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**A dynamic analysis of birthweight, abortion, and prenatal care  
in Tennessee**

Reichman, Nancy E., Ph.D.  
City University of New York, 1993

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A

A DYNAMIC ANALYSIS OF  
BIRTHWEIGHT, ABORTION, AND  
PRENATAL CARE IN TENNESSEE

by

NANCY E. REICHMAN

A dissertation submitted to the graduate Faculty in  
Economics in partial fulfillment of the requirements for  
the degree of Doctor of Philosophy, The City University  
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1993

c 1993

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*Abstract*A DYNAMIC ANALYSIS OF  
BIRTHWEIGHT, ABORTION, AND  
PRENATAL CARE IN TENNESSEE

by

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This paper examines the dynamic relationship between abortions, prenatal care, and low birthweight in an infant health production function context. Race-specific vector autoregressions were estimated using monthly aggregate birth and abortion data from the state of Tennessee. It was found for whites that a decrease in the abortion rate resulted in a higher rate of prenatal care delay and a higher rate of low birthweight. The implication is that unanticipated decreases in the abortion rate and/or unanticipated increases in the rate of mothers delaying prenatal care would worsen birth outcomes in Tennessee.

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## INTRODUCTION

The incidence of low birthweight in the United States has had a considerable long-term impact on the health, welfare, and economic well-being of its citizens. It has been well documented that aside from being a major determinant of infant mortality, low birthweight also increases the risks of both illness and long-term disability. Despite dramatic technological advances in neonatal intensive care and the recent decline in infant mortality, the rate of low birthweight remains higher in the United States than in many other developed countries, including Canada, Israel, Japan, and the United Kingdom [Institute of Medicine (1985)]. Though lives are being saved, it is not without cost. The Office of Technology Assessment has estimated the overall incremental long-term costs (to age 35) of a low birthweight birth to be between \$14,040 and \$30,525. Of this amount, between \$4,238 and \$6,723 represents the initial incremental hospitalization cost [U.S. Congress, Office of Technology Assessment (1988)].

It has been shown in a vast number of studies that birth outcomes can be improved by increasing the quantity and/or quality, especially through early intervention, of the prenatal care received by pregnant women. The Institute of Medicine has projected that for every dollar spent on prenatal care for high-risk women, \$3.38 would be saved in neonatal intensive care and related longer-term costs [Institute of Medicine (1985)]. The women considered at high risk for delivering a low birthweight baby are those who are at medical risk for a variety of physical reasons, those falling within specific demographic groups,

and those who engage in behaviors that are counter-productive to a positive birth outcome. According to the Institute of Medicine (1985, 1988), the demographic risk factors are: age (less than 17 or over 34), race (blacks are more likely than whites to deliver a low birthweight baby), poverty, out-of-wedlock pregnancies, and low levels of education. The behavioral risks include smoking, poor nutrition, and alcohol and drug abuse.

Most people would agree that prenatal care should begin before conception. However, they would also agree that there will always be some fraction of pregnancies that are unintended and/or unwanted. The successful prevention of unwanted pregnancies is expected to result in an increased average use of prenatal care. Prevention of an unwanted pregnancy can occur prior to conception, via the effective use of birth control, or it can occur after the fact, by induced termination. While most people would agree that the preferable means of avoiding an unplanned pregnancy is through contraception, induced abortion nevertheless plays a significant role in fertility control. By reducing the number of unwanted pregnancies, induced terminations are expected to decrease the rate of low birthweight by increasing the average use of prenatal care.

This paper will analyze the incidence of low birthweight within an infant health production function framework, focusing primarily on the effects of prenatal care usage and the rate of induced abortion. Moral considerations preclude the direct estimation of the bio-technical relationship between prenatal care and birthweight by means of a controlled research design. As a result, the effect of prenatal care usage on birthweight must of necessity be evaluated ex-post. Furthermore, since induced abortion and live birth represent

mutually exclusive options for every pregnant woman, the relationship between the resolution decision and the resulting birth outcome, if abortion is not chosen, cannot be tested directly using data on individual women. For these reasons, aggregate data are more readily applied to the estimation of this particular relationship.

Monthly birth and abortion data from the state of Tennessee are used to estimate the effects of both prenatal care and abortion on the rate of low birthweight births from 1978 to 1988. After race-specific vector autoregressions are presented, the expected impacts on low birthweight of changes in both prenatal care usage and the abortion rate will be predicted. While past studies have employed similar analyses, none has placed emphasis on the role of prenatal care on low birthweight using a vector autoregressive model.

Chapter I presents an overview of the infant health production function framework itself and a description of past empirical research relevant to the current analysis. Chapter II contains a detailed discussion of the data employed as well as the empirical model used to verify these relationships. Chapter III describes the results from the econometric specification described in Chapter II. Finally, Chapter IV summarizes the analysis and discusses the resulting conclusions.

# CHAPTER I

## REVIEW OF THE LITERATURE

### The Theoretical Framework

The analysis presented in this paper is based upon the widely applied theory of family behavior developed by Becker and Lewis (1973) and Willis (1973). It is assumed that the parents' utility function is as follows:

$$U = U(N, Q, S)$$

The parents' utility depends on their own consumption ( $S$ ), the number of births ( $N$ ), and the health of each child at birth ( $Q$ ). The parents' utility is maximized subject to the following full wealth constraint, which takes into consideration the both the household production and budget constraints:

$$I = \pi_c NQ + \pi_s S = \pi_c C + \pi_s S$$

In this constraint,  $I$  represents full wealth, and  $\pi_c$  and  $\pi_s$  refer to the shadow prices of  $C$  ( $= NQ$  = the parents' capacity to produce healthy children) and  $S$ . The shadow prices reflect the optimal marginal opportunity costs of both consumption goods and the factors of production for  $N$ ,  $Q$ , and  $S$ .

Maximizing the parents' utility function subject to the full wealth constraint yields the following derived demand functions for the number of children, infant health, and goods, respectively:

$$N = N(I, \pi_c, \pi_s)$$

$$Q = Q(I, \pi_c, \pi_s)$$

$$S = S(I, \pi_c, \pi_s)$$

The demand function for infant health and a child health production function, together, determine the derived demand functions for child health inputs. The production of infant health is determined by various prenatal inputs and a set of unobserved fixed and/or endogenous factors, some of which are often referred to in the literature as reproductive efficiency or the endowment of the fetus. Following Corman and Grossman (1985), the health production function framework can be formalized in the following 6-equation model:

$$1 - d = f_1(n, b) \quad (1)$$

$$b = f_2(m, a, c, z) \quad (2)$$

$$n = f_3(p, z, y) \quad (3)$$

$$m = f_4(p, z, y) \quad (4)$$

$$a = f_5(p, z, y) \quad (5)$$

$$c = f_6(p, z, y) \quad (6)$$

Equations (1) and (2) represent structural production functions, since they express the relationships between endogenous variables only. In equation (1),  $1 - d$  represents the probability that an infant will survive the first month of life (since  $d$  denotes the probability that an infant will die in the first month),  $n$  represents a vector of perinatal and neonatal inputs, and  $b$  represents the probability of a low birthweight birth. In some empirical applications of this framework, intermediate birth outcomes in addition to low birthweight, such as pre-term delivery, are included in the structural neonatal mortality production function (Equation 1). For clarity, however, it will be assumed in the present discussion that the only intermediate birth outcome is low birthweight. As will be shown in the subsequent review of the literature, the model easily accommodates the inclusion of additional intermediate birth outcomes. In equation (2), the probability of a low birthweight birth depends on a vector of medical and non-medical prenatal inputs ( $m$ ), the use of abortion services ( $a$ ), the use of contraception ( $c$ ), and the endowment ( $z$ ). Equations (3) through (6) represent input demand functions, which are expressed as functions of a set of price and availability measures ( $p$ ), demographic characteristics ( $y$ ), and the endowment.

Substitution of the input demand functions, equations (3) through (6), into the structural production functions yields the following set of reduced form production function equations:

$$1 - d = f_7(p, z, y) \quad (7)$$

$$b = f_8(p, z, y) \quad (8)$$

Equations (7) and (8) can also be referred to as demand functions for infant survival and birthweight. Equations (7) and (8) in conjunction with equations (3) through (6) represent the reduced form of the model.

