specifically, compared to women with no children, women with at least one child are 13.6 percent less likely to work full time,[11] and on average spend 6.8 hours less in working per week. An alternative way to present the quantitative impact of children on mother's labor supply is to see that one more child will reduce the likelihood of mother's working full time by 5.5 percent, and reduce the working hours per week by 2.57 hours.

[10] Basically I use a linear probability model when I state this conclusion. The conclusion is not affected by alternative modeling such as logit or probit models.

[11] Here the conclusion is also based on a linear probability model, and it will not change for logit or probit models.

The results do not indicate a noticeable impact of children on mother's employment status (work for pay or not), or the amount of her annual earnings.[12]

A test for the exogeneity of fertility variable in Equation (1) is given for each labor supply measure variable, assuming that the instrument is valid.[13] The maintained hypothesis that fertility is exogenous can only be rejected in a few cases. However, failure to reject the hypothesis may have to do with the relative large standard errors that the IV estimates have.

6.3 Comparing results with other studies

In Bronars and Grogger (1994), the authors used 1980 U.S. Census data and estimated that, for unmarried women who had at least one child, one more child reduced the likelihood of working for pay by 4.7 percent, and reduced annual earnings by 1053 dollars. They used the event of a twin first birth as the source of exogenous variation in the number of children for the identification of the causal effect of children.

In Angrist and Evans (1998), the authors used 1990 U.S. Census data and estimated that, for women who had had at least two children, having a third child reduced the probability of working for pay by 9.2 percent, and reduced weekly work hours by 4.08 hours and annual earnings by 2100 dollars. Their identification of the causal impact of children on mother's labor supply is based on the assumption that parents prefer a boy and a girl to two boys or two girls, and the fact the children's sexes are not chosen or affected by parents.

In general, my results are comparable to those in BG and AE, even though our instrumental variables are based on the results from different natural experiments during a woman's fertility history – the sex of the baby, having a twin birth or the success of a pregnancy – and the women in the samples of the studies systematically differ in the

[12] Considering the fact that probably many women with one child are working part time, the birth of the second child would probably affect the decision to work or not more significantly. For interesting reading, see Anna Quindlen's book "Living Out Loud" (1988), where it was mentioned that the second child tended to be the one that really cut into the mother's career.
[13] The test is to insert the residual from estimating Equation (2) by OLS to the OLS estimation of Equation (1). The exogeneity of fertility variable is rejected if the t statistics of the residual term is large. As reference, for this test, see Wooldridge (2001).

average number of births they have had. This provides more confidence in the quantitative measurement of the impact of children on mother's labor supply and earnings.

In Cristia (2008), the author estimated the impact of a first child on women's employment status after the birth by using a group of women who had sought help in conception and the fact that the success of fertility treatment is random. His result shows that having a first child reduced the likelihood of working after birth by about 27.7 percent. This estimated impact is significantly larger than both mine and that in BG and AE, however the result is only natural considering that it is the impact of a very young baby that is being measure in Cristia (2008) while in my study the estimate measures the impact of average children as opposed to young babies.

7. Conclusion

In this study I estimate the impact of children on mother's labor supply and earnings. To obtain the estimate of a causal impact of children I explore an natural experiment during a woman's pregnancy history: the possibility that a pregnancy ends in a miscarriage, which is shown to occur spontaneously in most cases. My result shows that there are a negative but modest impact of children on mother's employment and income. For example, a woman is 13.6 percent less likely to work full time if she has children as opposed to having no children.

In this study what I estimate is a parameter in a reduced-form statistical model that involves women's labor market outcome and fertility outcome. Estimates of parameters in a structural model are easier to interpret in terms of what they measure in the specified framework of economic agents' behaviors, however a quantitative measurement of the extent to which a woman's labor supply and earnings will be affected by having children can be seen as providing a stylized fact that indicates the significance of further structural work on the subject of labor supply and childbearing by women.

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Appendix: Background Information Regarding Pregnancy Losses

What are spontaneous pregnancy losses?

