THE IMPACT OF MATERNAL RISK FACTORS ON LOW BIRTHWEIGHT BIRTHS IN THE U.S. : TIME-SERIES CROSS-SECTION ANALYSIS

by

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Abstract

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Adviser: Professor Michael Grossman

This paper estimates a structural health production function that simultaneously considers the impact of a various maternal risk factors on race-specific rate of low birthweight birth with a pooled time-series cross-section of all United States live births, aggregated by state, controlling for fixed effects for the twenty-year period from 1973 to 1992. The maternal risk factors include the use of abortion service, out-of-wedlock births, prenatal care, education, and unemployment rate. Unlike the previous studies, this study applied estimated race-specific abortion, education, and unemployment which are not currently available in race-specific form at the state level.

This study has three main findings. First, the contribution of abortion use on the changes in the birth outcomes becomes less important over time and its impact on birth outcomes is not affected by the inclusion of education and unemployment. Second, the early initiation of prenatal care has no significant effect on birth outcomes once state and time fixed effects are included. The magnitude of impact on birth outcomes is greatly affected by the inclusion of education and unemployment. There is also a strong evidence of favorable selection for both races. Third, out-of-wedlock births is most significant and stable predictor of birth outcomes and makes the worst contribution to

predicted decline in the rate of low birthweight births for both races. Its impact on birth outcomes is not greatly affected by the inclusion of education and unemployment. The results of this study suggest that the increasing trend of low birthweight births can be lowered by by lowering the birth rates among unwed women on the one hand, and removing obstacles to easy access to early prenatal care for pregnancies among unwed women on the other.

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CHAPTER I

Introduction

Many of the causes of infant death with high proportions of neonatal deaths occur largely to low birthweight births, the birth of an infant weighing less than 2,500 grams or approximately 5 pounds 8 ounces. This has been identified as one of the most important risk factors for infant mortality. More than 60 percent of all infant deaths in the United States occur in about 7 percent of infants born at low birthweight. This is equivalent to 20 times those for normal birthweight births, those weighing 2,500 grams or more at birth (NCHS, 1989). The low birthweight births are also associated with a wide range of illnesses and disorders. Aside from personal and emotional costs, these disabilities place a financial burden on the family and may eventually limit the child's ability to work and earn a living in adulthood.

For the past 20 years neonatal mortality has declined by about 3 percent per year, a rate of decline more rapid than any noted since neonatal mortality was first separately recorded in national data in 1915. However, one of the principal determinant of neonatal mortality, low birthweight births, has changed little or not at all in this time period. The number of low birth-weight births among blacks increased to 13.3 per thousand live births in 1992 from 12.4 per thousand live births in 1985, or by 7 percent, while that for whites were the same in 1992 as in 1979, i.e., 5.8 low birthweight per thousand live births. The plateauing in whites and the recent sharp increase in blacks in the percentage of low birthweight births in the United States has probably had an adverse impact on the decline in infant mortality after mid 1980's. Infant mortality increases sharply as birth weight decreases. Moreover, much of the infant mortality among blacks is due to their low birthweight births. Hence, recent sharp increases in the black rate of low birthweight births is enough to draw special attention for further decrease in infant mortality rates in the United States.

Previous studies have focused on cross-sectional data set in the period of favorable declining trend of both infant mortality rates and the rate of low birthweight births. They have also made considerable progress to understand this favorable trend and attributed it to the increased utilization of appropriate prenatal care, better nutrition, legal abortion, education, a declining proportion of births to adolescents, and a variety of public programs aimed at the poor. There were many variations, however, such as measurement of controlling variables and functional form to estimate, in explanations of the impact of the proximate maternal risk factors on birth outcomes. Furthermore, it is hard to see clear-cut explanations of the increasing trend of the rate of low birthweight births after the mid 1980's despite the steady decline in the infant mortality rate based on the results of previous cross-sectional studies on infant health. Moreover, the impact of some risk factors on the low birthweight births changed significantly over time.

The recent time series studies on the infant health stated that the favorable trends have been offset by the prenatal consumption of illicit drugs and cigarette smoking during pregnancy, (Joyce and Mocan, 1992), and by the high proportion of births to unmarried women. Frank at al. (1992) reconfirm that the significant impact of prenatal care on the rate of low birthweight births for both races, yet they fail to show the significant impact of abortion on black birth outcomes, stated in bulk of previous cross-sectional studies

Therefore, the major concern of this study is to investigate the effects of maternal risk factors such as abortion, prenatal care, illegitimate birth, education ,and unemployment on race-specific low birthweight births as an attempt to understand the recent dramatic changes in the trend of low birthweight births. We will, unlike previous studies, use estimated race-specific abortion, education, and unemployment which are not currently available in race-specific form at the state level. Some specific questions that will be addressed in this study include: what are the effects of maternal risk factors on the race-specific rate of low birthweight births, controlling for state and time fixed effects? How are estimates of abortion, prenatal care, and illegitimate births altered when education and unemployment are included in the set of regressors? Do they sustain the level of significance and sign determined by previous studies? How do they contribute to the changes in the rate of race-specific low birthweight over time? To accomplish this, this study estimates a structural health production function with a pooled time-series cross-section of all United States live births, aggregated by state, controlling for underlying state and time fixed effects for the twenty-year period from 1973 to 1992. By using a fixed effects model, we can investigate the effects of maternal risk factors on the low birthweight births while controlling for state and time fixed effects for unmeasured heterogeneity that is not captured in this model.

The rest of the paper is laid out as follows: chapter II presents an overview of the general form of health production and reviews the past empirical research relevant to current analysis. Chapter III contains a detailed discussion of the data employed as well as the empirical model adopted in this study. Chapter IV presents the estimation results of the structural health production, which are reported separately by race. Finally, Chapter V summarizes the analysis and discusses the resulting conclusion.

CHAPTER II

Review of the Literature

A. Analytical Framework

In a number of previous studies, economists have developed empirical models of the health production function based on the theory of family behavior developed by Becker and Lewis (1973) and Willis (1973). Studies by Rosenzweig and Schultz(1982, 1988), Corman, Joyce and Grossman(1987), and Joyce (1987) are particularly relevant in this study.

Parents' utility is assumed to depend on their own consumption, the number of births, and the health of each child at birth. The number of births and the outcome of each birth are treated as endogenous variables. Infant health is assumed to depend on the quantity and quality of medical care, nutrition, marital status, abortion, maternal stress, and mothers' reproductive efficiency which includes an unobserved biological component as well as other aspects of her efficiency in household production. Maximizing the utility function subject to production and resource constraints generates a demand function for the number of children, infant health at birth, and other consumption goods. The interaction of infant health demand and production functions determines the derived demand functions for infant health. The preceding ideas are formalized in a following equations model:

(1) $$H = f_1 (a, b, c, d, \varepsilon)$$

(2) $$a = f_2 (p, w, y, d, \varepsilon)$$

(3) $b = f_3 (p, w, y, d, \varepsilon)$

(4) $c = f_4 (p, w, y, d, \varepsilon)$

Equation (1) is a structural production function of infant health and states that the health of the infant at birth depends on use of inputs such as quality and quantity of medical care utilization (a); endogenous risk factors such as abortion (b); demographic factors such as marital status and parity (c); exogenous risk factors such as social stress and environmental conditions (d); mothers' reproductive efficiency as well as mothers' health endowment (ε) which is presumably at least partially observable to the mother but not the researcher. Equation (2) through (4) are the input demand equations. They relate income and resource constraints (y), vector of price and availability measure (p), value of time (w), exogenous risk factors (d), and unobserved mothers' health endowment (ε).

Substitution of the input demand equations into the production function yields the following reduced form production equation:

(5) $H = f_5 (p, w, y, c, \varepsilon)$

The estimation of reduced form equation (5) enables us to investigate the impact of government programs associated with health outcomes while the estimation of structural production (2) enables us to investigate the mechanism through which a specific program operates. Some other empirical studies estimate the quasi-structural health production function such that structural production (1) might be expressed as a function of the endogenous risk factors along with the reduced form determinants.

The health endowment is included in both health production and input demand equations because such generally unavailable knowledge to the researchers as family history and previous pregnancies can motivate women with less favorable endowments to consume more care in order to avoid stressful situation. Failure to correct this potential bias will lead to biased coefficient estimates. Thus ordinary least squares does not produce consistent parameter estimates for this type of model. Previous cross-sectional studies have employed two-stage least squares or instrumental variable techniques to avoid this form of simultaneity bias (Rosenzweig and Schultz 1983, 1988; Corman, Joyce, and Grossman 1987). The use of aggregate time-series cross-section date, however, allows for a different approach to specification and estimation of the health production function. Since average health endowment within a state does not vary over time due to geographic clustering of women with similar health endowment (Frank at all, 1992), fixed-effects estimation would permit one to obtain unbiased estimates of the health production function directly (Chamberlain 1986). Therefore, this study will estimate equation (1) by using fixed-effects estimation for the empirical analysis while ordinary least squares estimators will be used for comparisons only.

B. Empirical Research

Previous empirical researches on birth outcomes are based on the economic model developed by Becker and Lewis (1973). The first empirical study in this area in a multivariate context was conducted by Grossman and Jacobowitz (1981). They estimated race-specific infant health production functions in which the dependent variable, the neonatal mortality rate, was regressed on various measures of prenatal health input availability, as well as measures of the abortion rate and abortion availability. A striking finding of their cross-sectional study was that the increase in legal abortion was the most important factor in the decline of the United States neonatal mortality rate since 1964 for both whites and nonwhites.

Rosenzweig and Schultz (1982, 1983, 1988) pointed that individuals have some information of their own genetic components which are not available to the researcher. If they alter their behavior based on this information, which was later termed in the literature as "adverse selection", then observed consumption of health inputs are correlated with unobserved inputs. If there is inadequate control for the endowment, the model will be misspecified in that the effect of this omitted set of factors will surface in the error term of the production function and will bias the estimates of the effects of input usage. In order to overcome this bias, Rosenzweig and Schultz suggest that the determinants of the health inputs must be used as instruments to purge the correlation between the inputs and the error term. The authors showed significant differences between the structural equation coefficients estimated by OLS and those obtained by TSLS methods using a cross-sectional sample of approximately 10,000 individual births in the United States from 1967-1969. They found that the effect of a delay in the initiation of prenatal care appeared insignificant in explaining birthweight in a single equation OLS production function model. However, the methodologically appropriate TSLS procedure, which corrects for adverse selection, indicated that late initiation of prenatal care had the expected negative and significant impact on birthweight. They also argued that education had an allocative effect on birth outcome. Thus, it must be used as an input for reduced form equation. But they failed to reject the null hypothesis that education should be excluded from the structural health production function.

Corman and Grossman (1985), the updated version of Grossman and Jacobowitz (1981), estimated race-specific reduced-form single equation production functions, in which the neonatal mortality rate was regressed upon a set of availability measures, socioeconomic characteristics that reflect command over real resources and tastes, and the biological endowment. The results, over all, were consistent with those of Grossman and Jacobowitz in that abortion and other inputs such as neonatal intensive care, schooling levels, and medicaid appeared to significantly affect the neonatal mortality rate for blacks. Several of the inputs excluding abortion, were significant for whites. Corman at al. (1987), extended work of Corman and Grossman, found similar results: for both blacks and whites, abortion was the most significant input in explaining neonatal mortality, and that prenatal care was the second most significant health input. The black mortality rate, however, was more responsive to input usage of all types than was the rate for whites.

Joyce (1987a, 1987b) estimated race-specific effects of health inputs, especially prenatal care and abortion on neonatal mortality, low birthweight, and prematurity. The last two were considered to be intermediate birth outcomes and were treated as endogenous to the structural model. The author found that abortions had a negative and significant effect on neonatal mortality for both whites and blacks, although coefficients for whites were less significant and the primary effect of abortion on neonatal mortality was through the low birthweight for both races. The effect of abortion on the intermediate birth outcomes themselves, however, was not as straightforward. For whites, abortions appeared to lower the rate of low birthweight primarily by reducing the number of births to mothers in high risk age groups. For blacks, abortions had no direct effect on low birthweight, but reduced neonatal mortality by reducing preterm births. In addition, he found that while early initiation of prenatal care had insignificant direct and total effects on neonatal mortality for blacks, it did have a significant total effect but insignificant direct effect on the rate of black low birthweight births. This is consistent with Harris's (1982) results based on sample of black births in Massachusetts between 1975 and 1976 and with medical evidence summarized by Harris. For whites, however, early prenatal care had significant total and direct negative effects on both neonatal mortality and low birthweight for whites.

Joyce and Grossman (1990b) and Grossman and Joyce (1990) estimate a health production function controlling for self-selection in pregnancy resolution and in prenatal care by using cross-sectional data on individual births and abortions from New York City in 1984. They assume that women who give birth are actually a self-selected sample from the population of pregnant women. Because of widespread availability of contraception and abortion services, a woman can now control the timing of pregnancy and the number of births. A woman who chooses to give birth will differ from those who choose abortion in several unobserved ways including wanting their pregnancy. It is expected that the more wanted a given pregnancy is, the more prenatal inputs would be used holding constant the other determinants of prenatal care usage. They found that statistically significant negative relationship between a delay in the prenatal care and an infant's birthweight for blacks and insignificant relationship for whites. Their results reconfirmed adverse selection of prenatal care use. A general implication of their analysis is that a black woman who aborts would have given birth to a lighter infant than would have a black woman with the same observed characteristics had she instead chosen to give birth. A black woman who does not abort, and for whom the pregnancy was ostensibly more wanted, would initiate prenatal care earlier and give birth to heavier babies.