Quasi-structural infant health production functions are, as the name implies, part structural and part reduced-form. For example, in equation (1), survival probability is structurally related to a set of endogenous prenatal inputs, as well as to the intermediate birth outcome of low birthweight. In a quasi-structural version of equation (1), survival probability might be expressed as a function of the same set of endogenous prenatal inputs, but with the reduced form determinants of low birthweight in place of the intermediate outcome itself. By estimating both the structural and the quasi-structural models, the direct and indirect (through low birthweight) effects of the inputs on survival probability can be determined.

## Empirical Research

The infant health framework described above has been widely applied and tested in the literature. Grossman and Jacobowitz (1981), in their cross-sectional study of variations in infant mortality across counties in the United States in 1971, found that abortion, and to a lesser extent the use of subsidized family planning services, had a significant negative effect on neonatal mortality. 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. Though no intermediate birth outcomes were included, the production functions were quasi-structural in that the regressors included both exogenous factors (availability measures) and an input itself (the abortion rate).

Later research by Harris (1982) and Rosenzweig and Schultz (1982, 1983, 1988) stressed the importance of treating health inputs as endogenous to the model. They argued that the endowment factor in a single equation birth outcome production function, which is more likely known to a greater extent by the household than it is to the researcher, is heterogeneous in the population and is very likely to be correlated with input usage. 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. Rosenzweig and Schultz argued, for example, that there is self-selection involved in the level of prenatal care usage based in part on a pregnant woman's assessment of her own reproductive efficiency. In anticipation of an inferior birth outcome, a woman may seek to offset her lesser endowment by consuming additional prenatal inputs, or conversely, a relatively reproductively efficient woman who foresees a favorable birth outcome may find the need for and use less prenatal health inputs. In both of these cases, the effect of input usage on birth outcomes would be underestimated if the endogeneity of input demand were not taken into account. The authors argued that infant health production functions are characterized by this type of self-selection in input usage, which later in the literature became termed 'adverse' selection, and therefore that

single equation production function estimation would mask much of the effect of prenatal input usage on birth outcomes.

To allow for the presence of endowment heterogeneity and adverse selection in input usage, Rosenzweig and Schultz jointly estimated child health production functions and the demand functions for several endogenous health inputs using a cross-sectional sample of approximately 10,000 individual births in the United States from 1967-1969. They used Two Stage Least Squares (TSLS) to obtain unbiased parameter estimates. In the first stage, they estimated reduced-form input demand functions and predicted input usage based on observed levels of the reduced-form determinants. These predicted input levels were then used in the second stage in place of the inputs themselves as independent variables in the estimation of the infant health production function, where the dependent variable was the weight of an infant at birth. The substitution of *predicted* input usage based on exogenous factors supposedly uncorrelated with the unknown endowment, for *actual* input usage, served to effectively purge any problematic correlation between the levels of input usage and the error term. They found that although the effect of a delay in the initiation of prenatal care appeared insignificant in explaining birthweight in a single equation OLS production function model, 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.

Corman and Grossman (1985), in their cross-sectional study of large counties in the United States in 1977, estimated race-specific reduced-form single equation production functions, in which the neonatal mortality rate was

regressed upon a set of exogenous determinants reflecting the availability of both prenatal care and abortion. In addition, they used a lagged neonatal mortality rate as a regressor in order to control for possible reverse causality relationships that might have biased some of the parameter estimates toward zero. As the authors noted, the inclusion of this last regressor exposed the model to the problem of possible correlation between the lagged mortality rate and the error term; therefore, they estimated the models both with and without the lagged mortality rate, and in the former case they predicted the direction of the biases. The models without the lagged mortality rate contained only exogenous variables, so the problem of potential endogeneity was not an issue. Overall, the results were consistent with those from Grossman and Jacobowitz in that abortion and many of the exogenous inputs appeared to significantly affect the neonatal mortality rate for blacks. Several of the inputs, but not abortion, were significant for whites.

Corman, Joyce, and Grossman (1987) extended the work of Corman and Grossman by using aggregate data from large counties in the United States in 1977 to estimate race-specific production functions reflecting a variety of prenatal inputs including the percentage of births for which prenatal care was begun in the first trimester, the abortion rate, and the rate of low birthweight. They estimated the production functions using both OLS and TSLS; in the latter case the endogenous inputs were predicted based on the reduced-form neonatal mortality regressors used in Corman and Grossman (1985), and then the predicted values of the inputs were used in the second stage as regressors in the production function, where the dependent variable was an average neonatal mortality rate. In addition, they controlled for the endowment directly by including the rate of low birthweight as a regressor in both the OLS and TSLS

models. They found that the inclusion of this risk factor effectively purged any significant correlation between the inputs and the error term when birthweight was held constant, and therefore that the OLS model containing this proxy for the endowment was appropriate for estimating the direct effect (holding birthweight constant) of an input on the neonatal mortality rate. The TSLS model not containing low birthweight as a regressor, however, was appropriate when analyzing the total effect (not holding low birthweight constant) of a prenatal input on infant mortality. They tested their models by predicting race-specific *United States* neonatal mortality rates from 1964 to 1977 based on the actual levels of input usage during this period. They found that 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) presented similar analyses using 1977 U.S. county data. He estimated the race-specific effects of abortion, prenatal care, neonatal intensive care and other health inputs on a set of birth outcomes consisting of neonatal mortality, low birthweight and preterm delivery. The last two were considered to be intermediate birth outcomes and were treated as endogenous to the structural model, as were a set of risk factors including the mother's age, marital status, and the number and spacing of previous births.

Structural and quasi-structural production functions for each birth outcome were estimated using both OLS and TSLS. All of the estimated production functions, of course, included the prenatal inputs as regressors. The structural production functions included both the intermediate outcomes and

risk factors as well. Specifically, the rate of preterm delivery and other risk factors were included as regressors in the low birthweight production function. Similarly, the rate of low birthweight, the rate of preterm delivery, and the set of other risk factors were among the regressors in the neonatal mortality production function. In the TSLS estimation, the intermediate outcomes and risk factors were treated as endogenous and were estimated based on reduced-form determinants in the first stage. The quasi-structural production functions for each birth outcome were estimated without the intermediate outcomes or the set of risk factors as regressors, but with the exogenous determinants of the risk factors instead. Statistically, Joyce found that TSLS was the appropriate procedure by which to estimate both the structural and the quasi-structural production functions. The structural model, which included the intermediate outcomes and set of risk factors as regressors, was used to measure the direct effect of an input on infant health, whereas the quasi-structural production function, which did not include the intermediate outcomes and risk factors as independent variables, was used to measure the total effect of a health input on birth outcomes.

Joyce found that abortions had a negative and significant effect on neonatal mortality for both whites and blacks, although the white coefficients were less significant, and that for both races the primary effect of abortion on neonatal mortality was through low birthweight. 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 (holding constant the percentage of preterm deliveries) on the rate of black low birthweight births. In contrast, early prenatal care had significant total and direct negative effects on both neonatal mortality and low birthweight for whites.

In a time-series analysis of the effect of unemployment on the race-specific rate of low birthweight births, Joyce (1989) found the effect of early prenatal care on black low birthweight to be statistically significant. He used race-specific monthly data for New York City births, for which prenatal care data are kept, from 1970-1986. Specifically, he estimated the black prenatal care elasticity of low birthweight to be significant at approximately  $-.15$ , which, as he pointed out, 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. The author mentioned that the latter result could be due to possible measurement error specific to 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.

Since the data were 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 present in each of the series, the two model specifications that were employed were: (1) detrended production functions in which a linear trend term was included and only white low birthweight and white prenatal care were expressed in levels (all of the other variables were

first-differenced), and (2) unadjusted production functions in which all of the variables were expressed in levels.

To allow for the potential endogeneity of prenatal care and the resulting correlation of this input with the error term, Joyce used instrumental variables in estimating the race-specific production functions. In addition, he used lagged values of low birthweight as regressors, arguing that they may be reasonable 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. The previously discussed relationship between early prenatal care and birthweight was significant only in the second model specification, although the sign was as expected in the detrended model.