Spontaneous pregnancy losses are an important and extensively studied phenomenon in both medical and epidemiological literature. It is important for various reasons: it is directly and closely connected to the human reproduction, and the health of pregnant women and the babies to be delivered as well; the public health statistics of pregnancy losses are important indicators of environmental changes, technological changes (e.g. new drugs and their impact on human reproductions), development and prevalence of diseases or illnesses (e.g. sexually transmitted diseases), and many other aspects related to human life. Below, the information of pregnancy losses mostly draws from Isabel Stabile, Gedis Grudzinskas, and Tim Chard (Ed.) *Spontaneous Abortions: Diagnosis and Treatment* (1992), though huge volumes of similar books are easily available in most medical libraries.

Spontaneous pregnancy losses (or, interchangeably throughout the paper, spontaneous abortion, early pregnancy failure, or simply pregnancy loss) are defined to be the expulsion of a fetus without signs of viability before a certain time during the pregnancy (e.g., 28 weeks of a pregnancy in the U.K.). Therefore the definition excludes still-births and neonatal deaths, which tend to be in the third trimester of the pregnancy. It clearly also excludes induced abortions which many people simply call "abortions". As noted in the book, on medical terms, a spontaneous abortion is more of a process rather than a one time event. Only some threatened abortions (painless vaginal bleeding) eventually become inevitable abortions, which means the expulsion of the fetus. There are different ways to categorize spontaneous abortions; for example, a recurrent abortion is defined as three or more consecutive spontaneous abortions. Another example of an early pregnancy failure is an Ectopic pregnancy, defined as the blastocyst being implanted on extrauterine tissues, rather than inside the uterus.

How often do spontaneous pregnancy losses happen?

Seemingly it is a simple question that only calls for one statistics, but in fact different studies have yielded results that vary greatly; reasons include that they have used different definitions (of early pregnancy failures), different pregnancy detection technologies, or different groups of women. For example, studies from various countries may differ in their standard to distinguish a fetus loss from a still-birth. The technology and methodology of research also vary a lot in how early a pregnancy are detected, and hence the calculated pregnancy loss rate. The ideal methodology will be to have a group of women who intend to conceive and follow them until the pregnancy is terminated; this is called a prospective longitudinal study. The development of a pregnancy usually can be marked by five stages, and a live child will be delivered only when the embryo and then fetus reaches all stages one by one. The five milestones are, in the order of the timeline: conception, implantation, clinical recognition (such as via ultrasound), fetal stage, and live birth. A pregnancy between conception and implantation is very difficult to detect even by very sensitive chemical test, let alone women themselves or their doctors. Better estimates are now available via in-vitro fertilization (IVF), and they show that pregnancy losses at this stage are common. Some early pregnancy tests such as human chorionic gonadotrophin (hCG) can identify pregnancies between implantation and clinical recognition stage; if a woman has intended to conceive and uses this test, the pregnancy could be identified at this stage. The pregnancy reaches the clinical recognition stage when the doctors could use ultrasound to demonstrate an intrauterine gestational sac, which is often possible six weeks after the last menstrual period. The pregnancy is considered to enter the fetal stage around eight weeks after the last menstrual period.

The following chart is the result from one prospective longitudinal study (from Isabel Stabile, Gedis Grudzinskas, and Tim Chard (Ed.), page 12). From it we can see the frequency of pregnancy losses and how different loss rates will be calculated when different observation methods are used.

	Number reaching the stage	Number lost before next stage, percentage of loss (out of those surviving from previous stage)	Percentage of cumulative loss
Conception	1000	272, 27%	-

Implantation	728	160, 22%	27%
Clinically recognized	568	54, 10%	43%
Fetal stage	514	14, 3%	49%
Live birth	500	-	50%

There are at least two patterns we can summarize from the chart. First, it is clear from the second column that the highest loss incidence is at the first few stages of the pregnancy. Once it reaches the clinical recognized stage, the loss incidence will be only ten percent or lower. The other observation is that we can calculate alternative (cumulative) pregnancy loss rates that correspond to the alternative detection technologies used. If the pregnancies are detected at conception, the loss rate will be (1000-500)/1000 = 50%. If the pregnancies are detected at the implantation, the loss rate will be (728-500)/728 = 31%. At the clinically recognized stage, (568-500)/568 = 12%. The fetal stage, (514-500)/514 = 3%.[14]

