Discussion Papers   Economic Growth Center

2-1-1981

Specification Biases in Estimating the Influence of Child Mortality on Fertility

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CENTER DISCUSSION PAPER NO. 369

SPECIFICATION BIASES IN ESTIMATING

THE INFLUENCE OF CHILD MORTALITY ON FERTILITY

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February 1981

Introduction

The proximate cause for today's rapid population growth in low income countries is the postwar decline in mortality, which has been particularly large for infants and young children. The effect of this reduction in mortality on the birth rate will influence the future path of population growth. The magnitude of any such effect may also modify development priorities among categories of public expenditure and international assistance, such as among health, family planning and education programs and non human capital investments. This paper discusses some of the problems of estimating the influence of mortality on fertility, and illustrates alternative approaches by an analysis of the 1971 Korean Fertility-Abortion Survey and 1970 Korean Population Census.

To the extent that fertility is determined by preferences subject to resource constraints, it represents an individual or family choice. Information on the couple is generally assumed to be more satisfactory for evaluating the factors conditioning reproduction than information on aggregate conditions and behavior.[1] Yet research on the multiple determinants

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[1] Intuitively, observations on the individual couple come closer to testing theories of household behavior than do data averaged over groups, defined by region-of-residence or another supposedly exogenous socioeconomic characteristic. To estimate the same fertility (demand) function from data for population aggregates as estimated from data for household, the aggregates must be defined independently of the variables conditioning the fertility outcome. In addition, the functional form and statistical structure of the process generating this relationship must be known and taken into account to infer without bias from the aggregated information the precise nature of the relationship pertaining to individual couples (Theil, 1954). For example, it may be reasonable to approximate a monotonic function by a linear specification, if one is cautious of such estimates for what they are. But when the underlying true functions are nonlinear, aggregation may conceal and change substantially the apparent relationships.

of fertility relied heavily in the late 1960s on regression analyses of regional aggregate data from censuses and vital registration systems (Schultz, 1973). Analysis has only more recently dealt with individual data drawn from household survey and census samples. Standard statistical techniques applied to these micro economic-demographic household data pose new problems as well as opportunities for estimating the effect of child mortality on fertility.

Two mechanisms are frequently hypothesized to connect causally mortality and fertility, an ex post replacement response and an ex ante expectation response (Schultz, 1969, 1976; Ben-Porath, 1976; Preston, 1978). If one neglects the uncertainty that attaches to the unpredictability of births and deaths within a particular family and the imperfect information on which parents must base their decisions, it can be shown that inelastic demands for surviving children in combination with plausible cost assumptions imply that parents would replace partially (i.e., incomplete replacement, on average) any of their own children that might die, if they were still biologically capable and if their demands for surviving offspring had not decreased due to other unanticipated developments (Schultz, 1976). This replacement effect for own-child loss might be evaluated from observations over time on the fertility behavior of couples and the survival

of these births.[2]

But with the introduction of uncertainty and biological limitations

on lifetime reproduction, a second mechanism by which

fertility can respond to mortality is likely to increase in importance.

Long-run expectations of probable levels of mortality and probable

capacities of parents to have in their lifetime the number of surviving

children they want will lead parents to adopt a reproductive lifetime

strategy that anticipates events. This second _expectation effect_ has

also been called an insurance or hoarding response of parents and might

involve, for example, the adaptation of social institutions, such as

intergenerational transfers to youth, to influence the timing of marriage

and childbearing in anticipation of future child and parent mortality conditions.

No one has as yet devised an entirely satisfactory way to measure how

these individual and social expectations are formed, or how large the

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[2]No distinction is drawn here between biologically autonomous and
behaviorally induced means by which a couple responds
to its child mortality experience, since we do not know how to separate
empirically the two mechanisms with any confidence. The biological
effect operates largely by the shortening of breastfeeding when the
deceased child had been nursing, and the cessation of hormones stimulat-
ed by suckling encourages the earlier resumption of ovulation. Hence, the
women whose infants died while still nursing are involuntarily provided
with additional reproductive capacity. See further discussion Schultz, 1976;
Preston, 1978.

expectation effect is, and whether it is acheved through variation in age

at marriage or marital fertility rates. If, as is often assumed, the

child mortality rate is a random variable at the individual level, there

is no reason to observe an expectational response in the cross section;

the partial correlation between community mortality levels and individual

fertility is in this case interpreted as due to the covariation of omitted

regional variables that influence fertility. Consequently, individual

cross sectional data may be more useful for estimating the replacement

effect of fertility to own-child mortality, while cross sections at higher

levels of aggregation, such as for local communities or socioeconomic

groups, and time series may provide a better basis for estimating the com-

bined magnitude of expectation and replacement effects on reproduction due to

actual and expected mortality variation across a population.[3] The statisti-

cal problems in separating these two affects may help to explain the diverse

conclusions drawn from the empirical evidence of a relationship between

child mortality and fertility (Schultz, 1976; Preston, 1978, Olsen, 1980).