Joyce and Grossman (1990b) addressed the necessity of incorporating the pregnancy termination decision into the prenatal care demand function. The decision of a pregnant woman to give birth or to abort reflects what the authors termed the 'wantedness' of the pregnancy. They hypothesized that the lack of control for some measure of the wantedness of a pregnancy would bias the coefficients in a prenatal care demand equation, since it is likely that women who give birth represent a self-selected group of pregnant women who differ in unobserved ways from their cohorts who choose to abort. 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. Using cross-sectional data on individual births and abortions from New York City in 1984, they estimated race and age-specific demand functions for prenatal care in

which the dependent variable was the number of months after conception a mother delayed before initiating prenatal care.

To capture the effect of the wantedness of a given pregnancy, they estimated a probability function for giving birth versus terminating, given that a woman was pregnant. The birth probability and prenatal care demand functions were estimated simultaneously using maximum likelihood techniques. The correlation between the residuals in the two equations was tested for the presence of selectivity bias, which was found to be significant and negative for both blacks and Hispanics, but not for whites. The implication of this finding is that for blacks and Hispanics the increased wantedness of a pregnancy leads to significantly decreased delays in the onset of the consumption of prenatal care. In analyzing the evidence of the lack of selectivity bias for whites, the authors speculated that the white pregnancies may have been more planned. Pregnancy wantedness might have been established prior to conception for whites and their contraceptive behavior adjusted accordingly. If this were the case, then the pregnancy resolution decision would not in general reflect pregnancy wantedness for the whites, since the self-selection based on wantedness presumably entered into the earlier decision to become pregnant. In contrast, for blacks and Hispanics the wantedness may have been determined to a greater extent after conception. An implication of this conjecture is that non-whites may substitute abortion for contraception more frequently than do their white counterparts, and that abortion increases the average use of prenatal care among black and Hispanic women. As the authors mentioned, an empirical test of this last proposition would require another equation for predicting the probability of a woman becoming pregnant.

Grossman and Joyce (1990) extended the analysis of Joyce and Grossman by incorporating the pregnancy resolution decision into the overall infant health production framework and by including the role of pregnancy wantedness both prior to and post-conception. They formalized and tested a model of infant health as a function of endogenous prenatal inputs, which in turn depended on the endogenously determined probability of a woman giving birth given that she was pregnant. They claimed that self-selection in input usage could be favorable, as opposed to the adverse type that was assumed in the two-stage modeling approach employed by Rosenzweig and Schultz, Corman et al., and Joyce. Favorable selection could take place if prenatal care had other unobserved endogenous complements such as a healthy diet, which when excluded from the model would cause the effect of prenatal care consumption on infant health to be overestimated. In addition, the authors pointed out in this and the previous article that just as self-selection in input usage must be controlled for in a health production function model, the pregnancy resolution decision also likely reflects a self-selection process which should be incorporated. Self-selection in the resolution decision can also be characterized as adverse or favorable. Selection would be favorable if unwanted or inferior fetuses were aborted, and selection would be adverse if the poorly endowed or less wanted fetuses were carried to term.

Grossman and Joyce claimed that the two-stage procedures used in the previous literature to control for adverse selection in input usage precluded the possibility of favorable selection in the consumption of prenatal care. In addition, the issue of self-selection in pregnancy resolutions was never addressed formally until Joyce and Grossman (1990b). In Grossman and Joyce, they estimated infant health production functions and tested for self-selection

in both pregnancy resolution and input usage. When self-selection was indicated, their model yielded information on whether this selection was most likely favorable or adverse. In addition, their model provided a good indication of the underlying process by which specific determinants of fertility control behavior indirectly affected birth outcomes in the cases where self-selection appeared to be significant.

Their model consisted of equations for the probability of a woman giving birth versus aborting given that she was pregnant, an infant health production function for birthweight, and a demand function for prenatal care. In the first equation, the probability of giving birth was regressed on a set of exogenous factors that in essence determine the optimal number of children in a given family, such as income, education and marital status. Other relevant regressors would be the cost of contraception, the cost of abortion, and the endowment of the fetus. Unfortunately, data were not available for these last three factors. The authors maintained, however, that valuable information regarding the relative contributions of these factors could be gleaned by incorporating their effects into the error term of the birth probability equation and by later analyzing the covariances of the residuals across equations. The error term in the birth probability equation was expressed as a linear function of the cost of contraception, the cost of abortion, and the health endowment of the fetus.

The birth probability function reflects both directly and indirectly, in its disturbance term, the same variables which would appear in an equation predicting the probability of becoming pregnant. Since the Grossman and Joyce production function framework includes the unobserved costs of abortion and

contraception and the unknown health endowment as well as the observed determinants of birth probability, it can generate inferences, via the signs of the residual covariances between equations, about the wantedness of a given pregnancy and the relative effects of the unknown factors on self-selection in the prenatal care and birthweight equations. Their model, therefore, is able to incorporate the wantedness of a given pregnancy prior to conception as well as after conception, the need for which was suggested by Joyce and Grossman (1990b).

The second equation regressed the birthweight of the infant (in the subset of all pregnancies that resulted in a live birth) on a set of relevant exogenous factors, as well on as the endogenously determined measure of prenatal care delay. In addition, for the same reason as was described above, the disturbance term in the birthweight equation was expressed as a linear function of both the unobserved endowment of the fetus and of another endogenous health input that included unmeasurable endogenous healthy behaviors such as nutrition and exercise.

In the final equation, the number of months that a pregnant woman (who did not abort) delayed the initiation of prenatal care was regressed on a set of exogenous determinants, including health insurance coverage and various measures of the availability of prenatal care. The error term in the prenatal care delay equation was expressed as a linear function of the same unknown and/or unobserved variables as was the birth probability equation.

Using data on births and abortions for over 20,000 pregnancies in New York City in 1984, Grossman and Joyce estimated the birth probability

equation by maximum likelihood probit. The prenatal care demand function was then estimated using OLS both with a correction for self-selection in input usage and without such a correction. The birthweight production function was estimated three different ways: It was first estimated by OLS, uncorrected for self-selection in both input usage and in the pregnancy resolution decision. The second variation, also estimated by OLS, corrected for self-selection in the birth probability equation but treated prenatal care as exogenous. The last, estimated by TSLS, contained corrections for selection in both prenatal care usage and the pregnancy resolution decision. Comparison of the different forms of a given equation yielded information about the relative effects of the unobserved factors which were included in its error term, and about the type of selection (if any) that characterized the underlying process.

Using both OLS and TSLS, Grossman and Joyce found the expected negative relationship between a delay in the onset of prenatal care and an infant's birthweight for both blacks and whites. This effect, however, was statistically significant only for blacks. These findings contrast with those from Rosenzweig and Schultz who estimated non race-specific infant health production functions and found insignificant effects using OLS, but significantly negative effects using TSLS. Grossman and Joyce also found that for black women there was evidence of significant favorable self-selection in both pregnancy resolution and the demand for prenatal care. For whites, there was no evidence of self-selection, either adverse or favorable, in either equation. For blacks, the signs of the covariances between the residuals of the birth probability and prenatal care delay equations, and of the birth probability and birthweight equations, were consistent with birthweight indirectly reflecting the unobserved cost of contraception. In the case of black women, it

appears that a relatively high cost of contraception would increase the likelihood of a woman aborting given that she becomes pregnant. The black women who do not abort, and for whom the pregnancy was ostensibly more wanted, would initiate prenatal care earlier and give birth to heavier babies.

The above inferences broaden the finding from Joyce and Grossman of a negative relationship between the probability of a black woman giving birth given that she is pregnant and the delay in the onset of prenatal care. A general implication of the Grossman and Joyce 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. Accordingly, policies intended to restrict abortion availability that do not simultaneously attempt to decrease the cost and/or increase the availability of contraception may result in the worsening of black birth outcomes.

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 estimated a vector autoregressive (VAR) model in which all of the variables were treated as endogenous, with each being regressed on lagged values of itself as well as on lagged values of all of the other variables in the system. By treating all of the variables as endogenous, this dynamic time-series estimation technique obviates the need to control for unobserved factors, a need that has plagued all of the previously discussed attempts to estimate unbiased infant health production functions and input demand equations.

The number of variables must be kept to a minimum when estimating VARs since the number of relevant lags must be the same for all of the variables in the system. The inclusion of the relevant independent variables as well as the optimal number of lags often results in VAR models being overparameterized relative to the number of available observations. The variables used in the Joyce-Grossman VAR model 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. The equation in which the dependent variable was the rate of low birthweight births represents an infant health production function. The other two equations in the system are input demand functions for early prenatal care and abortion.