Unlike previous studies on time-series relationships between unemployment and infant health, Joyce (1989) was able to control for the utilization of prenatal care and the incidence of out-of-wedlock birth. He estimated a health production function by using race-specific monthly data for New York City births from 1970-1986. He examined the stress hypothesis that unemployment as a proxy for maternal stress worsens the birth outcomes. Since the data was time-series, it was necessary for model specification to analyze and control for the behavior of each of the variables over time. After testing for the type of trend such as difference-stationary process and trendstationary process present in each of the series, he applied two model specifications: detrended production functions in which a linear trend term was included and only white low birthweight and white prenatal care were expressed in levels, and unadjusted production functions in which all of the variables were expressed in levels. Unlike previous cross-sectional studies, he could not reject null hypothesis that the prenatal care and illegitimacy were exogenous. He used lagged values of low birthweight as regressors, arguing that they were important proxies for unobserved endogenous factors such as cocaine use that may affect birthweight directly as well as indirectly via input usage. In both model specifications, he found that lagged low birthweight was an important predictor of black, but not white, low birthweight. For blacks, the early prenatal care was significant only in the second model specification , although the sign was as expected in the detrended model. He pointed out that the coefficient, -0.15, was similar to the results from Joyce (1987) and other aggregate cross-sectional studies. The effect of early prenatal care on white low birthweight, however, appeared to be insignificant in both specifications. The author mentioned that the latter result could be due to possible measurement error in this data set induced by the classification of Hispanics as white in New York City and the resulting changing ethnicity of the whites during the span of the data set. He could not find any evidence that unemployment worsens infant health in either specification.

Joyce and Grossman (1990a) used aggregate race-specific monthly data from New York City to model the relationship between the use of abortion, the early initiation of prenatal care, and the incidence of low birthweight. They estimate a race-specific vector autoregressive model in which all of the variables were treated as endogenous. The variables used in their analysis were the abortion rate, the percentage of low birthweight births, and the percentage of births for which prenatal care was initiated in the first trimester. They found that the shock in abortions led to a substantial increase in the rate of low birthweight births. The effect for whites, although directionally the same, was of a much smaller magnitude. These findings are consistent with results from their earlier cross-sectional studies on individual births which indicated that blacks are more likely to use abortion as a means of fertility control than are whites. The implication is that decreasing the availability of abortions would likely worsen birth outcomes, especially in the case of blacks in New York City.

The relationships within the overall infant health framework were empirically tested in several studies using pooled time-series and cross-sectional data. In order to investigate the dramatic rise in low birthweight births in New York City between 1980 to 1989, Joyce, Racine, and Mocan (1992) estimated the race- and ethnic-specific health production function in which the dependent variable, was regressed on the percentage of births to women with no prenatal care, the percentage of births out-of-wedlock, the percentage of births to women with four or more previous births, the percentage of births to women who smoked during pregnancy, and the percentage of births to women who use illicit substances prenatally. Three production functions were estimated using fixed effects, time-specific and time- and district-specific. They found that illicit substance use and marital status were important risk factors for blacks and Hispanics controlling for time-specific effects. But after controlling for district fixed effects, marital status loses its explanatory power. For whites, all coefficients are significant with time-specific effects but coefficients of illicit drug use and of marital status lose their significance with district-specific effects. They estimated the impact of illicit drug use on the rate of low birthweight births in the late 1980's by setting its level at 1984 while substituting annual means for each of the other variables. The results indicated that illicit drug use was an important contributory factor in the unprecedented rise in the black rate of low birthweight. But this impact droped significantly within the district over time. There was modest impact of illicit drug use on the non-black low birthweight births during the period 1985-1989 in New York City. They calculated that a number of excess low birthweight births were attributable to illicit drug use over this period and estimated the total excess neonatal treatment costs to be between $18 and $41 million.

In another pooled time-series and cross-sectional analysis, Frank, Strobino, Salkever, and Jackson (1992) estimated the race-specific quasi-structural birthweight production function to examine the impact of prenatal care on birthweight outcomes by race controlling for the use of abortion services, cigarette smoking, birth order, and income. They address that reducing the racial differences in the use of prenatal care is the first step to reduce the infant mortality differentials and estimate the impact of equalizing use of prenatal care in black and white women aged 20 to 34 years in US counties from 1975-1984. They estimated birthweight production functions using weighted least squares, including a separate intercept term for each county in the study. When the race-specific models were tested for the exogeneity of prenatal care, it appeared that the single equation models had indeed adequately controlled for unobserved heterogeneity. They found that the early initiation of prenatal care and the per capita income measure had a significant negative impact on the white percentage of low birthweight while the prenatal care indicator was significant for blacks only at conventional levels. By estimating the model both with and without controlls for the fixed effects and by comparing the resulting coefficients for prenatal care, they found evidence of adverse selection in the early use of prenatal care for blacks and favorable selection for whites. They project the black rate of low birthweight by setting its level equals to that of the whites at 1984. The results indicate that the expansion of early prenatal care in blacks would make only a small contribution to the reduction of racial differences in the rate of low birthweight births.

In summary, the previous empirical studies suffer from the trade-off between the precision of the resulting parameters and their economic interpretation due to problems of serious multicollinearity of regressors and lack of control for endogenous regressors. These have often blurred the distinction between structural and reduced forms and have had a tendency to estimate a hybrid equation. Although the levels of significance and magnitudes of variables could be varied along with controlling variables or model specifications, there is consensus throughout cross-sectional studies that the early initiation of prenatal care and the use of abortion services make a significant negative impact on the rate of low birthweight for blacks. For whites, however, the effects of the use of abortion services on the rate of low birthweight were less consistent across studies. Several recent time-series studies state that the role of the early prenatal care and the use of abortion services for blacks have concurred with the results of cross-sectional studies. For whites, however, there is no evidence of significant effects of the early prenatal care and the use of abortion services on the birth outcomes. This, however, may not indicate that there is no impact of the above variables on white birth outcomes but the strong effects of changes in their role over time.

CHAPTER III

Empirical Implementation

A. Data and measurement of variables

In order to measure the effects of maternal risk factors on low birthweight birth within the framework of a structural production function, we include by year and by state the percentage of births to women initiating prenatal care in the first trimester, the percentage of births to unmarried women, abortion rates, the percentage of the population 25 years of age and older with at least 4 years of high school education, and unemployment rate. The data set used here is time-series cross-section for all states in the United States for whites and for states with 10,000 or more black residential population for blacks (based on 1970 census) in order to attenuate the noisiness of state data. The results are provided for 38 states for blacks and for 50 states for whites for the 20 years, from 1973 to 1992.

The data for this study was collected for the various years from *Vital Statistics, Advanced Report of Final Natality Statistics, Statistical Abstract of the United States, Census of Population, Abortion Factbook, and Family Planning Perspectives.* The *Vital Statistics and Advanced Report of Final Natality Statistics* presents detailed race-specific state-level data on low birth weight births, prenatal care, and illegitimate births. State-specific education was available for the *Census of Population* years of 1970, 1980 and 1990. Values for other years were computed using state-specific exponential growth trends. These values were adjusted so that a weighted average of the variable at issue for an intercensal year was equal to the observed national rate as reported by the

Bureau of Census. The *Bureau of Labor Statistics* provides state-specific unemployment rates. The *Abortion Factbook* and *Family Planning Perspectives* provide the series of 51 states of abortion from 1973 to 1992 with the exception of 1983, 1986, 1989, and 1990 . Values for the missing years are interpolated from the surrounding years.

The District of Columbia is not included for both whites and blacks. Alaska, Hawaii, Idaho, Maine, Montana, New Hampshire, North Dakota, South Dakota, Utah, Vermont, and Wyoming are not included for blacks. Over all, 50 states of whites and 39 states of blacks data are used in this study. In table 1, the availability and source of the data used to construct the variables are shown. Summary statistics of annual means and standard deviations can be found in table 2.

B. Dependent variable.

The race-specific percentage of low birthweight birth is used as an indicator of infant health. This is the most proximate endogenous risk factor for neonatal mortality (Institute of Medicine, 1985) and contributes to two-thirds of the deaths of infants in the United States. The infant mortality rate has been decreasing rapidly, yet there has been relatively little change in the rate of low birthweight births during the past two decades. Figure 1 shows a decreasing trend in the rate of low birthweight births for both blacks and whites which ended in 1984 and shows that the gap between black and white low birthweight births has been widening since then. By contrast, infant mortality has been declining continuously with a slower rate after 1985 than before 1985. It has

Table 1. Data Sources and Definition of Variables

Variables	Defintions	Sources
LBW	The number of low birthweight births, weighing 2,500 grams or less, per 1,000 live births	Vital Statistics various years and Monthly Vital Statistics Report available from 1973-1992.
Abortion*	The number of abortions per 1,000 in women aged 15-44 by state of occurence	Abortion Factbook (1992) and Family Planning perspective (1994, v26, n3), available from 1973-1992 with no data in 1983, 86, 90. These years are interpolated with surrounding years
Illigitimacy	Percentage of live births to unmarried women aged 15-44	Vital Statistics from various years, Monthly Vital Statistics Report available from 1973-1992. Incompleted many states data are treated as missing values.
Prenatal	Percentage of live births for which prenatal care began in the first trimester (first 3 months) of pregnancy.	Vital Statistics various years and Monthly Vital Statistics Report available from 1973-1992.
Education*	Percentage of state population ages 25 and over with at least a high school education.	Data for census years ('70, '80, '90) obtained from the Statistical Abstract of the United States. Intercensal years are computed using an exponential growth rates.
Unemployment*	Total number of person unemployed over the non-institutional population 16 years and over.	Employment and Earnings, in various years, available from 1973-1992

An asterisk (*) next to a variable means that it is not available in race-specific at the state level. However, abortion, education, and unemployment variables are converted into race-specific based on procedure explained in the following section.

Table 2. Means and Standard Deviations by Year.

	N	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	73-92
Whites																						
LBW	1000	6.4	6.3	6.3	6.1	5.9	5.9	5.8	5.7	5.7	5.6	5.7	5.6	5.6	5.6	5.7	5.6	5.7	5.7	5.8	5.8	5.8
		(4.1)	(4.2)	(4.3)	(4.2)	(4.3)	(3.8)	(4.2)	(4.3)	(4.2)	(4.3)	(3.9)	(4.2)	(3.9)	(3.9)	(4.2)	(4.2)	(3.9)	(4.5)	(4.6)	(4.3)	(4.2)
Abortion	1000	13.8	15.6	17.1	18.7	20.8	22.2	23.9	24.2	24.2	23.7	23.2	23.0	22.5	21.7	21.0	21.1	20.8	21.4	21.2	21.1	21.1
		(89.1)	(61.2)	(55.7)	(54.1)	(57.3)	(57.6)	(59.1)	(57.8)	(60.5)	(58.3)	(59.5)	(63.2)	(64.4)	(59.5)	(55.9)	(56.2)	(58.4)	(63.1)	(64.1)	(62.7)	(60.9)
Prenatal	962	74.9	75.9	75.9	76.8	77.3	78.2	79.1	79.3	79.4	79.2	79.4	79.6	79.4	79.1	79.4	79.4	78.9	79.5	80.2	80.8	78.6
		(31.7)	(31.8)	(32.6)	(34.8)	(34.3)	(33.2)	(31.8)	(35.9)	(36.6)	(37.6)	(38.2)	(38.7)	(40.4)	(41.7)	(41.6)	(43.2)	(46.9)	(46.2)	(44.6)	(43.7)	(38.3)
Illegitimacy	921	6.2	6.3	7.0	7.4	7.9	8.5	9.0	11.0	11.6	12.1	12.8	13.4	14.5	15.7	16.7	17.7	19.0	20.4	21.8	22.6	13.1
		(8.0)	(8.2)	(9.0)	(9.6)	(10.5)	(11.6)	(12.7)	(25.8)	(26.7)	(26.3)	(29.2)	(30.1)	(31.3)	(34.0)	(34.3)	(36.8)	(40.8)	(46.8)	(50.3)	(52.5)	(26.7)
Education	1000	60.3	62.3	64.4	65.2	66.1	67.0	67.9	68.8	71.6	72.8	73.8	75.0	75.5	76.2	76.9	77.6	78.4	79.1	79.9	80.9	72.0
		(50.0)	(50.6)	(50.9)	(50.6)	(51.0)	(49.8)	(49.7)	(49.3)	(49.1)	(47.8)	(46.0)	(44.6)	(43.0)	(40.9)	(39.0)	(37.5)	(36.5)	(35.2)	(33.6)	(32.3)	(44.4)
Unemployment	1000	4.3	5.0	7.8	7.0	6.2	5.2	5.1	6.3	6.7	8.6	8.4	6.5	6.2	6.0	5.3	4.7	4.5	5.2	6.0	6.5	6.1
		(8.5)	(9.0)	(13.4)	(11.8)	(9.5)	(7.2)	(8.0)	(12.2)	(13.6)	(16.8)	(17.7)	(15.0)	(12.7)	(12.6)	(12.2)	(10.6)	(7.9)	(6.5)	(8.2)	(8.5)	(11.1)
Blacks																						
LBW	780	13.2	13.1	13.1	13.0	12.8	12.8	12.5	12.5	12.5	12.4	12.6	12.4	12.4	12.5	12.7	12.9	13.4	13.2	13.5	13.3	12.8
		(2.4)	(2.9)	(2.6)	(3.1)	(2.7)	(2.4)	(3.1)	(2.6)	(3.3)	(3.0)	(3.2)	(3.2)	(2.7)	(3.2)	(3.0)	(3.4)	(3.5)	(3.7)	(4.2)	(3.6)	(3.1)
Abortion	780	26.7	38.3	46.7	54.0	56.8	56.8	54.7	55.4	54.4	54.1	54.3	53.3	54.4	54.8	54.8	56.2	53.7	53.6	53.2	52.7	51.9
		(84.8)	(77.7)	(83.7)	(85.5)	(83.6)	(76.1)	(68.3)	(66.4)	(66.4)	(64.2)	(68.1)	(71.8)	(76.0)	(74.2)	(72.6)	(74.9)	(71.5)	(72.3)	(72.6)	(74.0)	(74.2)
Prenatal	752	51.3	53.7	55.6	57.6	58.9	60.2	61.6	62.6	62.4	61.4	61.5	62.1	61.7	61.5	61.1	61.0	60.0	61.3	62.6	64.0	60.1
		(27.2)	(27.1)	(26.2)	(26.0)	(27.0)	(27.3)	(28.5)	(28.5)	(28.5)	(29.6)	(28.8)	(27.5)	(27.0)	(27.5)	(26.6)	(23.3)	(20.9)	(20.2)	(20.0)	(20.5)	(25.9)
Illegitimacy	718	46.2	47.3	49.1	50.7	51.8	52.9	54.0	55.2	56.0	56.7	58.3	59.2	60.2	61.3	62.3	63.5	64.6	66.5	67.9	68.1	57.6
		(19.3)	(19.7)	(21.0)	(22.9)	(25.0)	(26.0)	(26.2)	(25.3)	(25.5)	(26.4)	(25.4)	(25.3)	(25.8)	(26.1)	(25.9)	(26.3)	(27.1)	(30.1)	(30.5)	(32.8)	(25.6)
Education	780	40.3	42.3	44.4	46.6	49.0	51.4	53.0	54.8	56.5	56.9	59.5	60.9	62.6	64.2	65.4	66.7	66.9	67.8	68.7	69.9	57.4
		(16.3)	(16.7)	(17.0)	(17.5)	(18.3)	(18.7)	(19.1)	(19.1)	(18.8)	(18.0)	(17.8)	(17.5)	(17.1)	(16.8)	(16.4)	(16.2)	(15.2)	(14.7)	(14.2)	(13.8)	(17.0)
Unemployment	780	8.9	9.9	14.1	13.2	13.2	12.0	11.4	14.5	15.8	19.2	19.7	16.1	15.3	14.7	11.7	10.5	10.2	10.7	11.3	12.8	13.3
		(7.8)	(7.9)	(10.7)	(10.5)	(9.3)	(7.6)	(8.4)	(14.0)	(15.0)	(18.4)	(19.8)	(17.4)	(15.6)	(17.1)	(15.0)	(13.5)	(9.8)	(7.2)	(7.5)	(7.3)	(12.0)