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[3] A strong association in Taiwan is noted between the timing of marriage
for birth cohorts and the region's own-child mortality (Schultz, 1980).
West European regional data also display a striking positive correla-
tion between child mortality and nuptiality. A study of Philippine survey data
introduced the average child death rate in the community of current resi-
dence together with the own-child death ratio as variables to account
jointly for individual variation in age specific cumulative fertility
(Harman, 1970). This empirical strategy, which we consider later in this
paper, confirmed that both the community level proxy for expectations and
the individual level measure of replacement were positively correlated
with the number of children born in the Philippines. Clearly, individuals
have much more information relevant to their expected mortality than the
community level mortality rate, and there is no obvious way for the re-
searcher to elicit all of this information (Heer and Wu, 1978).

Direct estimates of association among discrete measures of own-
child mortality and a woman's cumulative fertility are a source of
additional problems (Williams, 1977; Brass and Barrett, 1978).
The obvious spurious correlation between children born, C, and
children born, D, led to the substitution as regressor of the child
mortality ratio, namely, $r = D/C$, for the absolute number of children
dead. But if observations pertain to individuals, the child mortali-
ty ratio is concentrated at discrete points on the unit interval
that are themselves related to the level of fertility, and a spur-
ious nonlinear association between c and r may still
arise though no causal basis for the relationship exists (Williams,
1977; Wallace, 1979).

In this paper, we explore statistical approaches to estimat-
ing the nonspurious relationship between an individual's own-
child mortality and fertility. A standard demand model of fer-
tility is used in section 2 within which alternative specifications
of child mortality are considered. In section 3 we specify empiri-
cally a fertility equation based on information from a 1971 Korean
Fertility-Abortion Survey of 5,629 ever-married

women in combination with the ten percent sample survey of the 1970
Korean Census of Population. The object is to obtain estimates of
the replacement effect of own-child mortality on fertility. The
empirical findings are discussed in section 4 and other estimated para-
meters in the fertility equation are appraised for their sensitivity
to the alternative specifications of the fertility-child mortality
relation. Section 5 summarizes our findings.

2. The Treatment of Child Mortality in the Micro Fertility Equation

Standard demand models of fertility suggest that a significant
share of variation across a population in fertility should be accounted
for by the opportunity value of women's and men's time, their non human
wealth, the local opportunities for child labor, and the offsetting cost
of rearing children. To this list of conventional income and relative
price variables entering a reduced-form demand equation for fertility,
economists and demographers have added child mortali-
ty as a conditioning variable (Freedman, 1967; Schultz, 1969). At issue
here is how to estimate the response of fertility to child mortality, and
how does the estimation strategy affect the estimated responsiveness of
fertility to the traditional income and price variables. Models of se-
quential fertility decision making under uncertainty as to the qualitative
characteristics of births, such as survival, sex, or intelligence, have
thus far not led to any testable predictions, unless a great
deal is known, a priori, about the characteristics of the parents' utility
function (Ben-Porath and Welch, 1972). Under more simplified static

assumptions about parent goals for surviving children, and the relation

of costs to survivors, it is possible to show that if parent demands

for survivors are inelastic, their demand for births increases

when they lose a child (Schultz, 1973). The prediction of this simple

demand framework is that parents will be more likely to seek an addition-

al birth if one of their prior children dies or is suddenly expected to

die. But this replacement/expectation response will not be complete,

that is, the response derivative of the number of children-ever-born

with respect to the number of children-dead will be positive, but less

than one, i.e, $0 < dC/dD < 1$. The child's death entails a loss of family

wealth that should reduce the demand for all normal goods, including

children. A reduction in mortality would, in this case, lead to a par-

tially offsetting reduction in fertility, but the rate of population

growth would presumably still increase.

A response derivative in excess of one requires a strong cross

substitution effect in a more elaborate demand framework that recognizes

a "quality" dimension to children that is a substitute for numbers of

children in the parent's utility function. As mortality decreases it

is then possible to show that child "quality" will appreciate in

value relative to the "quantity" of children. If these two attributes of

children are sufficiently close substitutes to parents,

the   decline in mortality induces parents actually to shift their

consumption from fertility to investments in child "quality", leading

to an over-compensating reproductive response, i.e., $dC/dD > 1$ (O'Hara,

1975).