The race-specific VAR models were used to estimate the effect of a one-standard deviation negative shock in the abortion rate on the rate of low birthweight births for 36 months following the initial shock. They found that the shock in abortions lead to a substantial increase in the rate of low birthweight births for blacks. 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 abortions 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. Ohsfeldt and Gohmann (1992) estimated TSLs race-specific

quasi-structural production functions for the probabilities of both neonatal mortality and low birthweight using state-level aggregates for 1978 to 1987. The endogenous inputs were the probability of induced abortion, the use of neonatal intensive care services, the use of prenatal care, tobacco use, alcohol consumption, and the use of illicit drugs. Five reduced form input demand functions were estimated using instruments relevant for each input. The predicted levels of the inputs based on observed levels of the exogenous variables were used as regressors in the infant health production functions, as were several exogenous risk factors which were used as a proxy for the overall wantedness of the pregnancy. The neonatal mortality production function was estimated both with and without holding the risk factor of low birthweight constant. The input that was the focus of most of the analysis was the use of abortion services. Their results were consistent those of Grossman and Joyce (1990) and Joyce and Grossman (1990a, 1990b) in that abortion and wantedness appeared to significantly affect birth outcomes in the case of blacks. The effects of both variables were insignificant in explaining birth outcomes for whites.

In another pooled time-series and cross-sectional analysis, Joyce, Racine, and Mocan (1992) examined the effect on race-specific rates of low birthweight of illicit drug use by women during pregnancy. They found that for blacks, the increased prevalence of drug use among pregnant women appeared to be a significant factor contributing to the rise in low birthweight black births in New York City in the latter part of the 1980's. The effects for whites and Hispanics, however, appeared to be insignificant.

In a study analyzing the effect of prenatal care on low birthweight, Frank, Strobino, Salkever, and Jackson (1992) used data on U.S. counties from 1975-1984 to estimate the race-specific percentage of low birthweight births. They argued that with aggregate county data, the most likely source of unobserved heterogeneity would arise from the possible geographic clustering of women with similar endowments. They claimed that a fixed-effects model may be effective in controlling for this type of grouping. 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 had a significant negative impact on the percentage of low birthweight births for both blacks and whites. By estimating the model both with and without controlling for the fixed effects and 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.

## Summary

Several key findings emanate from the preceding review of empirical infant health studies. First, any model of infant health must correct for unobserved heterogeneity and the resulting selection biases that may arise.

Although more problematic in studies using data on individual births, unobserved heterogeneity can also bias production function estimates at the aggregate level. Secondly, every single study substantiated a strong relationship between the early initiation of prenatal care and the reduced incidence of low birthweight among blacks. All, with the exception of Joyce (1989) and Grossman and Joyce (1990), indicated a significant relationship between early prenatal care and birthweight for whites. The effects of the use of abortion services on the rate of low birthweight were less consistent across studies. Overall, most pointed to a significant relationship for blacks. Several recent analyses, however, indicated an insignificant relationship for whites. These findings regarding the role of abortion on birthweight are consistent with the speculation by Grossman and Joyce (1990) that on the whole a greater percentage of white pregnancies are planned, and therefore that the resolution decision would not have a significant impact on white birth outcomes.

## CHAPTER II

### EMPIRICAL IMPLEMENTATION

#### The Data

The data on low birthweight, prenatal care, and induced abortions are from micro-level vital statistics. Tennessee is one of only 13 states that report micro-level abortion data to the National Center for Health Statistics [National Center for Health Statistics (1989)]. Monthly totals for blacks and whites were compiled from January 1978 to December 1988. The measure of infant health used was the percentage of singleton live births in a given month in which the baby weighed less than 2500 grams.

Prenatal care delay was incorporated as the percentage of births in a given month for which the mother initiated her first prenatal visit after the first trimester of pregnancy. Many past studies also used the timing of the first prenatal visit [Rosenzweig and Schultz (1982, 1983, 1988), Corman, Joyce, and Grossman (1987), Joyce (1987a, 1987b, 1989), Joyce and Grossman (1990a, 1990b), Grossman and Joyce (1990), Ohsfeldt and Gohmann (1992), Frank et al.(1992)], whereas earlier studies considered the availability of prenatal care services [Grossman and Jacobowitz (1981), Corman and Grossman (1985)]. Another approach, not taken in any of the reviewed literature, would be to measure the quantity of prenatal care as determined by

the number of prenatal visits. This measure, however, would be complicated by the varying quality of prenatal care received. In addition, once prenatal care is initiated, the expected birth outcome influences the number of prenatal visits. A problematic pregnancy would require more frequent monitoring, whereas a routine pregnancy may necessitate less prenatal supervision. To the extent that prenatal care does not insure positive birth outcomes, it may be that those pregnancies with the 'most' prenatal care will result in inferior birth outcomes. Therefore, the quantity measure may underestimate the effectiveness of prenatal care.

Since there was no distinction in the Tennessee data set between births receiving no prenatal care and those getting unknown care, the denominator in the prenatal care delay formula includes only those births from women who definitely received some amount of prenatal care. Therefore, prenatal care delay was measured as the ratio of the number of births in a given month for which the initial prenatal visit occurred from the 4th to the 9th month of gestation, divided by the number of births that month for which at least some prenatal care was received during the course of the pregnancy.

The abortion rate in month  $t$  was measured as the number of abortions in month  $t-6$ , as a percentage of the sum of the number of abortions in month  $t-6$  plus the number of births in month  $t$ . Spontaneous abortions are not well recorded, and therefore are omitted from the analysis. The purpose of lagging abortions by six months was to compare the rate of pregnancies conceived in month  $t-9$  that were aborted in month  $t-6$  to the percentage of those pregnancies that ultimately resulted in a live birth in month  $t$ . Since the data represent monthly totals, there is a margin of safe variability embedded in the seemingly

rigid assumptions regarding the relative timing of conception and abortion and/or live birth. For example, a child could be born up to one full month prematurely without the assumption of conception in month  $t-9$  being inaccurate. Similarly, this computation could accommodate and correctly date the month of conception when induced abortion takes place at a little over 2 months of gestation. For example, suppose conception took place in late January and the pregnancy is terminated in early April after basically two months of gestation. Since the abortion took place in April, the calculations would assume that conception had taken place in January, which it had, and that the baby would have been born in October, which is not an unlikely event. Despite the margin for variation, however, there may be some inaccuracies in the computations arising from the predetermined time sequence. It is assumed that most of the errors will be largely self-canceling, and that any unidirectional biases will be insignificant or will be accounted for by the inclusion of the lagged values in the VAR system.

As in past studies, race-specific models were estimated since the rates of low birthweight, prenatal care delay and abortions are notably different for blacks and whites. Summary statistics for the data are presented in Table 1. To incorporate the seasonality of the data into the model, each equation contained 11 seasonal dummy variables. To analyze the type of trend present in each series over time, the Dickey-Fuller unit root test was applied [Dickey and Fuller (1981), Said and Dickey (1984)]. The series were tested for the presence of a likely trend-stationary process (TSP), versus a difference-stationary process (DSP). In the former case a linear trend over time is appropriate, whereas in the latter case the trend should be incorporated by differencing the

data.<sup>1</sup> The null hypothesis of a DSP specification was repeatedly rejected, suggesting that a trend rather than differences was appropriate for this data set. Therefore, the data were expressed in levels and a linear trend term was incorporated.

Table 1  
Summary Statistics

	BLACKS		WHITES	
	Mean	Standard Error	Mean	Standard Error
% Low birthweight	10.477	1.025	5.450	0.401
% Delayed Care	36.856	1.915	21.611	1.357
% Aborted	24.468	3.403	19.974	1.679

<sup>1</sup> In performing this test, a series of OLS regressions were run in which the dependent variables were the first differences of each of the three variables in the race-specific models. Each dependent variable was regressed upon (1) various lags of the difference being regressed, the first lag of the level of the variable itself, a constant, and a trend term, then on (2) the same various lags of the difference being regressed, and a constant term, and finally on (3) the same various lags of the difference being regressed. The data were tested for the presence of both first-order and higher order ARMA processes. F-statistics were computed as follows: The difference in the residual sums of squares between models (3) and (1) was divided by the residual sum of squares in model (1). Both the numerator and denominator were adjusted for the appropriate degrees of freedom. An analogous statistic was computed for model (2) vs. model (1). The computed F's were compared to the 'critical F's' from tables contained in the Dickey and Fuller article.