Notes:

1) Abortion, education and unemployment variables are not available in race-specific at the state level. However, race-specific figures are estimated by using procedures explained in the next section.

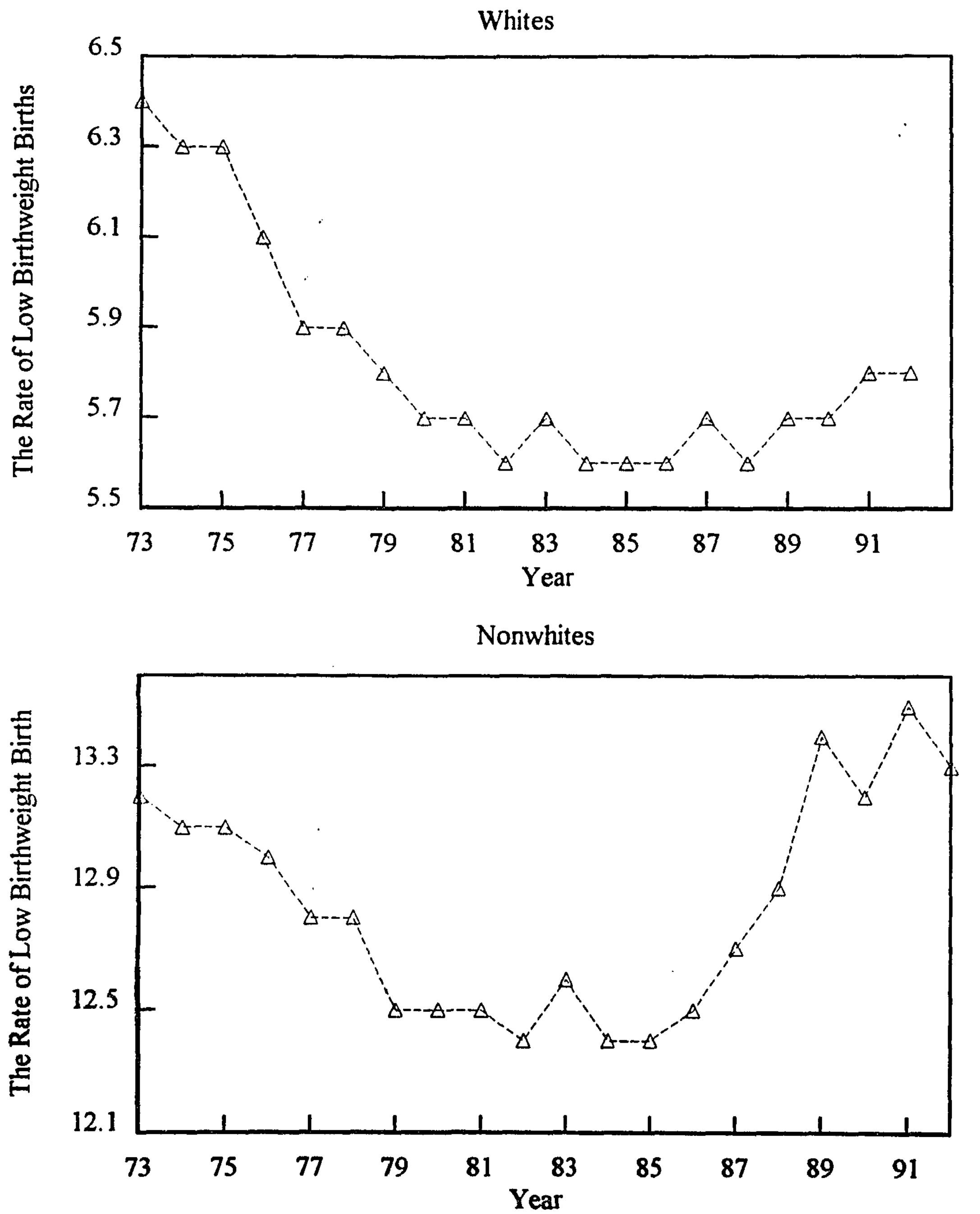
2) Means and standard deviations are weighted by total number of births in state each year.

3) Unless otherwise indicated, white means and standard deviations are based on 50 states while black means and standard deviations are based on 39 states.

4) District of Columbia is not included in both whites and blacks data. Alaska, Hawaii, Idaho, Maine, Montana, New Hampshire, North Dakota, South Dakota, Utah, Vermont, Wyoming are not included in blacks data.

Source: Statistical Abstract of the United States, annual: various years. US National Center for Health Statistics, Vital Statistics of the United States-Natality, annual: various years. Abortion Factbook, 1992 Edition. Census of population: 1970, 80, 90.

Figure 1. Trend of the Rate of Low Birthweight Births for Whites and Blacks, 1973 - 1992.



Data source: see footnote of table 2.

been attributed in some part to major advances in neonatal intensive care that have resulted in much lower mortality among infants with low birthweights[1]. One of the advantages of using low birthweight as a birth outcome measure in time-series study is that it has less potential confounding due to technological changes.

C. Independent Variables

The use of abortion[2] rate is measured by the number of abortion per 1000 women between the ages of 15-44 for each state and year. The abortion rate is selected rather than the abortion ratio (abortions per 1000 live births), because of the former indicates the abortion rate among the entire population at risk of conception, while the latter is more dependent upon the pregnancy rate and is the more endogenous than the former (Corman, Joyce and Grossman, 1985). Grossman and Jacobowitz (1981) pointed that the increase in legal abortion was the single most important factor in decline in the United States neonatal mortality between 1964 and 1977 for whites and nonwhites. This finding supports the hypothesis that abortion affects low birthweight

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[1] The impact of neonatology such as newborn intensive care units, renal dialysis, coronary care units and electronic fatal monitoring has been considered the dominant driver of strong decline in neonatal mortality in the United States. Mayfield, et al (1990) showed that low birthweight birth in hospital with newborn intensive care units experience substantially lower neonatal mortality than do infants born in hospital without such facilities. But the applications of these new neonatology are relatively uncommon, about 7 percent of live births [Nest, et al (1987)]. It means that the marginal benefit of these technology must be small.

[2] There are two primary source of abortion data in this country. The Center for Disease Control (CDC) publishes annual numbers on legal abortion by age and by race specific, white and non-white, from state central health agencies but not complete in many states. The second source of abortion data is the Alan Guttmacher Institute (AGI) publishes non-race specific annual number of abortion occurred in all states from 1973 to 1992 with exception of 1983, 1986, 1989 and 1990. We use AGI data on abortion since it is more complete than that of CDC. The data for missing years in each is interpolated from the surrounding years in order to keep variations in each state.

births and mortality by reducing the proportion of births within high-risk categories. But Frank et al. (1992) failed to find significant effects of abortions on the rate of low birthweight births for both races by using time-series cross-section data from 1975 to 1984.

Abortion affects the birth outcomes by reducing the unwanted births. The fact that the abortion rate for unmarried women is 5 times larger than that for married women, 46.2 vs. 9.3, and that 26 percent of all abortions performed in 1988 is by teenagers is highly suggestive of this [Henshaw and Van Vort (1992)]. This in turn improves birth outcomes by increasing the resources devoted to births which are not averted.

One important shortcoming of this variable is that it is not race-specific yet it covers the entire period since the Supreme Court ruled most restrictive state abortion laws unconstitutional. Two types of abortion data, by state of occurrence and state of residence, are available in the Abortion Factbook[3]. The former is available form 1973 to 1992, but is affected by a number of factors, including differences in the availability of abortion services, the proportion of the population, the degree of urbanization, and state and/or border-state policies on it[4]. The later is currently available from 1978 to 1987.

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[3] The Center for Disease Control (CDC), also, publishes annual numbers of whites and non-whites legal abortions by states of occurrence for a limited number of states. However, the CDC data for most states are obtained from state health departments, some of which do not receive information from all providers and may receive incomplete information from others. The AGI figures for most states and the nation as a whole are therefore believed to be more accurate.

[4] This is most noticeable in the District of Columbia for both Blacks and Whites. We eliminate the DC in our entire analysis not only for this reason but also the rate of low birthweight births for Blacks is unusually high compare to the rest of the states due to high percentage of black population in DC.

The non-race specific abortion rates can be converted into race-specific rates based on the following: first, the total abortion rate in jth state in year t is a weighted average of the white and nonwhite abortion rate:

(7) $$A_{jt} = k_{wjt}A_{wjt} + (1 - k_{wjt})A_{njt}$$

where

A_{jt} is the total abortion rate in state j in year t,

A_{wjt} is the representative white abortion rate in state j and time t,

A_{njt} is the representative nonwhite abortion rate in state j and time t,

k_{wjt} is the fraction of state white female population aged 15-44 in time t.

Since abortion rates are available in nonrace-specific at the state level and race-specific, white and nonwhite, at national level, it was assumed that the ratio of the nonwhite to white abortion rate was constant across the states[5] in time t. That is,

(8) $$A_t = A_{nt} / A_{wt} = A_{njt} / A_{wjt}$$

where

A_{nt} is nonwhite obasrved national abortion rate in year t,

A_{wt} is white observed national abortion rate in year t.

[5] This ratio is based on abortion rate by occurrence since race-specific abortion rate by residence is not available. Although nonresidents of the United States who obtained abortions in the United States are excluded in the total number of abortions by residence after 1978, that is less than 1 percent of total abortions by occurrence.

Then equation (7) can be solved for A_{wjt} and A_{njt} in terms of A_{jt}, A_t and k_{wjt}:

(9) $$A_{wjt} = A_{jt} \,/\, [\, k_{wjt} + (1\text{-}k_{wjt})A_t]$$

(10) $$A_{njt} = A_t A_{jt} \,/\, [\, k_{wjt} + (1\text{-}\, k_{wjt})A_t]$$

A_{wjt} and A_{njt} are adjusted so that a weighted average of each state abortion rate in each year is equal to the observed national rate. For example,

(11) $$A^e_{it} = \sum_j S_{ijt} A_{ijt}, \quad i = n, w$$

where

A^e_{it} is the estimated race-specific abortion rates for white and nonwhite in year t,

S_{ijt} is the share of jth state female population 15-44 over national total in year t,

n represents non-whites,

w represednts whites.