Even if economic theory did prescribe the sign and size of the long run equilibrium reproductive response derivative with respect to child deaths, one might, nonetheless, want actual parameter estimates from different populations, for the means for restricting fertility in response to decreasing child mortality are not uniformly distributed across the world's populations. Many factors, such as education, are implicated as improving the effectiveness of contraceptive choice and practice, given the available technological options and prices. Actual reproductive responses to variation in child mortality might be expected to differ across socioeconomic groups within a society and across societies over time. Indeed, some evidence suggests that response derivatives are larger for upper income groups than for lower income groups, at least in urban Latin America in the 1960s (Schultz, 1978).

One issue we do not deal with here is the possibility of joint determination of fertility and child mortality. The empirical association between fertility and mortality may indicate that both are influenced by coordinated household allocation choices. Both might then be viewed as outcomes of an implicit household demand system, and these two outputs may also be jointly produced. In some instances increased fertility may raise the risks of child mortality, while increased child mortality may increase the biological potential for bearing subsequent births, as noted earlier. More generally, the stochastic disturbances in unconditional demand equations for fertility and for child mortality may not be statistically independent of one another because both are displaced from their normal level by unforeseen and unobserved events,

such as natural disasters. The one-way causal effect of
child mortality on fertility in this general demand system is not readi-
ly estimated unless information is available on an
identifying variable that affects child mortality but does not affect
directly fertility.[4]

What is ultimately needed is _a priori_ theoretical insight into
an observed identifying variable, such as a child vaccination program
that reduces child deaths in some regions without altering appreciably
the economic environment of families in those regions. Unfortunately, we
lack information in this paper on such an identifying variable, and,
therefore, assume for simplicity that variation in r across individuals
is random and thereby independent of the disturbances in the fertility demand
equation. A corollary of this assumption is that parents in a cross section are
unable to collect sufficient information to revise their expected value of r, and

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[4]Economists have been tempted to follow the lead of demographers by ordering
lifecycle demographic events through time, to appraise the consequences of a
child's death on subsequent reproductive behavior and thereby alleviate the
simultaneous equations bias (Brass and Barrett, 1978; Ben-Porath, 1976;
Park, et al., 1979). But these direct estimates of factors conditioning
fertility are not free of bias because the observed population is selected
on the basis of an endogenous choice variable, prior reproductive behavior.
For example, it is common to measure fertility in these exercises as the
parity progression ratio, namely whether or not a mother has another child by
age b, given that she had exactly n births at age a, where, of course, b > a.
This parity progression ratio is then conditioned using the linear probability
model or the logistic model on the proportion of the mother's first n births
dead when she was age a. Although this time ordering of events can also be
used to analyze a sequence of subsequent birth intervals, both approaches
suffer from consideration of selectively drawn samples that cannot be assumed
representative of the entire population. Thus, residual variation in the
equation describing who is likely to have already reached their n'th birth at
age a will probably influence their subsequent reproductive behavior. Per-
sistent unobserved factors that impact on many types of household lifecycle
outcomes will be embodied in the disturbances in measured prior child mortality
and in the subsequent parity progression probability. These direct estimates
of the "structural" fertility equations have descriptive appeal, but remain
inconsistent estimates of the desired parameters in the fertility equation.

they instead act on the basis of the population average child
mortality rate until their own children accumulate survival/mor-
tality histories that differ from the population average.[5] What
we are assuming is that child mortality is essentially a random
variable whereas fertility contains a component of systematic
choice; undoubtedly, the margin of control parents exercise over
fertility is much greater, relatively speaking, than that exercised over
child mortality.

The number of children ever-born is a discrete variable with typi-
cally small values. For a family with n births, the family mortality ratio can
take on only n + 1 separate values; for example, a family with four
births can experience a mortality ratio of 0.0, .25, .5, .75, or 1.0.
Thus, if the family mortality rate is computed for individual families
in a sample, the families will be concentrated at particular points on
the unit interval. The coefficient estimates on the child mortality ratio
when cumulative fertility is regressed on a nonlinear transformation of
that ratio may, therefore, be biased, as Williams (1977) suggested by

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[5]This is more plausible where r is relatively low, the number of children
women have is moderate, and, of course, where perceptible socioeconomic
differentials in mortality are small.

two illustrations.[6] In an empirical study of contemporary U.S. data, Williams (1976) estimated a quadratic replacement relationship between cumulative fertility and the child mortality ratio--where the response derivative increased initially and then decreased.[7] In the next section we shall estimate and compare the linear and quadratic-form estimates.