## Methodology

Race-specific VAR models were estimated in which the rate of low birthweight, the percentage delaying prenatal care, and the abortion rate were each regressed on their own lagged values as well as lagged variables of each of the other variables. The lags in all of the variables in all equations were restricted to be the same. Following Joyce and Grossman (1990a), a simplified version of the model is as follows:

$$B_t = a_1 B_{t-1} + b_1 P_{t-1} + c_1 A_{t-1} + e_t$$

$$P_t = a_2 B_{t-1} + b_2 P_{t-1} + c_2 A_{t-1} + u_t$$

$$A_t = a_3 B_{t-1} + b_3 P_{t-1} + c_3 A_{t-1} + v_t$$

$B_t$  represents the percentage of low birthweight births in month  $t$ .  $P_t$  is the percentage of births in month  $t$  for which prenatal care was initiated after the first trimester of pregnancy. As explained earlier,  $A_t$  is the percentage of pregnancies conceived in month  $t-9$  which were terminated in month  $t-6$ . For illustrative purposes, the lag length has been set to one, and all deterministic regressors have been omitted. It is important to note that all three variables are endogenous; therefore the VAR specification obviates the need to control for unobserved heterogeneity and/or self selection.

Since by definition there will be a high degree of correlation between many of the explanatory variables in each equation, the t-statistics will be unreliable as a tool in assessing the probable significance of individual

relationships. Rather, F-statistics on the set of lags of each regressor will be analyzed in conjunction with a series of lag-length tests to derive inferences about the strength and order of the relationships between the variables in the system.

Since VARs are limited in the number of variables and/or the number of lags that can be employed relative to the number of observations used, there are some potential factors in the modeled relationships that cannot practically be included in the system. Among these are various risk factors for low birthweight such as age, marital status, education, smoking and drug abuse, and determinants of input demand such as the availability of prenatal care and access to abortion services. It can be argued that the effects of these omitted variables enter into the model indirectly via the lagged values of low birthweight, prenatal care delay, and abortions. To the extent that this is the case, the results from this estimation process will be unbiased. Several other studies [Corman and Grossman (1985), Corman, Joyce, and Grossman (1987), Joyce (1989)] included lagged birth outcomes as production function regressors and found that these measures effectively captured the effects of unobserved inputs and/or risk factors such as drug use. In the present study, it is assumed that the lagged values of low birthweight will serve accordingly. Similarly, the lagged values of abortions and prenatal care will attempt to incorporate the effects of the availability of both abortion and prenatal care services on the demand for these inputs. Since the lagged values of the variables play such a key role in a VAR system, it seems most likely that this broad and extensive set of regressors includes the effects of many variables that were of necessity omitted from the analysis. Furthermore, while VARs as a whole are of questionable value for estimating the marginal effects of specific regressors,

they do provide a useful tool by which to predict the response of the system to a random shock in one of the variables. It is the latter purpose for which the present analysis is being implemented.

The number of lags in the system should be less than 9 months since the rate of low birthweight is not expected to directly reflect prenatal care that occurred pre-conception. A series of lag length tests [Sims, 1980] were implemented to determine whether models with 1,2,...,8 lags were significantly inferior in their explanatory power to a system containing 9 lags.<sup>2</sup> In addition, to allow for the possibility that seasonality was not completely accounted for, and for indirect effects in that the lagged variables may serve as proxies for omitted regressors, models with 12 lags were estimated and tested against models with less than 12 lags. Computed values of the Akaike Information Criterion (AIC) were evaluated as a complementary determination of the optimal lag length [Maddala (1988), Hurvich and Tsai (1989)].<sup>3</sup>

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<sup>2</sup> An example of this test is as follows: In testing whether a model with 5 lags is an appropriate restriction on one with 9 lags, the null hypothesis would be that the coefficients of the 6th through 9th lags equal zero. The alternative hypothesis would be that these coefficients do not equal zero. A chi-squared statistic is computed in which the logs of the determinants of the residual covariance matrices from the restricted and unrestricted models are compared. Rejection of the null hypothesis implies that a model with 6 lags is an inappropriate restriction of a model with 9 lags, and therefore that a 9 lag model should be used.

<sup>3</sup> For each model the following statistic (AIC) is computed:  
 $AIC = n * \ln(SSR) + 2k$ , where  $n$  is the number of observations,  $SSR$  is the sum of squared residuals, and  $k$  is the number of parameters. The appropriate model is where AIC is minimized. A refinement of the Akaike Information Criterion facilitates the model comparison process by adjusting for the decreasing degrees of freedom resulting from alternative model specifications employing longer lag lengths. The AIC statistic is modified as follows:  
 $Adjusted\ AIC = AIC + \{2(k+1)(k+2) / (n-k-2)\}$ .

Finally, the models were tested for the presence of autocorrelation. Since the Durbin-Watson test is inapplicable when a model contains lagged values of endogenous variables, the Lagrange Multiplier (LM) test [Godfrey (1978), Maddala (1988)] was performed.<sup>4</sup>

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<sup>4</sup> The residuals from each equation in the system were regressed upon the complete set of regressors and selected lagged values of the residuals from that particular equation. For example, the residuals from the low birthweight equation were regressed on all of the explanatory variables in the model, as well as on the first lag of the residuals themselves. Three additional regressions on the low birthweight residuals were run. They were identical to that just described, except that they incorporated different lags of the low birthweight residuals. The specific lags that were used were as follows: 12 lags, 6 lags, and the twelfth lag (only) of the low birthweight residuals. Analogous runs were performed upon the residuals from the prenatal care and abortion equations. The null hypothesis is that the coefficients of the lagged residuals are equal to zero, which, if true, would indicate the absence of an autocorrelation problem.

## CHAPTER III

### RESULTS

The results from the autoregressive models are presented in Tables 2 and 3. Based on the various lag length tests described above, the 5-lag model was applied for the whites. Both of the AIC statistics were minimized in the model with 5 lags; also, there was a dramatic increase in the model R-squared's as a result of including the 5th lag. In addition, the results from the lag length test [Sims (1980)] supported the use of the 5-lag model for whites.

The situation with the black data was more complicated. As with the whites, models of 1 through 12 lags were estimated. According to the lag length tests and to a lesser extent the model R-squared's, the appropriate model appeared to be the one with only 1 lag. The fit in the 1-lag model, however, was quite poor. Graphical inspection of the equation residuals from various models revealed two relevant phenomena. First, a seasonal pattern was still apparent despite the use of the monthly dummies, and second, the trend in the data over time looked distinctly non-linear. In response to these findings,

TABLE 2  
ESTIMATES OF AUTOREGRESSIVE EQUATIONS - WHITES<sup>a</sup>

Dependent variable				
Independent variable	Lag	% Low birthweight	% Late care	% Aborted
% Low birthweight	1	0.163 (1.66)	-0.222 (-0.91)	0.007 (0.02)
	2	-0.056 (-0.60)	-0.001 (-0.00)	-0.474 (-1.65)
	3	-0.070 (-0.77)	-0.452 (-1.98)	0.292 (1.03)
	4	0.238 (2.54)	0.160 (0.68)	0.074 (0.26)
	5	-0.117 (-1.24)	-0.061 (-0.26)	-0.724 (-2.50)
	F-Statistic		1.79	1.06
% Late care	1	0.043 (1.05)	0.190 (1.87)	-0.035 (-0.28)
	2	-0.140 (-3.27)	0.092 (0.87)	-0.000 (-0.00)
	3	0.038 (0.90)	0.179 (1.67)	0.059 (0.45)
	4	-0.025 (-0.58)	0.093 (0.89)	0.012 (0.09)
	5	0.092 (2.21)	-0.012 (-0.11)	-0.094 (-0.73)
	F-Statistic		2.88**	2.99**
% Aborted	1	-0.024 (-0.99)	-0.008 (-0.14)	0.128 (1.72)
	2	0.056 (2.24)	-0.092 (-1.48)	0.177 (2.32)
	3	0.002 (0.08)	-0.019 (-0.29)	-0.064 (-0.82)
	4	-0.055 (-2.29)	-0.021 (-0.34)	-0.069 (-0.93)
	5	-0.002 (-0.12)	0.042 (0.81)	0.156 (2.47)
	F-Statistic		3.19***	1.93*
R <sup>2</sup>		0.46	0.71	0.68

<sup>a</sup> t-ratios are in parentheses. The coefficients on the trend and the seasonal dummies are not shown.