Then the adjusted state- and race-specific abortion rate is, A^*_{ijt}, given by

(12) $$A^*_{ijt} = (\, A_{it} \,/\, A^e_{it})\, A_{ijt}, \quad i = n, w$$

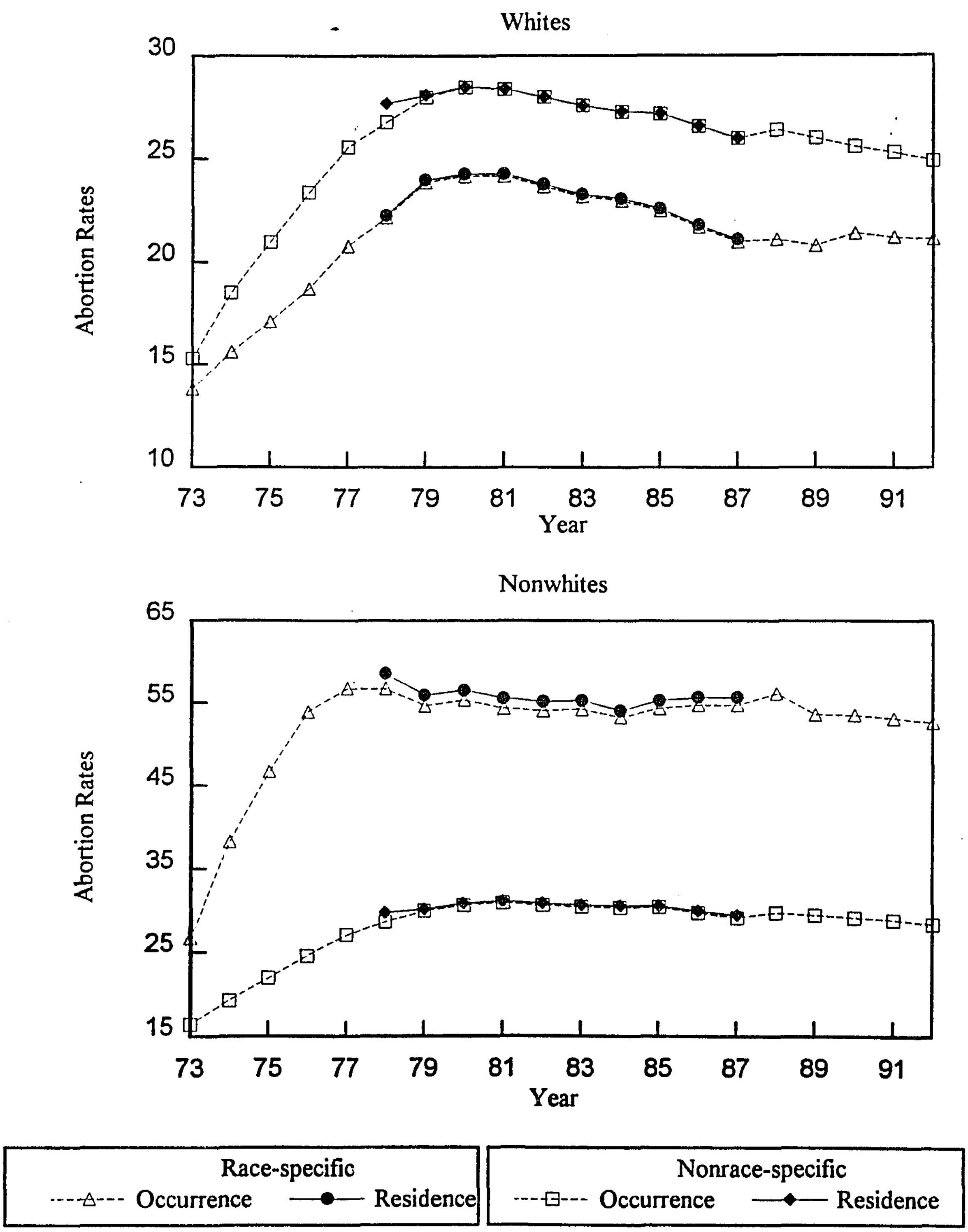
Data of nonrace-specific resident abortion rates are available at the state level for the restricted time periods in Abortion Factbook, 1978 - 1987[6], and nonrace-specific

[6] 1983 and 1986 are not available and interpolated.

state level abortion rates by state of occurrence are available for the entire time periods. Race-specific United States national total abortion rates, A_{nt} and A_{wt}, are available for the entire time periods based on occurrence data[7]. Given these limitations and need for race-specific series for entire time periods, this study will use the series based on state of occurrence data in order to analyze the entire time periods. We can compare four series, see figure 2, based on actual nonrace-specific abortion rates and estimated race-specific abortion rates by occurrence for the entire time periods, from 1973 to 1992, and by resident for the restricted time periods, from 1978 to 1987. The series of abortion rates based on state of resident and state of occurrence are visually identical for both whites and nonwhites. For the series based on occurrence, the non-race specific series overstates the series of estimated white abortion rates, on average by 19 percent, and understates that of the nonwhites, on average by 45 percent, for the time period between 1978 and 1987. For the series based on state of resident, the non-race specific series overstates the series of the whites, on average by 20 percent, and understates that of the nonwhites, on average by 46 percent, for the same time period. Although the race-specific series based on occurrence data slightly understate the race-specific series based on resident for blacks, We believe that the race-specific series reduces the measurement errors compare to the direct use of nonrace-specific abortion rates on the estimation of race-specific health production function.

[7] One caveat of this measurement is that numerator is based on state of occurrence which could be affected not only by own-state policy but also by surrounding states policies, yet denominator is based on state of residence female fertile population.

Figure 2. Trend of Race and Non-race Specific Abortion Rates by Occurance and Resident Data for Both Whites and Nonwhites, 1973-1992



Data source: see footnote of table 2.

Illegitimacy is measured by the percentage of births to unmarried women as a proportion of all live births. This variable is expected to capture the effect of poor health endowment or less access to high quality prenatal care, low socio-economic status, and unstable family status as well. Thus unmarried women are more likely to obtain late or no prenatal care and have high probability of having low birhtweight births. The number of births to unwed mothers soared by 48 percent, to 68.1 from 46.2, for blacks and more than 360 percent, to 22.6 from 6.2, for whites from 1973 to 1992. These trends are highly correlated with not only recent sharp rise in the rate of low birthweight birth, especially for blacks, but also the decline in prenatal care in the decade of the 1980s as speculated by previous several studies. The recent sharp rise can be attributed partly due to changes in traditional family structure, especially in blacks, to financial incentives for poor unmarried women, and to delay in marriage[8]. Given these, we cannot eliminate the possibility of wantedness of illegitimate births in a segment of the pregnant population. The fact that 44 percent of unmarried pregnant women carried term, although 83 percent of all abortions are performed on unmarried women (AGI, 1992). If this is the case then illegitimate births can be viewed as planned births and not be used as a appropriate proxy for a marital risk factor in that population. However, the magnitude of this offsetting effect is unknown.

[8] The out-of-wedlock birthrates rose in the 1960's when the value of welfare benefits went up. Yet the rate continued to rise in the 1970's and 80's, even though the value of the benefits declined because they did not keep pace with inflation. Lundberg and Plotnick(1990) argued that the level of welfare benefits is positively significantly related to the probability of teen out-of-wedlock births for whites, but not for blacks. Duncan and Hoffman (1990) showed that insignificant positive effect of AFDC benefit levels on the incidence of teen out-of-wedlock births.

The use of prenatal care, as a proxy of medical care utilization, is measured by the race-specific number of live births to women who began care in the first trimester[9]. This measure has been widely used as an indicator of access to prenatal care. It has the advantage of being unrelated to the length of pregnancy for live births. However, this measure does not reflect quality of prenatal care received by women who develop complications during their pregnancy or who begin pregnancy with underlying medical problems (Corman, Joyce, and Grossman, 1987). Moreover, the initiation of early prenatal care may not represent the adequacy of care obtained, which is determined not by the physician but by the pregnant women. Other studies use different measures for prenatal care such as the number of months of elapsed pregnancy before the mother visited doctor (Rosenzweig and Schultz ,1982 and 1983), and the number of prenatal visits (Harris, 1982).

A woman who anticipates a problematic birth, based on the conditions unknown to the researcher, will demand more remedial care than those who anticipate a problem free birth. Because of this adverse selection, estimates of the effect of prenatal care obtained from the regressions that do not correct this simultaneous bias will underestimate its impact on birth outcomes. A potentially, however, more serious source of bias would be the existence of favorable selection in input use (Gortmaker, 1979, and Institute of Medicine,1985). That is, women's demand for prenatal care may

[9] This measurement of prenatal care includes only those births from women who definitely received some amount of prenatal care. Thus, it was measured by the number of births in a given year for which the initial prenatal visit occurred within the first 3 months of pregnancy, divided by the number of births in that year for which at least some prenatal care was received during the course of the pregnancy.

be another manifestation of the many health-enhancing behaviors. Thus a woman who seek out prenatal care early in her pregnancy may be inclined to choose a more nutritious diet, follow an appropriate exercise and try to avoid stress. If such inputs are left out because of the difficulty in measuring them, then the impact of prenatal care on birthweight will be overestimated. That is, the health endowment not only affects the pregnancy and birth outcome, but it conditions a women's behavior during the pregnancy.

Previous studies applied two-stage least squares in order to eliminate possible correlation with not only included but also omitted variables. But this study does not consider possible endogeneity of prenatal care. Since we use aggregate data and fixed-effects model, the issue of endogeneity is not crucially important for this study.

Education is measured by the state-specific percentage of the population 25 years of age and older with at least high school education. This is used as a proxy for parental efficiency based on the assumption that education raises market and nonmarket productivity (Grossman 1972). More formally, given equal amounts of health inputs, parents with more education can achieve greater birth outcomes then their less educated counterparts holding all else constant, consequently termed as efficient effect. Rosenzweig and Schultz (1982), however, argued that education may enhance parent's ability to correctly perceive the true relationship between an input and child health, termed as allocative effect. Hence, it must be used as an input for reduced form demand for infant health. Grossman and Joyce (1990) showed that the impact of education on low birthweight births was minor, yet was a powerful determinant of prenatal care. This study uses education as a proxy measure of parents efficiency effect on their infant health production function. Given this, we would expect large and significant coefficient for education. We, however, cannot rule out the possibility of an allocative effect as well.

Shortcomings of this variable are that it is not race-specific and available for the Census of Population years of 1970, 1980 and 1990. Values for other years were computed using state-specific exponential growth trends. These data are converted into race-specific, white and nonwhite, based on the following: first, the percentage of the population 25 years of age and older with at least 4 years of high school education on the *j*th state in year *t* is a weighted average of the whites and nonwhites education rates:

(13) $$E_{jt}'' = k_{wjt}E_{wjt} + (1 - k_{wjt})E_{njt}$$

where

E_{jt}'' is the total population education rate in state *j*,

E_{wjt} is the representative white education rates in state *j* in year *t*,

E_{njt} is the representative white education rates in state *j* in year *t*,

k_{wjt} is the fraction of white population aged 25 and over in state *j* in year *t*.

Since observed education rates as reported by the Bureau of Census are nonrace-specific at the state level but race-specific, whites and nonwhites, at national level, it is assumed, in order to estimate race-specific state education rate, that the ratio of the nonwhite to white education rate was constant across the states in time t. That is,

(14) $$E_{nt} = E_{nnt} / E_{wnt} = E_{njt} / E_{wjt}$$

where

E_{nnt} is the national total nonwhite observed education rates in year t,

E_{wnt} is the national total white observed education rates in year t.

Then equation (13) can be solved for E_{wjt} and E_{njt} in terms of E_{jt}, E_{nt} and k_{wjt}:

(15) $$E_{wjt} = E_{jt} / [\, k_{wjt} + (1-k_{wjt})E_{n}]$$

(16) $$E_{njt} = E_{nt}E_{jt} / [\, k_{wjt} + (1- k_{wjt})E_{n}]$$

E_{wjt} and E_{njt} were adjusted so that a weighted average of the variable at each year was equal to the observed national rate as reported by the Bureau of the Census. For example,

(17) $$E^{e}_{it} = \sum_{j} S_{ijt}E_{ijt}\,, \qquad i = n, w.$$

where

E^{e}_{it} is the estimated race-specific national education rates in year t,

S_{ijt} is the share of state population 25 years and over in year t,
n represents nonwhites,
w represents whites.

Then the adjusted race- and state-specific education rate is, E^*_{ijt}, given by

(18) $$E^*_{ijt} = (E_{it} / E^e_{it}) E_{ijt} , \quad i = n, w.$$

However, these estimated race-specific education variables are expected to have high correlation with marital status, abortion and other omitted variables. Hence, this study will highlight how the estimates of other variables are altered when education is included.

Finally, The use of unemployment rate is measured by the total number of person employed over the non-institutional population 16 years and over and used as a proxy for maternal stress. Several studies, Brener(1973, 79, 83), Macavinch and Eastern(1988), and Joyce(1990) used unemployment as a proxy for maternal stress based on assumption that business cycle has an impact on infant health. But the direction of impact is still disputed. Since recessions could have negative effect on infant health if the stresses associated with the unemployment status have unfavorable consequences on the birth outcomes and have positive effect on birth outcome if it lower the opportunity cost of pregnant women's time which in turn increases more time intensive inputs such as exercise or rest (Joyce, 1990). Although instruments for assessing stress are difficult to construct, this study follows Brener's stress hypothesis of unemployment based on assumption that it worsens birth outcomes directly by increasing the maternal stress and indirectly by altering the investment on health inputs. Thus, this variable is possibly related to income measure, own time of mother and good nutrition.