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[6] Williams constructed two hypothetical populations, namely, a uniform and a "realistic" frequency distribution of fertility to examine the statistical effect of child mortality on fertility. Families in the former are distributed equally among alternative numbers of children-ever-born, whereas in the latter, the percentage of families at the different values of children-ever-born are equal to the actual frequency distribution of family sizes among older women in the U.S. 1965 National Fertility Study. In both populations the distribution of families according to number of child deaths is determined using the binomial probability tables in such a way that, by construction, the families in these populations do not respond to child mortality. Within each children-ever-born category, child mortality strikes randomly 20 percent of the children. The conditional probability of child death rates in a family is not independent of births, even though the binomial probability of child death is itself assumed to be independent of family size. When families with 100 percent mortality were retained in the fertility regression, a linear function of the child death rates does not help to explain children-ever-born. The regression bias arises for nonlinear transformations of the child mortality ratio that are not independent of fertility.

[7] Her interpretation of this response pattern was that families who experience low mortality rates replace their losses more completely and therefore have a substantial positive response to mortality, i.e., $dC/dD > 0$. But those who experience very high mortality are often discouraged (and so revise downward their goal for surviving children, because they perceive the cost of attaining that goal as higher than they originally anticipated) or unable (due to underlying reproductive limitations, of which the child mortality may be one manifestation) to have complete replacement, and thus exhibit a smaller response to mortality, perhaps even negative. Based on this reasoning, Williams rationalized the inverse-U-shaped response pattern she found, and proposed the use of a quadratic form in the child death ratio instead of the linear form in the estimated cumulative fertility equation. But the quadratic specification of the child mortality ratio in the fertility equation may have exaggerated a spurious nonlinear component of the relationship.

To compensate for the spurious correlation between C and D or a
nonlinear form of r, Wallace (1979) has proposed using a transformed
measure of fertility that is by construction conditionally independent
of child mortality. If there were no causal relationship between fer-
tility and measured mortality, then a regression of Wallace's transformed
measure of fertility on mortality would yield an unbiased estimate of the
"true" effect of mortality, that is, zero. But if the "true" effect of
mortality on fertility is positive, then this estimate is downward biased
(Wallace, 1979). The Wallace estimation strategy is warranted if the
behavioral model is thought to link D to C or link a nonlinear function
of r to C. These specifications of the fertility equation could also
be estimated consistently by an instrumental variable procedure that
would purge D or a nonlinear function of r of its endogenous association
with C. Since r is by assumption independent of C, it will be the instru-
ment we use later to obtain consistent two-stage estimates of such a specifi-
cation of the fertility equation (Olsen, 1980).

To obtain the expected value of fertility conditional on child mortality,
Wallace makes two assumptions about the process generating child mortality.
First, as already noted, the probability of child mortality is assumed con-
stant across the population such that its expected value must be equal to
the average ratio in the population of women of a given age. Second, child
mortality is assumed to be generated by a binomial process. Suppose we want
to regress the number of births, C, on the number of child deaths, D, in a
family. The expected number of child deaths conditional on numbers of births is:

$$E(D|C) = \binom{C}{D}P^D(1 - P)^{C-D}; \quad C,D = 1,2,\ldots,N; \quad C \geq D,$$ where N is the largest number of children born in the population. The expected probability that a woman will have a specific number of child deaths is calculated from the actual fertility of the mother and our assumption that P is constant across mothers with different levels of fertility in each age group of mothers. The procedure is then reversed to calculate the expected value of fertility given that a certain number of child deaths are known to have occurred to the individual woman, defined as follows:

$$E(C|D) = \frac{\sum_{C=1}^{N} Cg(C)\binom{C}{D}P^D(1 - P)^{C-D}}{\sum_{C=1}^{N} g(C)\binom{C}{D}P^D(1 - P)^{C-D}}$$

where g(C) is the relative frequency of births for women of a given age. This expected value of fertility conditional on the number of child deaths tends to be positively correlated with the number of deaths, and this is the quantity that Wallace subtracts from the actual level of fertility to obtain his dependent variable.

The same procedure is repeated to obtain the expected value of fertility conditional on a nonlinear function of the child mortality ratio, and since the conditional expectation of C given r and r^2 is the same as the conditional expectation given r, $C^* = C - E(C|r,r^2) = C - E(C|r)$, while if D is thought to be the correct variable in the fertility equation, we have as described above $C^{**} = C - E(C|D)$.[8]

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[8] Appendix B Tables B-1 through B-4 report the frequency distribution of births by age groups of mothers, g (C) and illustrates how the expected value of fertility conditional on child mortality is calculated for the Korean sample.

3. Empirical Specification of Explanatory Variables

The fertility equation is interpreted by us to be an unconditional household demand function, and includes, therefore, all appropriate price and income variables, but excludes other simultaneously determined household demand variables that might interact with or be jointly determined with fertility, such as mother's age-at-marriage or duration of marriage and mother's time allocation or labor force participation. To capture the nonlinear functional form of the cumulative fertility schedule with respect to age, age is introduced as single year dummy variables. The fertility equation is also estimated within five year birth cohorts to minimize problems of age aggregation due to interactions between age and other conditioning variables, and to avoid the need to impose an arbitrary "natural" age normalization on cumulative fertility (Boulier and Rosenzweig, 1978). Table A-1 in Appendix A reports the descriptive statistics for the six five-year birth cohorts of Korean women analyzed below.