\*\*\* p-values on the set of lags is less than 0.01.

\*\* p-values on the set of lags is less than 0.05.

\* p-values on the set of lags is less than 0.10.

TABLE 3  
ESTIMATES OF AUTOREGRESSIVE EQUATIONS - BLACKS<sup>a</sup>

Independent variable	Dependent variable			
	Lag	% Low birthweight	% Late care	% Aborted
% Low birthweight	1	-0.293 (-2.46)	0.348 (2.00)	0.075 (0.39)
	2	-0.330 (-2.51)	0.424 (2.21)	-0.224 (-1.05)
	3	-0.278 (-1.95)	0.118 (0.57)	-0.093 (-0.40)
	4	-0.309 (-2.27)	0.167 (0.84)	-0.053 (-0.24)
	5	-0.259 (-1.94)	0.119 (0.61)	-0.194 (-0.89)
	F-Statistic	2.21**	1.22	0.44
% Late care	1	-0.032 (-0.42)	-0.294 (-2.65)	0.131 (1.07)
	2	0.074 (1.01)	-0.089 (-0.84)	-0.045 (-0.38)
	3	0.026 (0.33)	-0.232 (-1.97)	0.307 (2.35)
	4	0.029 (0.33)	-0.175 (-1.37)	-0.069 (-0.49)
	5	-0.061 (-0.73)	-0.054 (-0.44)	-0.004 (-0.03)
	F-Statistic	1.26	1.95*	1.83*
% Aborted	1	-0.082 (-1.26)	0.111 (1.16)	-0.127 (-1.19)
	2	-0.103 (-1.50)	0.131 (1.31)	-0.304 (-2.72)
	3	-0.027 (-0.41)	-0.046 (-0.48)	-0.277 (-2.60)
	4	-0.032 (-0.47)	0.136 (1.36)	-0.397 (-3.57)
	5	0.023 (0.30)	0.177 (1.57)	-0.255 (-2.03)
	F-Statistic	0.91	1.95*	2.75**
R <sup>2</sup>		0.54	0.72	0.89

<sup>a</sup> t-ratios are in parentheses. The coefficients on the monthly and yearly dummies and the smoothed trend parameters are not shown. Although the model consisted of 7 lags, the coefficients and t-ratios are shown for the first five lags only. The F-statistic reflects all 7 lags.

\*\*\* p-values on the set of lags is less than 0.01.

\*\* p-values on the set of lags is less than 0.05.

\* p-values on the set of lags is less than 0.10.

a set of yearly dummy variables were included in addition to the monthly seasonals, and a crude smoothing technique was employed to account for the non-linear trend.<sup>5</sup> When the models were re-estimated, the graphs of the residuals indicated that these measures had indeed been effective. According to the various lag length indicators, the appropriate model for blacks was that which included 7 lags.

The LM test for serial correlation in the 5-lag model for whites and the 7-lag model for blacks resulted in the consistent non-rejection of the null hypothesis that the coefficients of the lagged residuals were equal to zero. Therefore, according to this test, there was no significant first, sixth, or twelfth degree autocorrelation in either of the models.

In the white low birthweight equation, the F-statistic on the set of lags of late prenatal care is statistically significant at the 0.05 level, with an observed significance level of 0.018. The F-statistic for abortions in the low birthweight equation is significant at the 0.01 level. Neither prenatal care delay nor abortions is statistically significant in explaining low birthweight for blacks, however. Consistent with the time-series result of Joyce (1989), the lagged values of low birthweight are significant at the .05 level in the black low birthweight equation, but are insignificant at conventional levels in the low birthweight equation for whites.

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<sup>5</sup> Instead of incorporating the linear trend directly, the following was used as a parameter in the model to accommodate a non-linear trend: (The yearly dummy) \* (The linear trend).

Impulse response functions, which map out the effects of a one-time shock to the system while taking into consideration the interrelationships between equations, were computed and graphed for the whites. The effect on the percentage of low birthweight births over a 36 month period following a specified shock in prenatal care delay is presented in Figure 1. The shock imposed is a one standard deviation positive shock in the percentage of births receiving late prenatal care, representing an increase of 0.827%. This figure is the standard error of estimate in the prenatal care equation in the 5-lag VAR system. The confidence bands were created as a result of 2000 Monte Carlo simulations in which the slope coefficients used were randomly assigned, based on a normal distribution around the parameter estimates from the 5-lag model.<sup>6</sup> Responses were computed both with and without orthogonalizing the residual variance-covariance matrix.<sup>7</sup> The responses were nearly identical in both cases. This was to be expected given that the residual correlations were negligible.<sup>8</sup> Thus, all discussion and illustrations in the present paper refer to the simulations that were performed without orthogonalization.

Figure 1 depicts a cumulative increase of 0.0097% in the rate of low birthweight as a result of an increase of 0.827% in the births having delayed

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<sup>6</sup> The generation of the confidence bands via Monte Carlo simulation were based on a procedure described in the time-series package, RATS [Doan (1992)].

<sup>7</sup> The purpose of orthogonalization is to avoid overestimating the variability of the random coefficients, and thereby generating overly conservative confidence bands. This often occurs when a significant linear relationship exists between columns in the covariance matrix.

<sup>8</sup> The residuals that had the highest degree of correlation were those from the abortion and low birthweight equations. The Pearson product moment coefficient of correlation,  $r$ , was equal to -0.075.

FIGURE 1

Response of % low birthweight to a one standard deviation increase in % delayed care (Whites)