Shortcoming of this variable is also that it is not race-specific. However, this data will be converted into race-specific, white and nonwhite, based on same methodology used for abortion and education: first, the percentage of the population 16 years and over on the *j*th state in year *t* is a weighted average of the whites and nonwhites:

(19) $$U_{jt}'' = k_{wjt}U_{wjt} + (1 - k_{njt})U_{njt}$$

where

U_{jt}'' is the total unemployment rate in state *j* in time *t*,

U_{wjt} is the representative white unemployment rates in state *j* in year *t*,

U_{njt} is the representative nonwhite unemployment rates in state *j* in year *t*,

k_{wjt} is the fraction of state white population aged 16 and over in year *t*.

It is assumed that the ratio of the nonwhite to white unemployment rate was constant across the states in time *t*. That is,

(20) $$U_{nt} = U_{nnt} / U_{wnt} = U_{njt} / U_{wjt}$$

where

U_{nnt} is the nonwhite observed unemployment rates in year t.

U_{wnt} is the white observed unemployment rates in year t.

Then equation (19) can be solved for U_{wjt} and U_{njt} in terms of U_{jt}, U_{nt} and k_{wjt}:

(21) $$U_{wjt} = U_{jt} / [\ k_{wjt} + (1\text{-}k_{wjt})U_n]$$

(22) $$U_{njt} = U_{nt}U_{jt} / [\ k_{wjt} + (1\text{-}\ k_{wjt})U_n]$$

U_{wjt} and U_{njt} were adjusted so that a weighted average of the variable at each year was equal to the observed national rate as reported by the Employment and Earnings. For example,

(23) $$U^e_{it} = \sum_j\ S_{ijt}U_{ijt}\ , \qquad i = n, w.$$

where

U^e_{it} is the estimated race-specific unemployment rates in year t,

S_{ijt} is the share of state population 16 years and over in year t,

n represents nonwhites,

w represents whites.

Then the adjusted race- and state-specific unemployment rate is, U^*_{ijt}, given by

(24) $$U^*_{ijt} = (\ U_{it} / U^e_{it})\ U_{ijt}\ , \quad i = n, w.$$

D. Estimation

The direct estimation of the health production function (2) will lead to biased estimates. The reason for the bias is that the unobserved health endowment may influence both choice of inputs and birth outcome. The implication of this potential bias is that ordinary least squares without controlling this form of simultaneity may not provide consistent parameter estimates for this type of model [Rosenzweig and Schultz (1982,1983)].

Previous empirical studies estimated their birth outcome production function by using two-stage least squares in order to eliminate the possible correlation between the health inputs and the error term that could be caused by the unobserved mothers' health endowment. For example, if a women has had a difficult first birth, she is more likely to seek early prenatal care than a woman has had an easy first delivery (Rosenzweig and Schultz, 1982). Joyce (1987) pointed that if parents anticipate certain birth outcomes due to problematic pregnancy, or information of the fetus obtained through ultrasound and amniocentesis then they would alter the consumption of health inputs. All the above arguments suggest that error term of the low birthweight production function is correlated with included health inputs. In the first stage, input demand functions were fitted using variables reflecting the price of inputs. The second stage used the predicted values of the inputs to estimates the health production function[10].

[10] Endogeneity of health inputs such as prenatal care indicator, abortion and gestinational age has been tested rigorously in previous studies based on Wu-Hausman test. They rejected the null hypothesis of no correlation between these variables and the rate of low birthweight births or neonatal mortality. But the use of two stage least square does not guarantee the correct instrument for these variables. Since the

The use of pooled cross-section time-series approach with fixed effect in order to estimate equation (2) will allow us to distinguish between the role of variables in explaining differences between the states in the rate of low birthweight births on the one hand, and changes over time in the rate of low birthweight births within state on the other. By using a fixed-effects model, we can concentrate on the causes of changes in the percentage of low birthweight birth within the state and over time. This model allows each state to have its own average rate of low birthweight birth and attempts only to explain the temporal pattern of deviation from that average.

It assumes that the effects of the unobserved mothers' health endowment and other omitted variables can be absorbed into the intercept term of a regression model as a means to explicitly allow for the state and/or time heterogeneity contained in the temporal cross-sectional data. For example, consider fitting a general health production function for state i and time t for equation (2)

$$H_{it} = \mu + \sum_{k=1}^{n} \beta_k X_{kit} + \nu_{it}, \qquad i = 1,\ldots, N, \quad t = 1,\ldots, T \tag{25}$$

where

H_{it} is the percent of low birthweight birth,

μ is the intercept,

β_k is the vector of coefficient,

X_{kit} is the vector of the health inputs,

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use of many explanatory variables those are supposed to be serving as control posses similar obstacles to interpretation because of measurement errors in control variables and causal relationship between control variables. There is a caution if instrument is a poor one, the results will tend to misleading [Nelson, Startz(1990)].

ν_{it} is the error term.

Unlike the classical procedure which is assumed the effects of omitted variables, ν_{it}, are independent of X_{kit} and are independently identically distributed, we can introduce state- and time-effect variables, say S_i and M_t then ν_{it} can be written as

$$(26) \qquad \nu_{it} = \alpha S_i + \lambda M_t + \eta_{it}, \qquad i = 1,\ldots, N, \quad t = 1,\ldots, T$$

with η_{it} representing the effect of all remaining omitted variables. Unfortunately, there usually are no observations on S_i and M_t. A natural alternative would then be to consider the effects of the products, $\alpha_i = \alpha S_i$ and $\lambda_t = \lambda M_t$ which then

$$(27) \qquad H_{it} = \mu + \alpha_i + \lambda_t + \sum_{k=1}^{n} \beta_k X_{kit} + \eta_{it}, \quad i = 1,\ldots, N, \quad t = 1,\ldots, T.$$

Let α_i be represent state-specific heterogeneity that captures any permanent differences in birth outcome across states such as differences due to environmental conditions, policies and ethnic composition. Let λ_t be represent the time effects that capture any components in the rate of low birthweight birth that are common across all states in particular year, such as the effect of national economic trend, and η_{it} be the random error term that varies by state and year. Since we didn't include other important health variables such as nutrition, quality of medical care, and prenatal substance abuse variables which are potentially correlated with the included variables the orthogonality assumption on η_{it} is unlikely to hold even if we isolate the state and time heterogeneity.

The random-effects model may be somewhat more efficient under certain conditions. However, estimation of the fixed-effects model is probably appropriate in the presence of measurement error, underreporting, and unobserved heterogeneity. The advantage of fixed effect model is that it allows us to estimate the effect of changes in explanatory variables over the time within the states, controlling with fixed effects for unmeasured heterogeneity within the state that is not captured in included independent variables. Thus we can make inference conditional on the effects that are in the sample. The inability to capture these fixed effect means that ordinary least squares estimates of β_k from equation (21) will not be efficient due to omitted variables that are state- and time- specific (Maddala, 1983).

Equation (27) is estimated by weighted least squares with restricted dummy variables such as $\sum_i \alpha_i = 0$ and $\sum_t \lambda_t = 0$ in order to eliminate perfect multicollenearity since α_i and λ_t are treated as fixed parameters (Judge at.al, 1985). Therefore one dummy must be disregarded. This can be done arbitrarily, without affecting the result. However, for the sake of symmetry, one state and time dummy are deleted and one overall constant term is added. Thus, total (N-1) dummy variables are added in the state fixed model and (N-1) + (T-1) dummy variables are added in the state and time fixed model. The square root of the race-specific total number of births in state *i* and year *t* are used as a weight. It is assumed that the weight is inversely proportional to the variance of residuals so as to serve to reduce the impact of random fluctuations by weighting states with more births more heavily in the regression (Maddala, 1983). The non-dummy coefficients show how changes in their levels affects changes in the levels of the rate of low birthweight births net of each state effects over time. By examining the impact of changes in maternal risk factors on changes in the birth outcomes we can get some idea about which risk factors may be important in determining the levels and the trend of the rate of low birthweight births. We lose, however, cross-state variation with fixed effects estimator.

Certain inputs, such as maternal cigarette smoking and alcohol consumption, and the quality of prenatal care, are omitted from the health production function because of the data availability. Moreover, estimated race-specific variables may contain measurement error, especially for blacks. Therefore, it is possible that some of the observed input effects reflect in part correlation with unobserved variables. This caveat should be kept in mind in interpreting the empirical results.

CHAPTER IV

Empirical Results

A. Empirical Esitimates

Tables 3 through 5 present the weighted least squares and fixed-effects estimates of the low birthweight birth production function based on the data time period from 1973 to 1992. Table 3 presents the results which exclude the exogenous risk factors of education and unemployment from the set of regressors. Table 4 presents the results which include education, while table 5 represents the results which include both education and unemployment. In column A in each table, the data are treated as a large cross-section without any fixed effects. A substantial number of variables are highly significant. Column B includes a time-specific fixed effects, to control for the trends in the rate of low birthweight births within a state. Column C includes a state-specific fixed effects, to control for time invariant differences across states that may be correlated with both included variables and the rate of low birthweight births. And lastly, column D controls for both state- and time-specific fixed effects. It is clear that *inclusion of fixed effects* significantly changes the estimated coefficients. Time fixed or state fixed effects may overstate the impact of maternal risk factors on the rate of low birthweight births by attributing it to state fixed or time fixed heterogeneity. Specification with both state and time fixed effects tend to have relatively small estimates since all across the state and over time variations have been removed. Appendix A includes all results based on nonrace-specific variables such as abortion, education and unemployment.

Table 3
Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.017 **	-0.006 *	-0.036 **	-0.003
	(6.750)	(1.973)	(15.367)	(1.117)
Prenatal	-0.037 **	-0.039 **	-0.017 **	-0.000
	(11.366)	(11.216)	(4.365)	(0.055)
Illegitimacy	-0.013 **	-0.033 **	-0.009 **	0.007
	(4.004)	(6.115)	(4.857)	(1.630)
Education	-----	-----	-----	-----
Unemployment	-----	-----	-----	-----
Intercept	9.247	9.846	8.250	6.600
F	83.79	14.63	122.95	140.02
Adj R^2	0.22	0.25	0.88	0.92
Observation	898	898	898	898
State effect	no	no	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.006 **	-0.001	-0.021 **	-0.009 *
	(3.593)	(0.466)	(6.301)	(2.144)
Prenatal	-0.019 **	-0.002	-0.025 **	-0.002
	(4.019)	(0.479)	(4.009)	(0.354)
Illegitimacy	0.041 **	0.049 **	0.042 **	0.030 **
	(11.724)	(11.897)	(12.281)	(3.980)
Education	-----	-----	-----	-----
Unemployment	-----	-----	-----	-----
Intercept	11.854	10.076	11.239	10.706
F	49.13	15.38	35.16	37.83
Adj R^2	0.17	0.31	0.67	0.76
Observation	700	700	700	700
State effect	no	no	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.
a) The absolute value of t-statistics are in parathesis.
b) Abortion variable used in black equation represents nonwhite instead of black.

Table 4
Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.013 **	0.002	-0.028 **	-0.004
	(5.201)	(0.599)	(12.071)	(1.247)
Prenatal	-0.027 **	-0.032 **	-0.000	-0.002
	(8.036)	(9.266)	(0.070)	(0.560)
Illegitimacy	0.006	-0.026 **	0.015 **	0.011 *
	(1.444)	(4.893)	(5.505)	(2.268)
Education	-0.024 **	-0.030 **	-0.026 **	0.009
	(8.006)	(9.265)	(10.775)	(1.868)
Unemployment	-----	-----	-----	-----
Intercept	9.864	11.335	8.231	6.003
F	83.30	19.08	139.25	138.54
Adj R^2	0.27	0.32	0.89	0.92
Observation	898	898	898	898
State effect	no	no	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.003	-0.001	-0.019 **	-0.008
	(1.471)	(0.219)	(5.766)	(1.921)
Prenatal	-0.013 *	-0.002	-0.020 **	-0.003
	(2.540)	(0.372)	(3.070)	(0.437)
Illegitimacy	0.050 **	0.050 **	0.067 **	0.034 **
	(10.779)	(11.552)	(8.286)	(4.680)
Education	-0.016 **	-0.001	-0.022 **	-0.099 **
	(2.951)	(0.144)	(3.398)	(5.570)
Unemployment	-----	-----	-----	-----
Intercept	11.724	10.136	10.640	16.555
F	39.43	14.69	35.15	39.47
Adj R^2	0.18	0.31	0.67	0.77
Observation	700	700	700	700
State effect	no	no	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.
a) The absolute value of t-statistics are in parathesis.
b) Abortion and education variables used in black equation represent nonwhite instead of black

Table 5
Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.012 **	0.000	-0.027 **	-0.005
	(5.050)	(0.112)	(11.731)	(1.559)
Prenatal	-0.026 **	-0.030 **	0.000	-0.002
	(7.619)	(8.802)	(0.026)	(0.595)
Illegitimacy	0.004	-0.024 **	0.014 **	0.011 *
	(1.125)	(4.555)	(4.935)	(2.237)
Education	-0.023 **	-0.030 **	-0.025 **	0.009
	(7.902)	(9.228)	(10.347)	(1.812)
Unemployment	-0.031 **	-0.033 **	-0.010 *	-0.010
	(3.574)	(3.092)	(2.419)	(1.902)
Intercept	9.915	11.403	8.229	6.107
F	70.07	18.87	137.57	137.13
Adj R^2	0.28	0.32	0.89	0.92
Observation	898	898	898	898
State effect	no	no	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.002	0.000	-0.017 **	-0.010 *
	(1.158)	(0.173)	(5.294)	(2.400)
Prenatal	-0.008	-0.004	-0.002	0.001
	(1.567)	(0.687)	(0.347)	(0.166)
Illegitimacy	0.053 **	0.047 **	0.060 **	0.034 **
	(11.358)	(10.524)	(7.952)	(4.676)
Education	-0.019 **	-0.003	-0.023 **	-0.104 **
	(3.638)	(0.253)	(3.675)	(5.833)
Unemployment	-0.025 **	0.025 **	-0.047 **	-0.022 **
	(3.683)	(2.784)	(9.331)	(3.100)
Intercept	11.793	10.178	10.659	16.937
F	34.83	14.54	40.85	39.51
Adj R^2	0.19	0.32	0.71	0.77
Observation	700	700	700	700
State effect	no	no	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.
a) The absolute value of t-statistics are in parathesis.
b) Abortion, education and unemployment variables used in black equation represents nonwhite instead of black.