Education of wife and husband represents wage opportunities in the labor market and thus approximates the value of time. It is generally assumed that for the wife the substitution effect of the wage rate outweighs the income effect, prescribing a negative effect of the wife's education on fertility. The net effect of husband's education is not signed, however, and is frequently found to be positive or U shaped, at least in traditional agricultural societies where children are a productive asset (Schultz, 1973). Education is allowed to affect fertility nonlinearly by introducing five categorical educational attainment variables: no schooling, 1-6 years, 7-9 years, 10-12 years, and more than 12 years of schooling.

The mother's rural/urban background is summarized in four categories with reference to her birthplace, and longest residence before and after marriage. Our assumption is that relative prices favor higher fertility in rural areas and discourage large families in metropolitan urban areas. Particularly for older women who may have had many of their children in a prior residential area of Korea, these background effects may be important. Internal migration is common in Korea, and other studies have shown it is related to fertility patterns (Lee and Farber, 1980).

Finally, three variables are drawn from the 1970 Census 10 percent sample survey public use data file to represent conditions in the household's community of residence: agricultural and nonagricultural labor force participation rates for children age 14-19, and the average child mortality ratio for women in five-year age groups of mothers, age 25-29 to 45-49. The former two variables are intended to measure the community's labor force opportunities for child labor that would encourage higher fertility,

and the latter variable proxies the community's mortality regime that
might influence mortality expectations or represent omitted environmental
constraints that affect fertility apart from the direct replacement responses
to own-child mortality experience. These three variables, because they
pertain to the aggregate community of residence, cannot be affected appreciably
by an individual's behavior, and are therefore exogenous to the family's
reproductive behavior even though the child labor force participation
patterns embody both aggregate supply and demand effects.

The 1971 Korean Fertility-Abortion Survey was collected by the Korean Institute
for Family Planning. Retrospective histories and social, economic, demographic
and family planning information were collected from 5,629 ever-married
women and their families. The county. city, or metropolitan district of
current residence is used to merge with this household file additional in-
formation from the 1970 Census 10 percent sample survey. The cumulative
fertility and own-child mortality data from the 1971 survey appear to be
of high quality according to aggregate estimates of the levels and trends
of fertility and child mortality. The 1970 Census retrospective child
mortality data, however, may underreport slightly child death rates, parti-
cularly for younger mothers (Coale, et al., 1980). The decrease in mor-
tality has been substantial, however. Expectation of life at birth is
estimated as 45 years in 1942, 59 years in 1955-60, and 67 years in 1970-75
(Hong, 1978; Coale, et al., 1980). The total fertility rate (the sum of
age specific birth rates) peaked at 6.0 in 1960, and had fallen to
4.3 by 1971 (Coale, et al., 1980).

Because much of this decline in Korean fertility was accomplished by the
delay of marriage, our working samples of currently-married women with at

least one birth may not represent this phenomena fully. Fertility equations estimated for mothers less than age 30 should, therefore, be interpreted with this selection criteria in mind.[9]

4. Empirical Findings

Seven specifications of the fertility equation are estimated for each of six age groups of Korean mothers. Because of space limitations, Table 1 presents the full regression results for only the 30-34 age group.[10] However, the coefficient estimates for the mortality variables--r, r^2 and D--along with R^2's are reported in Table 2 for the other five age groups. In four of the specifications, (equations (1), (3), (5) and (7)), the dependent variable is observed cumulative fertility. Child mortality is specified in (1) by a quadratic function of the child mortality ratio, in (3) by a linear function of the child mortality ratio, and in (5) by a linear function of the number of children dead. Regression (7) is based on the same specifications as (5) but uses r as an instrument to obtain consistent estimates of the response of C to D*. Regressions (2), (4) and (6) have the same explanatory variables but employ Wallace's (1979) adjustment of fertility, subtracting from observed

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[9]There is no obvious reason why women who begin bearing children at an early age should be more or less likely than the average woman to replace deceased children. The mean age at first marriage for women had increased by 1971 to about 23 years, and therefore the composition of our samples of women 20-24 and even 25-29 is biased toward those that married and began childbearing at a relatively early age. But by age 30-34, relatively few Korean women remain single (1.3 percent in the 1970 Census) and 97 percent of the ever married women had one or more births. There is no obvious way to correct for this bias or judge its importance in a study of the reproductive replacement response to own-child mortality. Nonetheless, the expectational effect of the decline in mortality, if one exists, may be operating through the delay of marriage, and cannot be adequately assessed here.