Besides prospective studies, the other two kinds of studies often used to calculate pregnancy loss rates are the retrospective studies where women recall their pregnancy history, and the studies based on hospital records where information about women who come in for pregnancy related care, from pregnancy diagnosis to miscarriage treatment to delivery of babies. It is shown that most retrospective studies report pregnancy loss rates between 11 to 16 percent, while two studies from hospital records show loss rates between 6.8 to 7.2 percent, and 7.8 to 10.2 percent. Given our knowledge about how the pregnancy loss rates are calculated described in the last paragraph, it should come as no surprise that retrospective studies yield lower rates than prospective studies (assuming prospective studies use sensitive technologies that detect pregnancies since implantation), while the hospital records yield the lowest rate: not all women visit doctors or hospitals at the earliest time when pregnancies can be established by ultrasound, and as we have seen, the later the pregnancy is recognized, the lower the loss rate seems to be.

[14] It should be easy for readers to see that it is expected that the earlier the pregnancies are detected, the higher the loss rate will be: since all the "extra" pregnancies detected by the more sensitive tests will be pregnancies losses that are to be added to the numerator (as well as to the denominator).

What factors could cause or are associated with the occurrence of pregnancy losses?

Of particular interest to our study are the factors that contribute to or are associated with the occurrence of spontaneous pregnancy losses. Recall that in order for the instrumental variables constructed by using pregnancy loss information to be valid, it is necessary that conditional on the control variables in the regression, the occurrence of pregnancy losses is independent of all possible factors affecting the woman's labor market outcomes, while is correlated with the woman's fertility outcome.

Studies show that aberrance in chromosomal constitution is the most important contributor to pregnancy losses. As in the case of estimating the incidence of pregnancy losses where the calculated numbers depend on definitions and detecting methods used, the statistics of the ratio of chromosomally normal versus chromosomally abnormal pregnancies also have qualifications. An estimate is that about 40 percent of fetal losses have aberrant chromosomal constitution. In fact the proportion will depend on the gestational age too, where the ratio is around 30 to 40 percent in the earliest stage, rises to 50 percent or more at 8 to 11 weeks, and falls after that. To the extent that we suppose there is no statistical correlation between incidence of chromosomal anomaly and the factors that could possibly affect the woman's work related outcomes, this knowledge provides support for using pregnancy losses as a source for exogenous shocks to fertility outcome. This will be further discussed in the next sub-section.

Besides chromosomal constitution, other factors that are associated with the likelihood of pregnancy losses include: fetal malformation, sex of the fetus, multiple pregnancy (such as twins), and previous pregnancy outcomes. But to the view of economists, these events are no less "mysterious" than a pregnancy loss in terms of them providing information on how likely pregnancy losses are associate with work related results. Therefore they are non-issues in the context of this study.

Maternal age and parity (order of the pregnancy) have often been believed to be related to the likelihood of pregnancy losses. The evidence here is that the pregnancy loss rate does not rise up until the woman is in her late thirties. The pregnancy order is shown to be unrelated to chances of pregnancy losses – the seemingly close connection between the pregnancy loss probability and parity is just an artifact since women in higher pregnancy orders are more likely to be those who have had pregnancy losses earlier and they are the ones who have a higher probability to have another pregnancy loss. In the regression, we are going to control for the age at which the woman was pregnant, given suggestions that the age at which the woman is pregnant may be correlated to work related outcomes.

Another important aspect related to pregnancy losses is maternal health. There are various channels through which maternal health can affect the pregnancy outcome. It can be its impact on the fetus' chromosomal constitution, or maternal illnesses (such as diabetes and high fever), or genital malformations. Specifically, some behaviors or conditions have long been suspected to have notable impacts on the pregnancy outcome. Maternal smoking is often thought to be harmful to the fetus, even though evidence from various studies is not always consistent. The study by Kline et al. (1989) showed that there is a real increase in the risk of the fetal loss, but only for the group of women who are economically disadvantaged and were not treated privately; otherwise there is no significant increase in risks. Similarly, it is found that the negative impact of alcohol consumption is also restricted to public patients. Both findings imply the need to be cautious in directly treating smoking or drinking as a causal factor of fetal losses. Oral contraceptives and spermicides used before or during the time of conceptions are also shown not to affect the risk of pregnancy losses. However, the conception that occurred while the intrauterine device (IUD) was in situ is consistently shown to have a higher fetal loss risk. Previous induced abortions, if done with an appropriate procedure, do not raise risk of pregnancy losses.