Note that the use of dummies does not directly identify the variables which might cause the regression line to shift over time and/or within a state. Rather, it is an attempt to adjust for important missing information in the model. In doing so, a substantial portion of error variation can be explained without obtaining any knowledge on omitted variables in the model. Because of this fact, this study eliminates the interpretation of dummy variables.

Overall, the regression for whites and blacks work well once state fixed effects ,column C, and state and time fixed effects, column D, are included in contrast to the basic regression, column A, and regression controls for time fixed effects only in column B. Hence, the following analysis will concentrate on the results with state fixed effects, and state and time fixed effects. The adjusted R^2 range from 0.88 - 0.92 for whites and from 0.67 - 0.77 for blacks, approximately, 4 times higher than that without fixed effects in table 3. However, regression results for blacks are less satisfactory than that for whites, since the goodness of fit is substantially smaller for the blacks than that of whites. For blacks, all the variables in column C in table 3, are significantly different from zero at 1 percent significance level, controlling for state effects. Controls for both state and time fixed effects appears to have relatively consistent effects on blacks, column D, except for the prenatal care initiation variable that is now insignificant at conventional levels. For whites, all variables are significant at 1 percent level control for state fixed effect, column C. Controlling for, however, both state and time fixed effects eliminates all significant impact on white birth outcomes. This is consistent with the result of Frank at al.(1992).

The coefficient estimate of abortion suggests that the marginal impact of the use of abortion service on the rate of low birthweight birth is smaller in absolute value for blacks than whites, column C in table 3, controlling for state fixed effects. Both coefficients are significant at 1 percent level. But the coefficient for whites is not significant at conventional level while that for blacks is significant at conventional level, column D, once state and time fixed effects are included. The change in the abortion coefficient for blacks, 57 percent falls in absolute value, is not as dramatic when comparing state fixed effects and state and time fixed effects as that for whites, 92 percent drops in absolute value. The coefficient for whites suggests that 10 percentage point increase in the abortion rate would lead to a reduction of 0.4 percentage point in the rate of white low birthweight births while that for blacks leads to 0.2 percentage point reduction in the black low birthweight births. Corman et al. (1987) find, in their cross-sectional study, that negative significant effect of abortion, -0.006, on whites birth outcomes and positive insignificant, 0.005, effect of abortion on blacks. Joyce (1987) finds, in his cross-sectional study, that negative significant, -0.036, effect for whites and negative insignificant, -0.013, effect for blacks. The results of this study on the use of abortion service are somewhat very close to Joyce's findings, although the magnitude of coefficient estimate for blacks is relatively large in absolute value compare to his findings.

Controlling for state and time fixed effects, however, eliminates significant effect of abortion on whites and lowers the significant level of blacks. These results indicate that there is a sizeable and significant effect of abortion use on blacks birth outcomes, regardless of the specification used. These results are relatively large in absolute value compared to the results of Joyce and Grossman (1990a) who reported negative insignificant effect, -0.001, of abortion on white birth outcomes and negative significant effect, -0.004, on blacks in their time-series study. Frank at al (1992) reported substantially larger, in absolute value, insignificant positive effects of abortion on the both black and white birth outcomes in their time-series cross-sectional study. However, it may not be possible compare the results of each study directly because of different estimation strategies or different controlling variables

Although this study fails to show significant impact of abortion use on birth outcomes for whites over time within states, there is a measurable evidence of supporting the argument of previous studies on abortion that abortion affects the birth outcomes directly by lowering the fraction of births in high-risk categories, especially for blacks. Although the over all abortion rate has been declined since 1981, not all races, age-groups, or marital status groups are part of this trend. The fact that 40.7 percent of teenager pregnancies and 43.7 percentage of women aged 40-44 ended in abortion in 1988 (AGI, 1992). The former increases by 60 percent and the later increases by 10 percent compared to the figures in 1973. Part of this decline has been attributed to concerted efforts to limit the availability of abortion service through public policy, such as restrictions on public funding of abortion or parental notification and consent laws for minors seeking abortion (Rogers, et. al., 1991). This reduced form effect could be one of major causes of lowering the significant effect of abortion use over time within a state. We cannot, however, measure the magnitude of this effect in this model.

The prenatal care indicator, control for state-specific effects, has the correct sign in both white and black regressions and statistically significant at 1 percent level yet the significant impact of prenatal care on white birth outcomes disappeared over time within a state. It is interesting to note that the coefficient of prenatal care for blacks increases 35 percent in absolute value, to -0.025 from -0.019, and that for whites falls 54 percent in absolute value, to -0.017 from -0.037 with state fixed effects. However, the coefficient of prenatal care for both whites and blacks falls dramatically in absolute value once state and time fixed effects are included. These results suggest that there is evidence for black women with relatively poor health endowment are most likely to initiate prenatal care in the first trimester, adverse selection, and for white women with relatively richer health endowment tend to initiate prenatal care in the first trimester, favorable selection, controlling for state fixed effects. The existence of these relationship biased OLS estimates of the production function of the parameters of prenatal care toward zero for blacks and away from zero for whites. However, there is no evidence for this adverse selection of black pregnant women with state and time fixed effects. There is a evidence, rather, of favorable selection for blacks although it is not statistically significant. But for whites, there is a consistent evidence for favorable selection in both specification. These results with state fixed effects are same as the results of Frank at al (1992) that showed favorable selection for whites and adverse selection for blacks. However, these results are in contrast to previous cross-section studies, such as Rosenzweig and Schults (1982, 1983, 1988), Corman at al (1987), Joyce (1987), and Grossman and Joyce (1990) that showed adverse selection only. The results using nonrace specific variables show only statistically significant favorable selection for both race in both specification (see appendix table A-1).

Given, however, the measurement of prenatal care used in this study, it is difficult to determine whether these results reflect the importance of early initiation of prenatal care or are due to the excluded variables for quality of care associated with pregnant women for whom initiate early prenatal care.[11] There may be more direct and significant relationships between the adverse birth outcomes and other variables not controlled but closely related to the early initiation of prenatal care. It is, moreover, still unclear whether or not the true effect of prenatal care on birth outcomes is due to the effectiveness of prenatal care in preventing low birthweight births or is due to other differences between women who receive prenatal care and those who do not receive prenatal care. Alexander and Korenbrot (1995) showed that women who receive prenatal care are a heterogeneous group, but are generally healthier, more educated, and more advantaged than who do not receive prenatal care. Then, prenatal care may be another indication of the many health-enhancing behaviors that characterize healthy and insured women who have healthy children, rather than preventing low birthweight births.

[11] Based on quantitative assumption on prenatal care used in this study, routine prenatal care would be effective enough to decrease the incidence of low birthweight. But it may will be the case that the effective prenatal care for women at high risk of having low birthweight babies need to be more intensive than routine prenatal care for women of low risk

The coefficient for the out-of-wedlock birth for blacks is significant in 1 percent level with correct sign in both specification. Moreover the magnitude of impact of marital status on birth outcomes in blacks is the largest among other significant risk factors, column C in table 3. It is a highly significant and stable predictor of black birth outcomes. For whites, there is a significant and sizable effect with wrong sign with state fixed effects, yet its impact on birth outcomes turns out to be insignificant at conventional level once state and time fixed effects are included. The estimated coefficients suggest that a 1 percentage point increases in the illegitimate births would lead to a increase of 0.03 percentage point in the rate of black low birthweight births and practically no impact on whites over time within a state.

It is well known that the out-of-wedlock births are neither planned nor wanted. Moreover, the distribution of unwanted births is highly skewed toward the low income groups, low educational attainment groups, and teenagers. Given their weak economic conditions and unfavorable environment for infant health, marital status may affect the birth outcomes adversely through the lack of appropriate support for infant health.

The percent of births to unmarried women aged 15-44 has increased continuously, rising to 68.1 from 46.2, or 47 percent, for blacks and going up to 22.6 from 6.2, or 264 percent[12], for whites between 1973 and 1992. Other studies are attributed this upward trend of out-of-wedlock births due to proximate culture (Case and Katz)[13], limited access to abortion service, and incentive from welfare package

[12] Based on table 2.

(Plotnick, 1990). However, freezing or denying welfare benefits would not have much effect on the soaring out-of-wedlock births. Since the out-of-wedlock births rose in the 1960's when the value of welfare benefits went up. Yet the rate continued to rise in she 1970's and 80's, even though the value of the benefits declined because they did not keep pace with inflation.

Table 4 contains estimates of white and black low birthweight birth production functions that include the race-specific percentage of population ages 25 and over with at least a high school education as a regressor. The coefficients of education for both blacks and whites significant at 1 percent level control for state fixed effect (column C). The coefficient of blacks increased by, roughly, 4 folds and was highly significant while that of white decreased by 65 percent but turn out to be insignificant at conventional level once state and time fixed effects are included.

Controlling for education, the regression coefficients of abortion and prenatal care fall in absolute value yet that of illegitimacy rises in absolute value for both races with specification with state fixed effects (column C in table 3 and table 4). For whites, the sign of illegitimacy turns out to be correct and highly significant. However, estimated beneficial effect of prenatal care is practically zero and the abortion coefficient falls by 22 percent once education is held constant. For blacks, the coefficient of abortion and prenatal care falls by roughly 10 percent and 20 percent respectively whereas the coefficient of illegitimacy increases by 60 percent when

[13] Case and Katz (1991) addressed that nonwhite women were less likely to terminate a pregnancy by abortion than were white women, possibly because out-of-wedlock births are more accepted in nonwhite communities

education is held constant. The significance level of each input is not greatly affected by the inclusion of education. When state and time fixed effect are included, the coefficient of illegitimacy for whites is significant at conventional level with correct sign. For blacks, the coefficients of abortion, prenatal care, and illegitimate births are very close with the results without controlling for education variable (column D in table 3 and table 4), yet the coefficient of abortion loses its significance at conventional level.

In summary, the education coefficient is always negative and significant at 1 percent level except that of whites with state and time fixed effects. The coefficients of illegitimacy for both races and prenatal care for blacks are greatly affected by the inclusion of education variable. In other words, the inclusion of education underscores the importance of the role of education on birth outcomes. This result is not consistent with findings of Grossman and Joyce (1990) that mother's education had little impact on birth outcomes but powerful determinant of prenatal care.

Previous studies showed that the education variable is not only highly significant on birth outcomes but also highly correlated with include other variables. Rosenzweig and Schultz (1982) argued that education has strong allocative and taste effects but does not have efficiency effects in the health production function which contrasts to the Grossman's (1972) original ideas of educations on infant health. Indeed, the simple correlation coefficient between education and illegitimate births for whites is .69, the simple correlation coefficient between education and abortion is .44 and the simple correlation coefficient between education and prenatal care is .23. For blacks, the simple correlation coefficients equals .66, .42 and .40 respectively. Given this high correlation between education and include variables, it is very difficult to draw any conclusions as to the efficiency versus the allocative effect of education in both races. However, the large and highly significant coefficient of education for blacks (column D) reflects efficient effect while small and insignificant coefficient of education (column D) suggests allocative effect on whites birth outcomes, more or less.

Table 5 contains estimates control for unemployment used as a proxy for maternal stress. The coefficients of unemployment for blacks are significant at 1 percent level with both specification (column C and D). For whites, it is significant at conventional level only with state fixed effects (column C). The regression coefficients of abortion, prenatal care, and illegitimacy are not greatly affected by the inclusion of unemployment rate for both races and in both specifications except the coefficient of prenatal care for blacks. Once unemployment is held constant, the coefficient of black prenatal care falls by 90 percent in absolute value and loses its significance at conventional level with state fixed effects. There is no impact of prenatal care on black birth outcomes over time. For white, the sign of prenatal care changes to positive from negative control for state fixed effects, yet there is no changes in the coefficient.

The coefficient estimate of unemployment indicate that 10 percentage point increase in unemployment rate was associated with a significant 0.1 percentage decline in the rate of low birthweight births for whites, and with highly significant 0.5 percent decline for blacks within a state. Although the impact of unemployment of birth outcomes falls over time for both races, its significant impact on black birth outcomes persists. These results may suggest that there are strong offsetting effect from some segment of black women who work in physically demanding position. They can have more time to stay at home thus less pressure from work during the recession. In other words, unemployment may worsen birth outcomes for some segment of population due to income effect while it may improve birth outcome indirectly by lowering the job pressure for the other segment of population, especially for blacks.