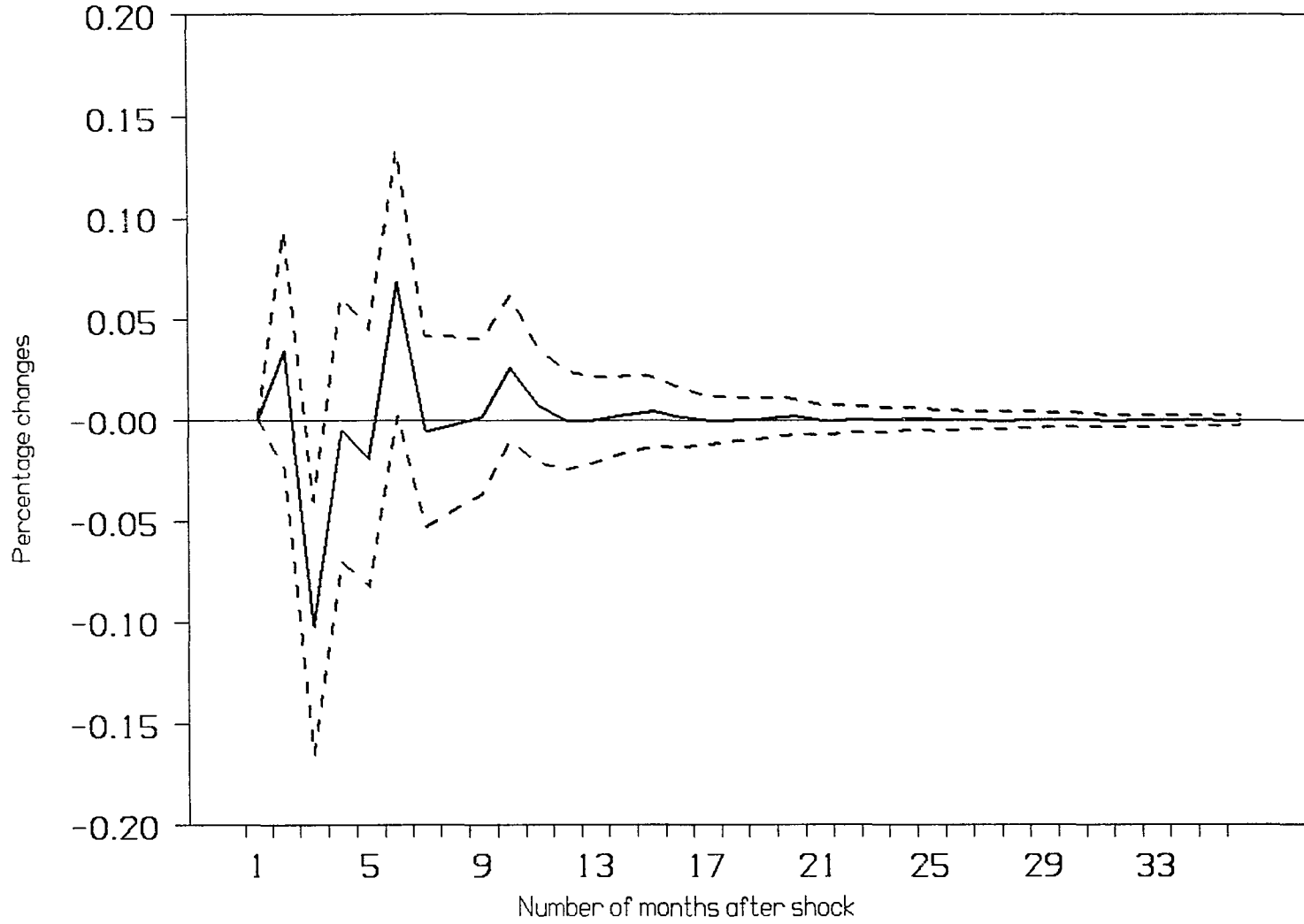


FIGURE 2

Response of % low birthweight to a one standard deviation decrease in % aborted (Whites)

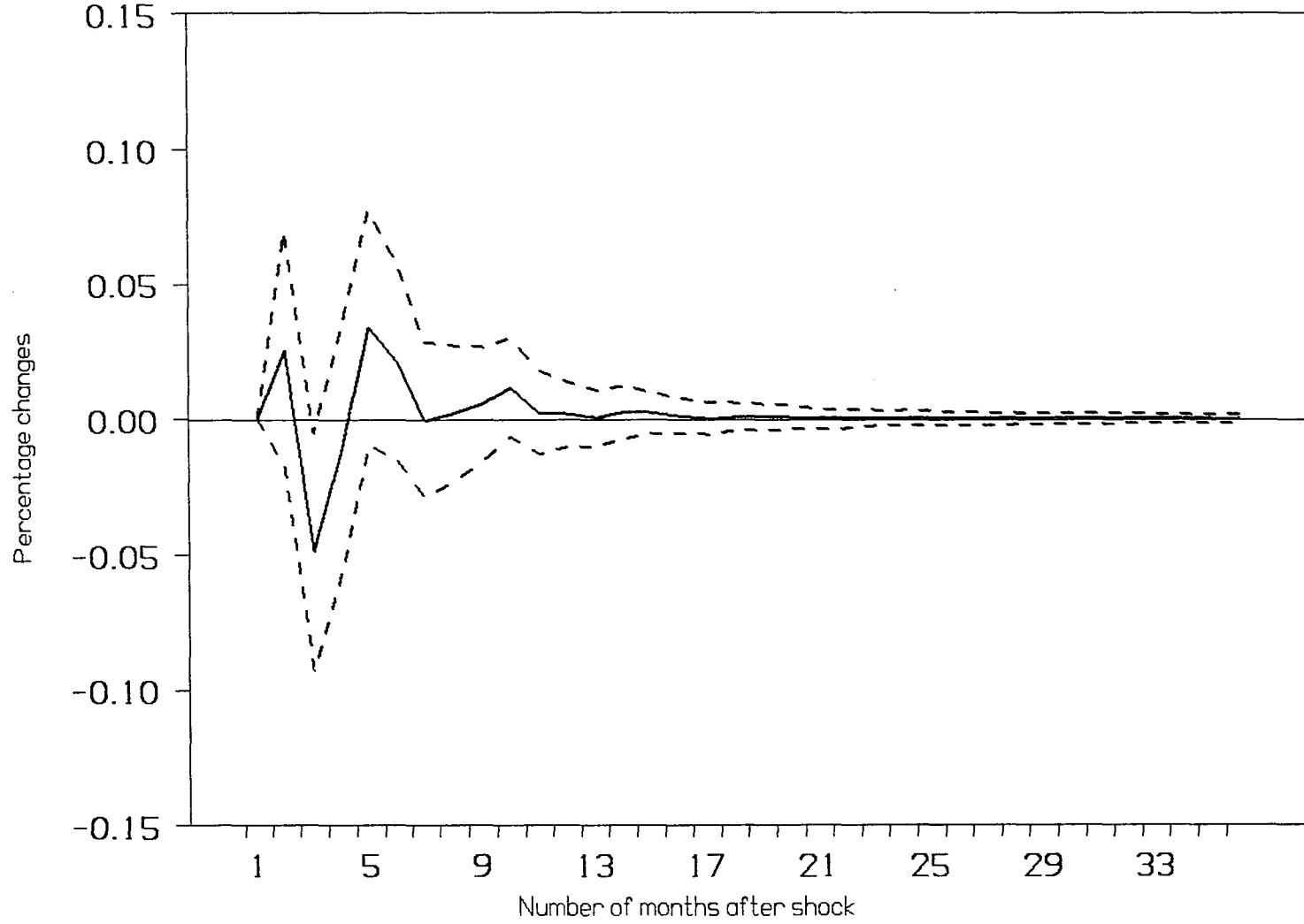
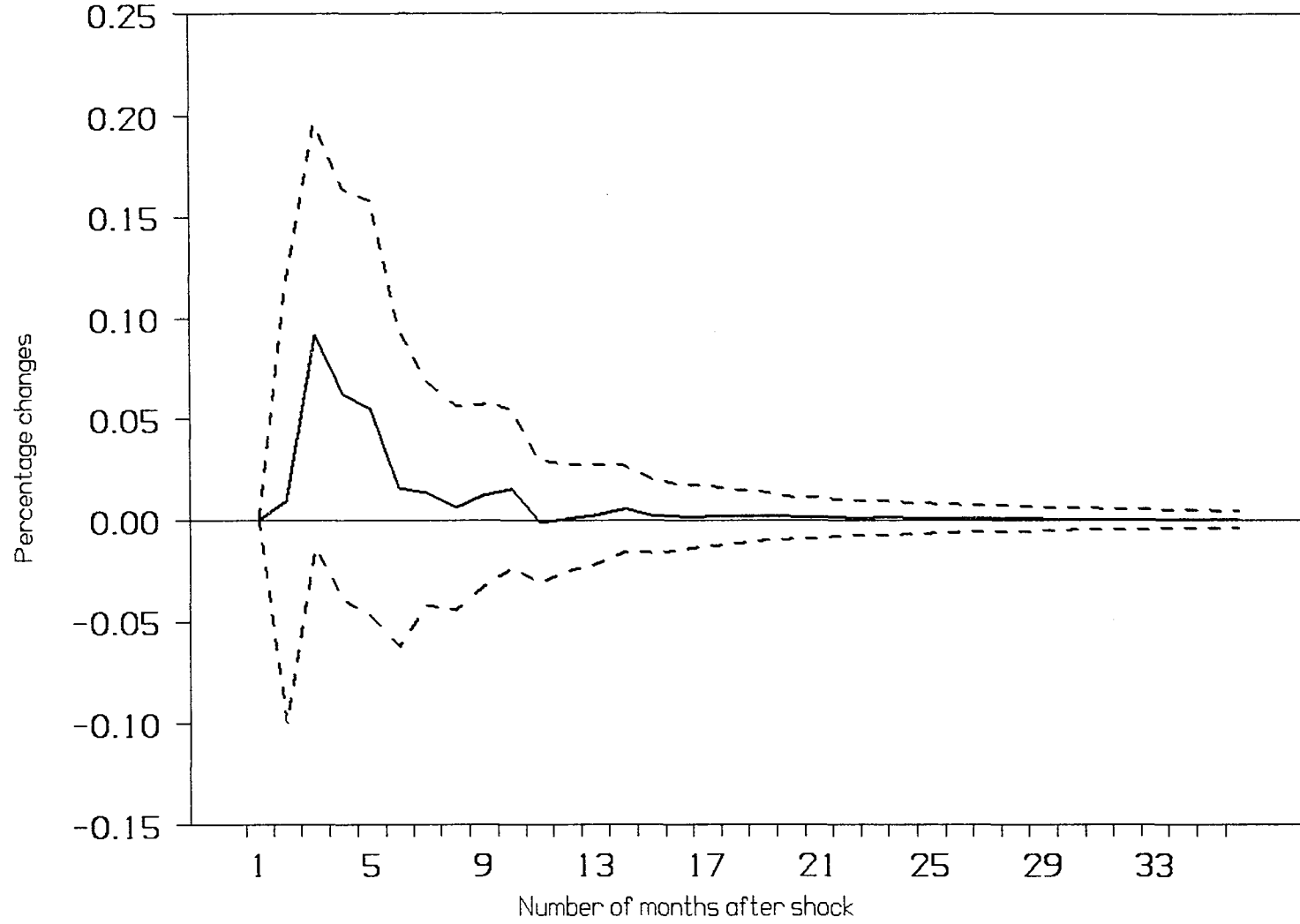