[10]The complete set of regression results for the other five age groups is reported in Tables B-5 through B-9 in Appendix B.

Table 1
Alternative Specifications of Fertility—Child Mortality Regressions
Women Aged 30-34

	1) C		2) C*		3) C		4) C*		5) C		6) C**		7) C	
	b	t	b	t	b	t	b	t	b	t	b	t	b	t
Intercept	3.060	(10.54)	-.308	(-1.14)	3.118	(10.16)	-.308	(-1.14)	3.219	(11.24)	-.364	(-1.27)	3.171	(10.8)
DA1	.271	(2.51)	.225	(2.24)	.377	(3.31)	.226	(2.25)	.336	(3.14)	.336	(3.16)	.349	(3.21)
DA2	.559	(5.40)	.432	(4.47)	.606	(5.53)	.432	(4.48)	.548	(5.32)	.545	(5.33)	.579	(5.52)
DA3	.665	(6.33)	.558	(5.71)	.769	(6.96)	.559	(5.74)	.682	(6.60)	.684	(6.62)	.732	(6.91)
DA4	.963	(9.22)	.753	(7.75)	1.066	(9.69)	.754	(7.79)	.946	(9.18)	.942	(9.15)	1.008	(9.54)
DWEDZ	-.082	(-.90)	-.129	(-1.52)	-.082	(-.85)	-.129	(-1.52)	-.083	(-.93)	-.081	(-.91)	-.072	(-.84)
DWED69	-.376	(-3.28)	-.406	(-3.79)	-.429	(-3.53)	-.407	(-3.80)	-.387	(-3.41)	-.388	(-3.42)	-.422	(-3.63)
DWED912	-.410	(-2.67)	-.398	(-2.78)	-.579	(-3.58)	-.399	(-2.80)	-.513	(-3.40)	-.512	(-3.39)	-.534	(-3.45)
DWED12U	-.763	(-2.73)	-.709	(-2.73)	-.867	(-2.94)	-.709	(-2.73)	-.774	(-2.81)	-.776	(-2.82)	-.838	(-2.97)
DHEDZ	.137	(1.02)	.134	(1.07)	.158	(1.11)	.134	(1.07)	.143	(1.08)	.140	(1.06)	.142	(1.05)
DHED69	-.305	(-3.09)	-.139	(-1.52)	-.363	(-3.47)	-.140	(-1.53)	-.313	(-3.20)	-.317	(-3.24)	-.347	(3.47)
DHED912	-.411	(-4.16)	-.229	(-2.49)	-.425	(-4.06)	-.229	(-2.49)	-.377	(-3.86)	-.384	(-3.94)	-.419	(4.18)
DHED12U	-.485	(-3.40)	-.333	(-2.51)	-.469	(-3.12)	-.333	(-2.51)	-.410	(-2.92)	-.418	(-2.98)	-.480	(3.33)
r	5.597	(12.73)	.569	(1.39)	1.228	(5.28)	.527	(2.58)						
r^2	-7.956	(-11.47)	-.077	(-.12)										
D									.739	(14.02)	.196	(3.71)	.346	(5.52)
PBBSM1	-.102	(-.78)	-.182	(-1.50)	-.109	(-.79)	-.182	(-1.50)	-.139	(-1.09)	-.136	(-1.06)	-.105	(-.80)
PBBSM2	-.113	(-.88)	-.087	(-.72)	-.115	(-.85)	-.087	(-.72)	-.095	(-.75)	-.091	(-.72)	-.100	(-.77)
PBBSM3	-.155	(-1.56)	-.172	(-1.87)	-.142	(-1.35)	-.172	(-1.87)	-.138	(-1.41)	-.134	(-1.37)	-.136	(-1.36)
MICR	2.649	(1.75)	.595	(.42)	3.484	(2.18)	.603	(.43)	1.718	(1.15)	1.739	(1.16)	3.144	(2.05)
PPAGR	1.061	(2.27)	.903	(2.08)	.882	(1.79)	.901	(2.08)	.768	(1.67)	.739	(1.60)	.826	(1.75)
PPNAG	-.290	(-.42)	-.388	(-.61)	-.586	(-.81)	-.391	(-.61)	-.647	(-.95)	-.689	(-1.02)	-.627	(-.90)
R^2 (F)	.371		.223		.297		.223		.388		.274		(27.02)	

Note: DA1, DA2, DA3 and DA4 are dummy variables with suffixes denoting the deviation of the mother's age from the youngest age in the five-year-age-interval. For example, DA1 has a value 1 in age group 30-34 if the mother's age is 31. Small b refers to the regression coefficients and t to their t-statistics.