The health production function was reestimated without illegitimate births. Table 6 contains estimates of white and black low birthweight birth production functions with and without illegitimacy controlling for state fixed effects (column A and C) and controlling for state and time fixed effects (column B and D). Column A and B are from table 5. For whites with state fixed effects, the omission of illegitimate births changes the sign of the prenatal care to negative from positive and the coefficient of prenatal care becomes larger in absolute value and statistically significant at 6 percent level, whereas the coefficients of education and unemployment become smaller in absolute value. However, there is no change in the coefficient of abortion use and its significant level. All the coefficients, with state and time fixed effects, become smaller in absolute value except prenatal care which becomes larger in absolute value, to -0.003 from 0.000, yet there is no statistically significant effects. For blacks with state fixed effects, its omission lowers the coefficient of abortion and education and changes the sign of education to positive from negative. The impact of prenatal care increased to -0.022 from -0.002 and statistically significant at 1 percent level. All the coefficients, controlling for state and time fixed effects, become smaller in absolute value except education which becomes larger in absolute value. The significant effects of abortion, prenatal care, and unemployment are disappeared. Theses results show that failing to control illegitimate births overstate the impact of prenatal care and understate the impact of abortion use and education on black birth outcomes.

In summary, surprising results of this study are that out-of-wedlock births makes the statistically significant effects in explaining birth outcomes whereas there is no statistically significant beneficial effect of prenatal care regardless of races and specifications once education and unemployment are held constant. Regardless of the measure of prenatal care and the characteristics of data used, most of previous studies substantiated a strong negative relationship between prenatal care and the birth outcomes for both races. They also confirmed a significant negative relationship between abortion use and black birth outcomes and weak relationship for white birth outcomes. The results of this study appear to have no support of their findings. However, out-of-wedlock births are closely related with abortion and education attainment in one way or the other. Indeed, the simple correlation coefficient between illegitimate births and education is 0.69, the simple correlation coefficient between illegitimate births and abortion is 0.55 for whites. For blacks, the corresponding simple correlation coefficients equals 0.66 and 0.22, respectively. Given these high correlation between illegitimate births and abortion, between illegitimate births and education, the results of this study must be interpreted with caution once both education and unemployment are held constant.

Table 6
Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.027 **	-0.005	-0.027 **	-0.002
	(11.731)	(1.559)	(13.221)	(0.920)
Prenatal	0.000	-0.002	-0.008	-0.003
	(0.026)	(0.595)	(1.919)	(0.824)
Illegitimacy	0.014 **	0.011 *	----	----
	(4.935)	(2.237)		
Education	-0.025 **	0.009	-0.019 **	-0.000
	(10.347)	(1.812)	(12.666)	(0.132)
Unemployment	-0.010 *	-0.010	-0.008	-0.002
	(2.419)	(1.902)	(1.815)	(0.348)
Intercept	8.229	6.107	8.584	6.997
F	137.57	137.13	128.66	139.64
Adj R^2	0.89	0.92	0.88	0.91
Observation	898	898	962	962
State effect	yes	yes	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.017 **	-0.010 *	-0.009 **	0.000
	(5.294)	(2.400)	(3.338)	(0.080)
Prenatal	-0.002	0.001	-0.022 **	-0.009
	(0.347)	(0.166)	(3.514)	(1.570)
Illegitimacy	0.060 **	0.034 **	----	----
	(7.952)	(4.676)		
Education	-0.023 **	-0.104 **	0.015 **	-0.095 **
	(3.675)	(5.833)	(5.850)	(6.244)
Unemployment	-0.047 **	-0.022 **	-0.047 **	-0.010
	(9.331)	(3.100)	(8.917)	(1.517)
Intercept	10.659	16.937	13.083	18.885
F	40.85	39.51	35.09	39.88
Adj R^2	0.71	0.77	0.66	0.76
Observation	700	700	752	752
State effect	yes	yes	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.
a) The absolute value of t-statistics are in parathesis.
b) Abortion, education and unemployment variables used in black equation represents nonwhite instead of black.

B. Decomposition

The relative contribution of each independent variable can be explained by examining the components of change in the predicted rate of low birthweight births. The changes in each components for 1973-84, 1984-92, and entire time period 1973-92 are summarized in table 7 which is based on the estimations control for state fixed effects in table 5. We can investigate whether the contribution of each variable in the first time period has the same effects in the next time period where the rate of low birthweight births rises dramatically especially in blacks. Some caution should be exercised in interpreting the results in table 7, since these results do not include the effects of dummy variables.

During the first time period, from 1973 to 1984, the whites rate of low birthweight births decreased from 6.41 to 5.60, or by 13 percent, and increased by 0.23 or by roughly 4 percent, during the second time period, 1984-1992. Over all, the actual whites rate of low birthweight births declined by 9 percent, 6.4 to 5.8, during the entire time period 1973 to 1992. The corresponding black figures are decreased from 13.25 to 12.36, or by 7 percent between 1973 and 1984, and increased by 0.91, or by 7 percent between 1984 and 1992, and over all increased by 0.02.

In the case of whites, the predicted change in the low birthweight births accounts for 67 percent of the actual decline in the first time period 1973-84 and 14 percent of the actual increase in the second time period. The predicted net change of 0.508 low birthweight birth per thousand live births in the entire time period is closely matched by the actual change of 0.582. This accounts for 87 percent of actual decline

Table 7. Components of Predicted Change in the Rate of Low Birthweight Birth, 1973-1992.

Variables	Whites 73-84	Whites 84-92	Whites 73-92	Blacks 73-84	Blacks 84-92	Blacks 73-92
Abortion	-0.252	0.054	-0.198	-0.441	0.010	-0.431
Prenatal	0.000	0.000	0.000	-0.024	-0.004	-0.028
Illegitimacy	0.100	0.127	0.227	0.787	0.535	1.322
Education	-0.367	-0.147	-0.514	-0.465	-0.205	-0.670
Unemployment	-0.022	-0.001	-0.023	-0.370	0.183	-0.187
Total predicted change	-0.541	0.033	-0.508	-0.513	0.519	0.005
Actual change	-0.813	0.231	-0.582	-0.888	0.909	0.021
		Percent			Percent	
Abortion	46.6	161.4	39.0	86.0	1.9	-8207.1
Prenatal	-0.0	0.0	-0.0	4.6	-0.8	-530.5
Illegitimacy	-18.4	380.6	-44.6	-153.4	103.1	25152.6
Education	67.7	-440.0	101.1	90.7	-39.5	-12748.3
Unemployment	4.1	-2.0	4.5	72.1	35.3	-3566.7
Total	100	100	100	100	100	100
Total explained change	66.6	14.5	87.3	57.8	57.1	25.4

Notes:
1) All variables are race-specific
2) All figures are based on table 2 and column C in table 5.

in this time period. In the decomposition, abortion, illegitimate birth, and education are relatively important contributors for predicted changes in the rate of low birthweight births especially in the second time period. They account for 39 percent, 45 percent, and 101 percent of actual decline of 0.6 low birthweight birth per thousand live births over the entire time period, respectively. There is no contribution from changes in early initiation of prenatal care while unemployment tends to decline with time. The changes in out-of-wedlock births makes the worst contribution to predicted decline in the rate of low birthweight births in entire time period.

In the case of blacks, the predicted change in the rate of low birthweight births accounts for 58 percent of the actual decline in the first time periods 1973-84, 57 percent of the actual increase in the second time period 1984-1992, and 25 percent of actual increase in the entire time period. The predicted blacks net changes of 0.005 low birthweight births per thousand live births underpredicts the actual net increase of 0.021 for the entire time period. In the decomposition, all the variables except prenatal care are the important contributors to predicted changes in the rate of low birthweight births. The changes in the out-of-wedlock births appear to be the worst contributor in the predicted decline of the rate of low birthweight births in entire time period, yet its importance declines over time. The contribution of abortion use becomes less important over the time. It accounts for 86 percent of predicted decline in the first time period, yet its contribution in the second time period fall significantly, only account for 2 percent of predicted increase. The predicted changes of prenatal care does not make significant contribution to changes in the rate of low birthweight births, although it contributes, but not substantial, 0.03 predicted decline in entire time period. The contribution of education and unemployment tend to decline over time but maintain marginal impact on the changes in the rate of black low birthweight births.

In summary, predicted changes in education make the largest contribution to predicted decline followed by abortion and unemployment, yet the illegitimate births make the worst contribution to predicted decline in the rate of low birthweight births in the entire time period for both races. The predicted change in prenatal care is weakly associated with changes in blacks birth outcomes only. Abortions are expected to decrease the rate of low birthweight by reducing the number of unwanted pregnancies. However, the declining trend of abortion for both races in the second time period may represent an increased birth rate of unmarried women by reducing their abortion. This could be a possible explanation for the increasing trend of the rate of low birthweight births for blacks. There is, however, no strong evidence for whites in the same time period.

CHAPTER V

Conclusion

This paper estimated a race-specific structural health production function that simultaneously considered the impact of various of maternal risk factors on the rate of low birthweight birth with a pooled time-series cross-section of all United States live births, aggregated by state, controlling for underlying state- and time-specific fixed effects for the twenty-year period from 1973 to 1992. The maternal risk factors include the use of abortion service, out-of-wedlock births, prenatal care, education, and the unemployment rate. By using a fixed effects model, we can concentrate on the causes of changes in the percentage of low birthweight birth within the state and over time. This model allows each state to have its own average rate of low birthweight birth and attempts only to explain the temporal pattern of deviation from that average.

For whites, all of the above risk factors, except for prenatal care, are significant once state fixed effects are included. However, none of above risk factors, except out-of-wedlock births, are significant controlling for state and time fixed effects. These results are inconsistent with previous cross-sectional and time-series studies. For blacks, nearly all of the risk factors, except for prenatal care, were significant in both specifications.

Like the result of previous studies on the effect of abortion on birth outcomes, those substantiated the early finding of Grossman and Jacobowitz (1981) and Corman and Grossman (1985), this study finds a significant effect of abortion on the birth outcomes for both races control for state fixed effects. Controlling for state and time fixed effects, however, eliminates significant effects of abortion on whites and lowers the significant level of blacks. The coefficient of abortion is not affected by the inclusion of education and unemployment, surprisingly. Moreover, the contribution of abortion use on the changes in the rate of low birthweight births becomes less important over time. Some possible explanations for the lack of significance of this variable over time are due either to measurement errors in the estimated race-specific abortion rates or to radical changes in political environment against abortion, such as restrictions of public funding on abortion and parental consent law, after the mid 1980's.

A surprising result from this study is the early initiation of prenatal care had no significant effect on birth outcomes for both races once state and time fixed effects were included. Furthermore, negatively significant effects with state fixed effects were eliminated when education and unemployment variables are included in the regressors. These results are inconsistent with the bulk of past studies which have relied primarily on cross-sectional data and have substantiated a strong and significant negative relationship between prenatal care and low birthweight. The result of this study indicates that there is strong evidence of favorable selection instead of adverse selection of prenatal care. The weak effect of changes in prenatal care on birth outcomes over time within a state could be attributable to omitted variables that vary across state or fail to control for possible endogeneity.

The effect of out-of-wedlock births for blacks appears to be the most significant and stable predictor of birth outcomes in both specification, whereas that for whites appears to have no significant effect on birth outcomes when state and time fixed effects are included. Moreover, it makes the worst contribution to predicted decline in the rate of low birhweight births in the entire time periods for both races. In general, these results are predictable and consistent with past studies. Given high correlation with included variables, this result says that out-of-wedlock births adversely affect the birth outcomes since live births to unwed mothers represent neither planned nor wanted births. This is perhaps because they are less likely to have planned babies or have more difficulty in planning their contraceptive use. In particular, the class distribution of out-of-wedlock births is highly skewed toward the lower income and socially unstable group. Thus, the rising birthrate among unwed women is enough to draw special attention to reduce the adverse birth outcomes and social burden. There are many possible explanations why fewer women are choosing to have abortions, including changed attitudes towards both single parent and abortion, wider and more effective contraceptive use, and limited access and tighter laws. But which reason is most important is not clear. Thus, in order to hold down the increasing trend of low birthweight births, there is a great need to understand the underlying social reasons for out-of-wedlock births on the one hand, and on the other hand to remove obstacles to easy access to early prenatal care for those pregnancies that are unintended. This will reduce the risk of poor birth outcomes for births to unwed women.

Education and unemployment appear to have a significant impact on birth outcomes for both races. The contribution of these variables to the changes in the low birthweight births tend to decline over time for blacks and rise over time for whites. Given high correlation between education and included variables, it is very difficult to draw any conclusions as to the efficiency versus the allocative effect of education in both races. However, there is suggestive evidence of efficient effect for blacks and allocative effect for whites. The inclusion of unemployment greatly affects prenatal care, especially for blacks. This result suggests that unemployment may improve blacks birth outcome indirectly by lowering the job pressure, yet there is no such evidence for whites.

Although there is a large cross-sectional correlation at any point in time among variables, once state fixed effects are included, changes in these variables over time tend to have statistically an insignificant effect for whites birth outcomes, while there is a relatively consistent small effect for blacks. The major caveats of the results are that abortion, education, and unemployment variables are based on estimated race-specific series, whites versus nonwhites instead of blacks, because race-specific data are not available at the state level. The generalization of our results may be problematic, especially for blacks, since estimated series may have added more noise than it removed. Thus, in order to understand the recent cloudiness of the empirical evidence on the changes in the low birthweight births, we must wait for future analysis with a better data set.