FIGURE 3

Response of % delayed care to a one standard deviation decrease in % aborted (Whites)



prenatal care, taking into consideration the effects across equations in the system. When interpreting this result, it should be noted that the concept of a one-time shock in the percentage of births with delayed care is probably somewhat unrealistic. More likely, there would be a long-term increase in prenatal care delay, as there has been in the United States since 1980, whereas from 1969 to 1980 there had been a steady trend of decreased delay in the initiation of prenatal care [Institute of Medicine (1988)]. If a trend can be viewed as a series of repeated 'shocks,' the overall effect on white low birthweight, according to this model, of an increased incidence of prenatal care delay would be substantial.

Figure 2 displays the response over 36 months of white low birthweight to a one standard deviation *negative* shock in the abortion rate. This shock represents a decrease in abortions of 1.023%. The cumulative response to this one-time shock in abortions was an increase of 0.0497% in low birthweight. Again, the concept of a one-time shock of such a magnitude may be of limited applicability. According to this model, a negative trend or repeated negative 'shocks' in the white abortion rate would result in a sizable increase in the rate of low birthweight.

It has been posited that abortions affect low birthweight indirectly via prenatal care usage [Grossman and Joyce (1990), Joyce and Grossman (1990b)]. If the abortion rate suddenly declined, either because of new legislation and/or changes in access to abortion services, it is expected that an increased number of births would be 'unwanted' and there would be increased delays in the initiation of prenatal care. In the white prenatal care delay equation, the abortion rate was statistically significant at the 0.10 level (see

Table 2). Figure 3 presents the effect on prenatal care delay for whites resulting from a one standard deviation decrease in the white abortion rate. The projected cumulative increase in prenatal care delay over 36 months is 0.311%, resulting from a decrease of 1.023% in the abortion rate.

A surprising result was that neither prenatal care nor abortions were significant in any of the various model specifications in explaining low birthweight for blacks. As discussed earlier, all prior studies substantiated a strong relationship between prenatal care and black low birthweight, regardless of the measure of prenatal care and the characteristics of the data used. Most also confirmed a significant relationship between the pregnancy termination decision and the rate of black low birthweight. The relationships for whites were generally weaker. The results in this paper are just the opposite: Both prenatal care delay and abortions appear to be significant indicators of the rate of white, but not black, low birthweight in Tennessee.

One possible explanation for the inconsistency with previous results is that there was simply not enough data for blacks to fully model the complex relationship between abortions, prenatal care, and low birthweight. In a given month, there were 3-4 times as many white as black births in Tennessee. The mean number of births per month was 1304 for blacks and 4322 for whites. In addition, the standard errors of low birthweight, prenatal care delay, and the abortion rate were substantially higher for blacks (see Table 1). The limited and highly variable nature of the black data casts doubts on both its accuracy and overall representativeness. While the results for whites were more significant in this study than in much of the past research, the relationships conformed to the overall infant health framework. Specifically, the results from

the impulse response functions suggest that a trend of increased prenatal care delay would increase the rate of low birthweight among whites in Tennessee. In addition, a decrease in the abortion rate is expected to increase both prenatal care delay and the frequency of white low birthweight births in that state. The effects for blacks are expected to be similar; however, the data limitations precluded substantiation in this case.

## CHAPTER IV

### CONCLUSION

Using aggregate time-series data from Tennessee, this paper has examined the relationship between prenatal care, induced abortion, and the rate of low birthweight births. Separate vector autoregressive models were estimated for blacks and whites. Significant effects were found for both prenatal care delay and abortion in explaining low birthweight for whites. In addition, the percentage of white pregnancies aborted significantly explained white prenatal care delay.

None of the above relationships, however, were significant for blacks. This lack of significance is inconsistent with the bulk of past research, which has relied primarily on cross-sectional data from locations other than Tennessee. It is assumed that the weak results for blacks in the current analysis were due to both a lack of data points and to the highly variable nature of the black data used in the estimation process. Consistent with past studies, however, a significant relationship was found for blacks between low birthweight and the set of lagged values of low birthweight.

The results from the simulations for whites suggest that a one-time increase in the percentage of births for which prenatal care was delayed would

lead to an increased percentage of low birthweight births. In addition, an unanticipated negative shock in the abortion rate would substantially increase both the percentage delaying prenatal care and the percentage of low birthweight babies. Conversely, a positive shock in the abortion rate would decrease the percentage delaying care and would result in a percentage decline in the rate of white low birthweight births.<sup>9</sup>

While the concept of a singular shock is somewhat arbitrary, the findings from this paper further substantiate, if only qualitatively, the underlying relationships within the overall infant health framework. Although VARs in general provide only a limited representation of the complex relationships being modeled, the significant relationships confirmed here are consistent with the notion that unwanted pregnancies are more likely to result in delayed prenatal care or induced abortion. Specifically, past research has found that for pregnancies carried to term, prenatal care is generally sought later for those that were unplanned [Institute of Medicine (1988)]. It has also been shown that in many cases the abortion rate reflects overall pregnancy wantedness. Grossman and Joyce (1990) and Joyce and Grossman (1990b) argued that increased levels of prenatal care may be devoted to pregnancies that are carried to term, since induced abortion can act as a selection mechanism by which many unplanned and/or undesired pregnancies are eliminated. The implication is that the rate of prenatal care delay is negatively related to the abortion rate. Accordingly, an increase in the abortion rate would presumably reflect the termination of unwanted pregnancies on the margin, resulting in a decreased average delay of prenatal care. Conversely, a decrease

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<sup>9</sup> The impulse response functions for a positive shock in abortions were computed, but are not shown.

in the abortion rate would increase the percentage delaying care, since more unwanted babies would likely be born. Furthermore, assuming the well-documented negative relationship between prenatal care delay and a baby's weight at birth, a decrease in the abortion rate would increase the rate of low birthweight, since more unwanted (delayed care) babies would be born.

The dynamic relationship between abortion, prenatal care and low birthweight described above appears to be a plausible interpretation of the story told by the Tennessee data. For whites, the estimated effects of induced abortion and prenatal care delay on low birthweight are in general concordance with those in models specifically incorporating pregnancy wantedness. Most likely, given the past research results and access to more representative data, the same would be true for blacks. To the extent that the presumed scenario represents an accurate appraisal, it is reasonable to conclude that the prevention of unwanted pregnancies in the first place would reduce both the rate of prenatal care delay and the rate of low birthweight births. Given the significant costs associated with low birthweight births, resources devoted to preventing unplanned pregnancies would very likely be well spent. While there have been some studies documenting the cost-effectiveness of school-based programs in reducing unwanted teenage pregnancies [National Academy of Sciences (1987)], there remains more general research to be done in this area. Post-conception, it has been well documented that early prenatal care is a cost-effective means of preventing low birthweight. Given that prenatal care is generally sought later for pregnancies that were unintended or unwanted in the first place, this paper underscores the importance of preventing unplanned pregnancies and also of providing easy access to early prenatal care for those pregnancies that are unwanted but carried to term. Measures designed to

achieve these objectives would likely result in improved birth outcomes subsequent to decreased delays in the initiation of prenatal care, while at the same time possibly even reducing the abortion rate. In addition, a beneficial reallocation of resources may result. Decreased levels of economic resources may ultimately be required for the provision of neonatal intensive care and other longer-term care related to low birthweight, thereby enabling the flow of surplus resources to alternative productive uses.

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