Table 2

Alternative Specifications of Fertility — Child Mortality Regressions

Selected Explanatory Variables	1) C b	1) C t	2) C* b	2) C* t	3) C b	3) C t	4) C* b	4) C* t	5) C b	5) C t	6) C** b	6) C** t	7) C b	7) C t
Women Aged 20-24														
r_2	3.152	(4.40)	-.971	(-1.40)	.058	(.29)	-.029	(- .15)						
r^2	-3.574	(-4.48)	1.089	(1.41)										
D									.303	(2.48)	-.075	(- .61)	.039	(.29)
R^2(F)	.296		.254		.258		.250		.270		.246		(6.93)	
Women Aged 25-29														
r_2	5.168	(11.52)	-.209	(-.48)	1.063	(5.30)	.149	(.81)						
r^2	-6.867	(-10.11)	.598	(.92)										
D									.735	(11.07)	.206	(3.11)	.412	(5.48)
R^2(F)	.343		.212		.275		.211		.337		.248		(20.89)	
Women Aged 35-39														
r_2	8.076	(14.75)	1.863	(3.73)	2.519	(8.31)	1.270	(4.89)						
r^2	-11.161	(-11.87)	-1.190	(-1.39)										
D									.876	(18.27)	.278	(5.79)	.514	(9.01)
R^2(F)	.365		.167		.277		.166		.418		.243		(24.46)	
Women Aged 40-44														
r_2	8.891	(10.63)	.136	(.18)	2.849	(7.36)	1.350	(4.11)						
r^2	-12.00	(-8.07)	2.411	(1.84)										
D									.816	(16.45)	.103	(2.09)	.460	(8.01)
R^2(F)	.311		.151		.251		.148		.409		.174		(15.92)	
Women Aged 45-49														
r_2	11.996	(11.30)	1.421	(1.56)	2.576	(4.98)	.977	(2.41)						
r^2	-15.293	(-9.91)	-.721	(-.55)										
D									.931	(16.41)	.060	(1.07)	.414	(5.57)
R^2(F)	.272		.084		.133		.083		.402		.101		(5.42)	

Note: All the independent variables as listed in Table 1 are included in the above regressions.

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cumulative fertility the expected value of fertility for each woman

conditional on the measure of her own child mortality that enters

the specific form of the fertility equation.

When actual fertility is regressed on the quadratic and linear

form of the child mortality ratio (compare regressions (1) and (3)), all

age groups display the nonlinear relationship noted by Williams (1976).

The derivative of fertility with respect to the own-child mortality

ratio increases initially and then decreases, reaching its maximum

when the child mortality ratio is approximately one-third.

But if the conditional dependence between fertility and the child

mortality ratio is removed, under our working assumptions, the remain-

ing association does not appear nonlinear.[11] The Korean data suggest

that the nonlinear response function found by Williams (1976) may

be accounted for by the spurious conditional dependence of fertility

on the nonlinear form of the child mortality ratio, as proposed by

Wallace (1979).

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[11] In the case of the sample aged 40-44, the squared child mortality
ratio receives a higher t statistic than the linear term of this
variable, but the simple linear specification is still preferable
on statistical grounds. The t values for the regression coefficients
of r and r^2 in regression (2) of Table 2 are the basis for concluding
that the quadratic specification is not supported by these data. However,
since r^2 is uniquely determined by r, the investigation of separate t
values for the two regression coefficients is not satisfactory. Another
approach is to calculate the statistical significance of the response, or
$dC*/dr = \beta + 2\lambda r$ where β is the regression coefficient on r. and λ is
the coefficient on r^2 in regression (2) of Table 2. The variance of this
response estimate is then Var $(\beta) + 4r$ Cov$(\beta, \lambda) + 4r^2$ Var (λ). Evaluating
this response (and its standard error), one obtains .56 (.33), 1.75 (.37),
.48 (.43) and 1.28 (.49) for the age groups 30-34, 35-39, 40-44, 45-49,
respectively. Only for ages 35-39 and 45-49 are the estimated responses
significantly different from zero at the 5 percent level; in the linear
specification they are all statistically significant after age 29.

The Wallace adjustment also reduces the association between (adjusted) fertility and the number of children dead in equation (6) by 70 to 94 percent for women over the age 24. The regression coefficient on the child mortality ratio in the adjusted fertility equation (4) is also markedly reduced, even though it should not be biased in the original specification (3). Although these adjusted fertility regression coefficients on the child mortality variable are biased downward, if the true replacement response is positive, they suggest a lower bound on the true value. The instrumental variable estimates of regression (7) are substantially larger than Wallace's estimates (6), but only about half the size of the direct estimates (5) that include the obvious spurious component.