In relation to assessing the validity of using pregnancy losses as basis for instruments, from the evidence in the previous paragraph we can see that smoking, if possible, should be controlled for in the regression, since it seems to be a factor that could be linked to both the pregnancy loss risk and work related outcomes at the same time.

Lastly, the environment or job surroundings could affect the pregnancy outcome too. Studies show that jobs that involve solvents, anesthetic gases or heavy lifting are related to a higher rate of fetal losses, and women subject to irradiation are at a higher risk. But it is probably not essential to control for these information in this study since there will be only a very low percentage of women who will be affected by these factors, and also that these factors are not connected with the women's work outcomes in a consistent way.[15]

[15] The exposure to environmental hazards obviously is closely associated with the occupation that the woman holds, if she works. In this sense, there may be the possibility that the exposure to environmental hazard is correlated with one's work status. But as argued in the text, possible exposure will probably only affect a very small percentage observations in the sample so that the bias induced by this association (assuming we have no data to control for the exposure) will hopefully be small enough not to change the main conclusions of this study.

Table 1: Summary Statistics (Women Who Have Had At Least One Pregnancy)

Means	1988	1995	2002
Sample size	5778	7660	4945
Age	33.3 (6.8)	33.8 (6.9)	33.7 (7.1)
Black	.14	.15	.15
Hispanic	.11	.12	.16
Education	12.8 (2.3)	12.9 (2.4)	13.1 (2.6)
Spouse education (if married)	13.4 (2.5)	13.4 (2.5)	13.5 (2.6)
Married	.69	.65	.62
Education of Mother	11.0 (3.3)	11.1 (3.5)	-
Total family income (in 1995 dollars)	38751 (20867)	42032 (26935)	33409 (19847)
In poverty	.15	.15	.23
Smoked during the last pregnancy	.29	-	-
Drank during the last pregnancy	.13	-	-
Used medication during the last pregnancy	.03	-	-
Smoked 100 cigarettes or more	-	.49	-
Have had children	.90	.89	.90
Number of children	1.95 (1.23)	1.89 (1.23)	1.98 (1.29)
Age at the first pregnancy	21.9 (4.3)	21.9 (4.7)	22.2 (5.1)
First pregnancy ended in miscarriage	.11	.11	.13
Work for pay (last week)	.67	.69	.72
Full time worker	.47	.50	.55
Hours worked per week	24.2 (19.5)	26.0 (20)	-
Annual earnings (in 1995 dollars)	13879 (15137)	14866 (16850)	-

Note: Standard deviations are in parentheses. – indicates that the information is not available in that year.

Table 2: Test of Mean Equality of Demographic Variables [1]

	First pregnancy ended in miscarriage	First pregnancy did not end in miscarriage	p-value of t-test [2]
Age at pregnancy	21.93 (5.13)	21.67 (4.64)	0.014
Education	12.93 (2.40)	12.75 (2.39)	0.001
Mother's education [3]	8.36 (5.00)	8.54 (4.91)	0.115
White	0.62 (0.48)	0.55 (0.50)	0.000
Has smoked 100 cigarettes or more	0.30 (0.01)	0.29 (0.46)	0.499
Number of observations	2088	16294	

Note:

1. The number and number in the parenthesis are the sample mean and standard deviation. The calculations are based on the same observations as used in Table 1.
2. The maintained hypothesis of the t-test is that the means of the variable for the two groups are equal, and the alternative hypothesis is that the means are unequal.
3. Calculation only uses data from 1988 and 1995 as mother's education is not contained in the data from 2002 survey.