Table A-1
Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.011 **	-0.003	-0.032 **	-0.004
	(5.949)	(1.213)	(16.177)	(1.576)
Prenatal	-0.039 **	-0.039 **	-0.020 **	-0.001
	(11.834)	(11.397)	(5.447)	(0.151)
Illegitimacy	-0.013 **	-0.036 **	-0.007 **	0.007
	(4.120)	(6.593)	(4.172)	(1.633)
Education	-----	-----	-----	-----
Unemployment	-----	-----	-----	-----
Intercept	9.340	9.896	8.439	6.625
F	79.65	14.48	126.24	140.25
Adj R^2	0.21	0.25	0.88	0.92
Observation	898	898	898	898
State effect	no	no	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.013 **	-0.002	-0.056 **	-0.019 *
	(4.471)	(0.592)	(9.134)	(2.391)
Prenatal	-0.018 **	-0.002	-0.014 *	-0.002
	(3.903)	(0.491)	(2.278)	(0.363)
Illegitimacy	0.041 **	0.049 **	0.042 **	0.029 **
	(11.820)	(11.859)	(12.706)	(3.914)
Education	-----	-----	-----	-----
Unemployment	-----	-----	-----	-----
Intercept	11.874	10.098	10.715	10.729
F	51.93	15.39	38.37	37.91
Adj R^2	0.18	0.31	0.69	0.76
Observation	700	700	700	700
State effect	no	no	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.
a) The absolute value of t-statistics are in parathesis.
b) Abortion variable, used for this result, is nonrace-specific.

Table A-2
Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.011 **	-0.001	-0.025 **	-0.004
	(5.794)	(0.464)	(12.987)	(1.650)
Prenatal	-0.028 **	-0.031 **	-0.005	-0.004
	(8.204)	(9.128)	(1.387)	(0.996)
Illegitimacy	0.007	-0.024 **	0.015 **	0.015 **
	(1.835)	(4.554)	(5.479)	(3.059)
Education	-0.024 **	-0.028 **	-0.023 **	0.019 **
	(8.680)	(9.425)	(10.040)	(3.442)
Unemployment	-----	-----	-----	-----
Intercept	9.905	11.178	8.414	5.353
F	83.54	19.10	140.39	140.28
Adj R^2	0.27	0.32	0.89	0.92
Observation	898	898	898	898
State effect	no	no	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.011 **	-0.001	-0.052 **	-0.017 *
	(3.016)	(0.334)	(8.493)	(2.178)
Prenatal	-0.016 **	-0.002	-0.010	-0.001
	(3.210)	(0.377)	(1.516)	(0.198)
Illegitimacy	0.044 **	0.050 **	0.070 **	0.039 **
	(9.657)	(11.242)	(9.242)	(5.221)
Education	-0.006	-0.001	-0.032 **	-0.079 **
	(1.054)	(0.211)	(4.114)	(5.738)
Unemployment	-----	-----	-----	-----
Intercept	11.942	10.155	10.819	15.520
F	39.23	14.70	38.77	39.70
Adj R^2	0.18	0.31	0.69	0.77
Observation	700	700	700	700
State effect	no	no	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.
a) The absolute value of t-statistics are in parathesis.
b) Abortion and education variables, used for this result, are nonrace-specific.

Table A-3
Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.010 **	-0.001	-0.025 **	-0.005 *
	(5.440)	(0.629)	(12.722)	(1.968)
Prenatal	-0.027 **	-0.030 **	-0.005	-0.004
	(7.918)	(8.898)	(1.263)	(1.114)
Illegitimacy	0.007	-0.023 **	0.013 **	0.015 **
	(1.685)	(4.275)	(4.546)	(3.023)
Education	-0.024 **	-0.029 **	-0.022 **	0.019 **
	(8.758)	(9.726)	(9.269)	(3.409)
Unemployment	-0.025 **	-0.028 **	-0.013 **	-0.010 *
	(3.171)	(2.902)	(3.447)	(2.059)
Intercept	9.998	11.374	8.394	5.473
F	69.52	18.81	139.79	138.96
Adj R^2	0.28	0.32	0.89	0.92
Observation	898	898	898	898
State effect	no	no	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.011 **	0.000	-0.049 **	-0.021 **
	(2.979)	(0.006)	(8.092)	(2.678)
Prenatal	-0.015 **	-0.004	-0.002	0.002
	(2.828)	(0.800)	(0.357)	(0.379)
Illegitimacy	0.044 **	0.048 **	0.065 **	0.039 **
	(9.761)	(10.698)	(8.680)	(5.239)
Education	-0.007	0.000	-0.029 **	-0.082 **
	(1.239)	(0.020)	(3.798)	(5.984)
Unemployment	-0.021	0.052 **	-0.059 **	-0.045 **
	(1.389)	(2.896)	(5.312)	(3.160)
Intercept	12.024	9.887	10.862	15.857
F	31.82	14.59	40.09	39.77
Adj R^2	0.18	0.32	0.71	0.77
Observation	700	700	700	700
State effect	no	no	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.
a) The absolute value of t-statistics are in parathesis.
b) Abortion, education, and education variables used for this result, are nonrace-specific.

Table A-4

Summary of the Result of Fixed Effect Estimates of Low Birthweight Birth Production Function, 1973-1992

Variables	A	B	C	D
Whites				
Abortion	-0.025 **	-0.005 *	-0.0246 **	-0.00158
	(12.722)	(1.968)	-14.367	-0.743
Prenatal	-0.005	-0.004	-0.01185 **	-0.00418
	(1.263)	(1.114)	-3.032	-1.16
Illegitimacy	0.013 **	0.015 **	—	—
	(4.546)	(3.023)		
Education	-0.022 **	0.019 **	-0.0159 **	0.00284
	(9.269)	(3.409)	-11.379	0.722
Unemployment	-0.013 **	-0.010 *	-0.0113 **	-0.00234
	(3.447)	(2.059)	-3.036	-0.506
Intercept	8.394	5.473	8.707	6.855
F	139.79	138.96	132.509	139.698
Adj R^2	0.89	0.92	0.8788	0.9122
Observation	898	898	962	962
State effect	yes	yes	yes	yes
Time effect	no	yes	no	yes
Blacks				
Abortion	-0.049 **	-0.021 **	-0.03564 **	-0.002
	(8.092)	(2.678)	-6.456	-0.324
Prenatal	-0.002	0.002	-0.02156 **	-0.00795
	(0.357)	(0.379)	-3.374	-1.339
Illegitimacy	0.065 **	0.039 **	—	—
	(8.680)	(5.239)		
Education	-0.029 **	-0.082 **	0.0241 **	-0.06039 **
	(3.798)	(5.984)	-7.07	-5.569
Unemployment	-0.059 **	-0.045 **	-0.06159 **	-0.0175
	(5.312)	(3.160)	-5.395	-1.305
Intercept	10.862	15.857	12.183	17.1588
F	40.09	39.77	33.233	39.309
Adj R^2	0.71	0.77	0.6432	0.7568
Observation	700	700	752	752
State effect	yes	yes	yes	yes
Time effect	no	yes	no	yes

* significant at 5% level, ** significant at 1% level.

a) The absolute value of t-statistics are in parathesis.

b) Abortion, education, and education variables used for this result, are nonrace-specific.

REFERENCES

Alexander, G., C. Korenbrot, 1995, The Role of Prenatal Care in Preventing Low Birth Weight, The Future of Children 5, No 1, 103-120.

Becker, G., and H. Lewis, 1973, On the Interaction Between the Quantity and Quality of Children, Journal of Political Economy 81, S279-S288.

Corman, H. and M. Grossman, 1985, Determinants of Neonatal Mortality Rates in the U.S., Journal of Health Economics 4, 213-236.

Corman, H., Joyce, T., and M. Grossman, 1987, Birth Outcome Production Functions in the United States, The Journal of Human Resources 22, 339-360.

Frank,R., D. Strobino, D. Sulkever, and C. Jackson, 1992, Updated Estimates of the Impact of Prenatal Care on Birthweight Outcomes by Race, The Journal of Human Resources 27, 629-642.

Greenberger, M., K. Conner, 1991, Parental Notice and Consent for Abortion: Out of Step with Family Law Principles and Policies, Family Planning Ferspectives, Vol 23:1, 31-35.

Grossman. M., 1972, The Demand for Health: A Theoretical and Empirical Investigation, New York, Columbia University Press (for the National Bureau of Econo Research).

Grossman, M., S. Jacobowitz, 1981, Variations in Infant Mortality Rates Among Counties of the United States: The Roles of Public Policies and Programs, Demography 18, 695-713.

Grossman, M. and T. Joyce, 1990, Unobservables, Pregnancy Resolutions, and Birthweight Production Functions in New York City, Journal of Political Economy 98,983-1007.

Harris,J., 1982, Prenatal Medical Care and Infant Mortality, in Economic Aspects of Health, ed. Victor R. Fuchs, Chicago: University of Chicago Press (for the National Bureau of Economic Research).

Henshaw S.,J. Van Vort, 1992, Abortion Factbook, 1992 Edition, Alan Guttmacher Institute, New York.

Hsiao, C., 1986, Analysis of Panel Data, Cambridge University Press.

Hughes D., K. Johnson, S. Rosenbaum, J. Liu, 1989, The Health of America's Children (maternal and child health data book), Children's Defense Fund.

Institute of Medicine, 1985, Preventing Low Birthweight, Washington D.C., National Academy press.

Institute of Medicine, 1988, Prenatal care, Washington D.C.: National Academy Press.

Institute of Medicine, 1985, Preventing low birthweight, Washington DC: National Academy Press.

Joyce,T., 1987a, The Demand for Health Inputs and Their Impact on the Black Neonatal Mortality Rate in the U.S., Social Science and Medicine 24, 911-918.

Joyce,T., 1987b, The Impact of Induced Abortion on Black and White Birth Outcomes in the U.S., Demography 24, 229-244.

Joyce,T., 1989, A Time-series Analysis of Unemployment and Health: The Case of Birth Outcomes in New York City, Journal of Health Economics 8, 419-436.

Joyce,T. and M. Grossman, 1990a, The Dynamic Relationship Between Low Birthweight and Induced Abortion in New York City: An Aggregate Time-series Analysis, Journal of Health Economics 9, 273-288.

Joyce,T. and M. Grossman, 1990b, Pregnancy Wantedness and The Early Initiation of Prenatal Care, Demography 27, 1-17.

Joyce,T., A. Racine and N. Mocan, 1992, The Consequences and Costs of Maternal Substance Abuse in New York City: A Pooled Time-series, Cross-section Analysis, Journal of Health Economics 11,297-314.

Judge, G., W. Griffiths, R. Hill, H. Lutkepohl, T. Lee, 1985, The theory and Practice of Econometrics, Second Edition, Wiley, New York.

Kleinman, J.C., 1990, The Recent Slowdown in the Infant Mortality Decline, Pediatric and Pernatal Epidemiology 4,379-287.

Meier, K., R. Deborah, McFarlane, 1994, State Family Planning and Abortion Expenditure: Their Effect on Public Health, American Journal of Public Health, Vol.84, No. 9, 1468-1472.

Maddala, G., 1983, Limited Dependent and Qualitative Variables in Econometrics, Econometric Society Monographs No. 3, New York, Cmbridge University Press.

__________, 1988, Introduction to econometrics, New York: Macmillan.

Marsiglio, W., F. Mott, 1988, Does Wanting to Become Pregnant with a First Child Affect Subsquent Maternal Behaviors and Infant Birthweight, Journal of Marriage and the Family 50, 1023-1036.

National Center for Health Statistics, 1989, Kenneth D. Kochanek, 1989, Induced Terminations of Pregnancy: Reporting states, 1985 and 1986, Monthly Vital Statistics Report 37, no. 12, Suppl. DHHS Pub. No. (PHS) 89-1120, Hyattsville, MD: Public Health Service.

Ohsfeldt, R. and S. Gohmann, 1992, Abortion and Infant Health Production Functions, Working Paper, School of Public Health, University of Alabama, Birmingham, Alabama.

Powell-Griner E., K. Trent, 1987, Sociodemographic Determinants of Abortion in the United States, Demography, 24, 553-561.

Racine, A., T. Jouce, and M. Grossman, 1990, Eddective of Health Care Services for Pregnant Women and Infants, American Journal of Public Health80, 40-57.

Rosenzweig, M. and T, Schultz, 1982, The behavior of Mothers as Inputs to Child Health: The Determinants of Birth Weight, in Economic Aspects of Health, edited by Victor R. Fuchs. Chicago: Univ. of Chicago Press (for the National Bureau of Economic Research).

__________,1983, Estimating a Household Production Function: Heterogeneity, the Demand for Health Inputs, and Their Effects on Birth Weight, Journal of political Economy 91,723-746.

__________,1988, The Stability of Household Production Technology: A Replication, The Journal of Human Resources 23,535-549.

U. S. Bureau of the Census, various years, Statistical Abstract of the United States, Washington, D.C., U.S. Government Printing Office.

U. S. Congress, Office of Technology Assessment, 1988, Healthy Children: Investing in the Future, Washington DC: U.S. Government Printing Office.

Willis, R., 1973, A New Approach to the Economic Theory of Fertility Behavior, Journal of political Economy 81, S14-S64.