Table 3: Fertility Outcome Regression and Labor Market Outcome Regression: Full Estimates

	Fertility outcome regression	Labor market outcome regression			
Dependent variable:	Have children or not	Work for pay	Full time worker	Hours worked per week	Annual earnings
Independent variables:					
Age	**.040 (.003)**	**.028 (.005)**	**.050 (.005)**	**1.80 (.25)**	**921 (172)**
Black	**.067 (.008)**	-.006 (.013)	**.065 (.015)**	.689 (.578)	183 (407)
Hispanic	-.003 (.014)	-.029 (.023)	.021 (.024)	-.136 (.934)	547 (630)
Education	**-.022 (.001)**	**.048 (.002)**	**.044 (.003)**	**2.06 (.11)**	2513 (91)
Married	-.0004 (.0156)	**.266 (.032)**	**.291 (.033)**	**11.98 (1.35)**	**2755 (1041)**
Spouse education (if married)	**.008 (.001)**	**-.022 (.002)**	**-.026 (.003)**	**-1.07 (.10)**	**-337 (84)**
First pregnancy ended in miscarriage	**-.194 (.009)**	-	-	-	-
Have children	-	-.059 (.054)	**-.136 (.058)**	**-6.79 (2.90)**	-2729 (2191)
Smoked 100 cigarettes or more	**-.028 (.007)**	-.014 (.011)	-.006 (.012)	-.294 (.479)	-142 (367)
Year dummy, 1995	.010 (.007)	**.036 (.012)**	**.039 (.013)**	**2.30 (.52)**	**1096 (432)**
Year dummy, 2002	.018 (.032)	**.311 (.046)**	**.344 (.049)**	-	-
Constant	**.710 (.166)**	**-1.22 (.24)**	**-1.88 (.24)**	**-77.1 (12.2)**	**-30755 (9111)**
R^2	.14	.08	.07	.10	.19
Observations	18323	18323	18323	13176	12976

Notes:

1. All estimates reported are ordinary least squares estimates. Standard errors are in parentheses.
2. If the numbers are in bold fonts, it indicates that the coefficient is significantly different from zero at 5 percent level.

Table 4: Impact of Children on Labor Market Outcomes

Panel A: Effect of Miscarriage on Fertility Outcome					
Dependent Variable	Coefficient (S.E.)	R^2	Marginal contribution of miscarriage variable to R^2	Incidence of Miscarriage	Sample Size
Have at least one child	-.194 (.009)	.14	.045	2088	18323
Number of children	-.481 (.026)	.25	.011	2088	18323

Panel B: Effect of Children on Labor Market Outcomes				
	OLS	IV	Test of Exogenous Children	Sample Size
Effect of Having One or More Child				
Work for pay	-.166 (.010)	-.059 (.054)	**-.113 (.055)**	18323
Full time worker	-.172 (.012)	**-.136 (.058)**	-.038 (.059)	18323
Hours worked per week	-9.56 (.57)	**-6.79 (2.90)**	-2.83 (2.90)	13176
Annual earnings (in 1995 dollar)	-6362 (497)	-2729 (2191)	-3692 (2200)	12976
Effect of Number of Children				
Work for pay	-.075 (.003)	-.024 (.022)	**-.052 (.022)**	18323
Full time worker	-.084 (.003)	**-.055 (.023)**	-.030 (.023)	18323
Hours worked per week	-4.00 (.15)	**-2.57 (1.09)**	-1.52 (1.14)	13176
Annual earnings (in 1995 dollar)	-2629 (107)	-1028 (823)	**-1602 (863)**	12976

Notes:

1. The control variables in the regression are the same as in Table 3.
2. If the numbers are in bold fonts, it indicates that the coefficient is significantly different from zero at 5 percent level.
3. The test of exogenous children is based on the t statistic of the residual term in the second stage regression, where the residual term comes from the first stage regression.
4. Hours worked per week and annual earnings are not available from the survey of 2002.

Table A1: Risk of miscarriage, by outcomes of previous pregnancies

<table>
<tr><td colspan="8">Number of women who had at least one pregnancy: 18382</td></tr>
<tr><td colspan="8">Age a the first pregnancy: 21.70</td></tr>
<tr><td colspan="4">First pregnancy ended in miscarriage</td><td colspan="4">First pregnancy ended in birth</td></tr>
<tr><td colspan="4">2088, 11.36 %</td><td colspan="4">13465, 73.25 %</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="4">Number of women who continued to have the second pregnancy: 1678 (80.36 %)</td><td colspan="4">Number of women who continue to have the second pregnancy: 10129 (75.22 %)</td></tr>
<tr><td colspan="4">Age at the second pregnancy: 24.02</td><td colspan="4">Age at the second pregnancy: 24.68</td></tr>
<tr><td colspan="2">Second pregnancy ended in miscarriage</td><td colspan="2">Second pregnancy ended in birth</td><td colspan="2">Second pregnancy ended in miscarriage</td><td colspan="2">Second pregnancy ended in birth</td></tr>
<tr><td colspan="2">364, 21.70 %</td><td colspan="2">1228, 73.16 %</td><td colspan="2">1142, 11.27 %</td><td colspan="2">8291, 81.85 %</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="2">Number of women who continued to have the third pregnancy: 289 (79.40 %)</td><td colspan="2">Number of women who continued to have the third pregnancy: 906 (73.78 %)</td><td colspan="2">Number of women who continued to have the third pregnancy: 897 (78.55 %)</td><td colspan="2">Number of women who continued to have the third pregnancy: 4280 (51.62 %)</td></tr>
<tr><td colspan="2">Age at the third pregnancy 25.52</td><td colspan="2">Age at the third pregnancy 26.14</td><td colspan="2">Age at the third pregnancy 26.37</td><td colspan="2">Age at the third pregnancy 26.48</td></tr>
<tr><td>Third pregnancy ended in miscarriage</td><td>Third pregnancy ended in birth</td><td>Third pregnancy ended in miscarriage</td><td>Third pregnancy ended in birth</td><td>Third pregnancy ended in miscarriage</td><td>Third pregnancy ended in birth</td><td>Third pregnancy ended in miscarriage</td><td>Third pregnancy ended in birth</td></tr>
<tr><td>38.06 %</td><td>53.98 %</td><td>17.11 %</td><td>76.40 %</td><td>21.18 %</td><td>73.80 %</td><td>12.13 %</td><td>79.67 %</td></tr>
</table>

Note: observations are from the pooled data of 1988, 1995 and 2002.

Table A2: Summary Statistics, All Observations from 1988, 1995 and 2002

Means (unless otherwise indicated)	1988	1995	2002
Sample size	8450	10847	7643
Age	29.8 (8.3)	30.6 (8.5)	30.0 (8.7)
Black	.13	.14	.14
Hispanic	.10	.11	.15
Education	12.8 (2.4)	12.9 (2.5)	13.0 (2.7)
Spouse education (if married)	13.5 (2.5)	13.5 (2.8)	13.6 (2.6)
Married	.50	.49	.46
Mother's Education	11.5 (3.2)	11.6 (3.5)	-
Mother worked when growing up	.57	.61	.69
Live in metropolitan area	.78	.79	.82
Total family income (in 1995 dollars)	36880 (21811)	42250 (27363)	33586 (19814)
In poverty	.14	.14	.21
Number of pregnancies	1.61 (1.71)	1.73 (1.80)	1.77 (1.85)
Number of births	1.21 (1.34)	1.23 (1.32)	1.25 (1.35)
Number of abortions	.16 (.51)	.24 (.65)	.22 (.63)
Number of pregnancy losses	.34 (.73)	.27 (.72)	.30 (.72)
Number of children	1.22 (1.36)	1.24 (1.34)	1.28 (1.41)
Age at the first pregnancy (if have been pregnant)	21.9 (4.3)	21.9 (4.7)	22.2 (5.1)
Age at the first birth (if have had a birth)	22.5 (4.4)	22.9 (4.9)	23.3 (5.2)
Number of observations in Sample 1 (pregnant at least once) as a fraction of all observations	63 %	65 %	65 %
Number of observations in Sample 2 (at least one child, one more pregnancy) as a fraction of all observations	42 %	43 %	43 %
Number of observations in Sample 3 (at least two children, one more pregnancy) as a fraction of all observations	19 %	19 %	20 %

Note: Standard deviations are in parentheses. – indicates that the information is not available in that year.