Table 3 converts the seven estimated specifications of the fertility equation in Tables 1 and 2 and into comparable response derivatives of number of children born with respect to number of children dead, evaluated at the sample means, i.e., dC/dD. The direct estimates of the quadratic function in the child mortality ratio (1) imply implausibly large response values, in excess of 75 percent of full compensation for all age groups, i.e., dC/dD > .75. It seems unlikely that young mothers could exhibit such large replacement responses. The direct estimates of the linear function of the number of children dead (5) also imply large responses, increasing with age.

From regression (6) the potentially downward biased Wallace estimates of the response derivative range from about .2 from age 25 to 34, to .3 for age 35-39, dropping thereafter to .1. The unbiased instru-

Table 3

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Comparisons of Estimates of Response Derivative

from Different Regressions, namely, dC/dD

Derived from Regressions, Table 2	Age Group of Mothers					
	20-24	25-29	30-34	35-39	40-44	45-49
1) $C = f(r, r^2)$	1.788	1.690	1.056	1.081	.815	.756
2) $C^* = f(r, r^2)$	-.603	-.061	.146	.322	.138	,.167
3) $C = f(r)$	.038	.432	.317	.487	.453	.365
4) $C^* = f(r)$	-.019	.062	.138	.252	.222	.145
5) $C = f(D)$	.303	.735	.739	.876	.816	.931
6) $C^{**} = f(D)$	-.075	.206	.196	.278	.103	.060
7) $C = f(D^*)$	.039	.412	.346	.514	.460	.414

Note: Regressions (1) and (2): $C = \alpha + \beta r + \lambda r^2$; the derivative response, $dC/dD = (\beta + 2\lambda r)/(C + (\beta + 2\lambda r)r)$.
Regressions (3) and (4): $C = \alpha + \beta r$; the derivative response, $dC/dD = \beta/(C + \beta r)$.
Regressions (5),(6) and (7): $C = \alpha + \beta D$; the derivative response, $dC/dD = \beta$.

Table 4

Reduced Form Regressions of the Duration of Marriage Equation

by Age Group of Mothers

Selected Explanatory Variables	Age Group of Mothers						
	20-24	25-29	30-34	35-39	40-44	45-49	50-54
MICR	6.39 (1.78)	8.46 (2.61)	12.2 (3.70)	8.76 (2.98)	2.15 (.55)	8.47 (2.40)	14.6 (3.69)
r	-.194 (.39)	.851 (1.71)	.755 (1.58)	.329 (.68)	1.63 (3.06)	.513 (1.22)	-.0684 (.15)
R^2	.3061	.3654	.4646	.5432	.4619	.5271	.4938
Mean Dependent Variable	3.18	6.19	11.57	17.91	24.39	29.99	35.27
Mean Age at Marriage	19.3	21.3	20.9	19.6	18.1	17.5	17.3
Sample Size	397	1001	1132	1048	779	538	387

Note: All independent variables as listed in Table 1 are included in the regression above.

mental variable estimates of the response derivative from regression (7)
range from .35 to .51 for these age groups. The direct unbiased estimates
of regression (3) imply a similar range of from .32 to .49. Thus, the
specification choice between regression (3) and (7) does not affect
greatly the estimated response derivative, whereas the Wallace adjustment
appears to underestimate the response derivative in (6) and (2) where it
is appropriate, and in (4) where it is not.[12]

In evaluating how expectations of parents regarding child mortality might
influence their reproductive behavior, the strategy adopted here is to
add to the list of conditioning variables the current residential community's
child mortality ratio (MICR), calculated from a 1970 Census sample.
But the deficiencies of this approach are obvious; development has pro-
ceeded at different rates in different regions of Korea, stimulating
high rates of internal migration. Thus, for many parents, the current
residential area is not that which they confronted when they were first
married, when their mortality expectations may have had the strongest
independent effect on their reproductive behavior before their own
children experienced the risks of mortality. However, in the unbiased

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[12]Period specific replacement response rates have also been estimated by
sequential analyses of these data. An epidemiological study by Park, et al.
(1979) appraised the effect of infant deaths on subsequent fertility,
measured both as the length of closed birth intervals (CBI) after a birth
of a given order, and as the probability of a mother progressing to the next
birth order (PPB). Their direct analysis of PPB data suggests that the
survival status of the previous and penultimate birth is inversely associated
with the probability that a mother continues on to her next birth (Park et al.,
1979, Tables 6, 7, and 8). A procedure for combining their CBI and PPB response
estimates implies an overall replacement response, or dC/dD in our notation, of
.24 before 1955, rising .31 in 1955-64, to .53 in 1965-71. Comparisons between
these period response rates calculated from birth intervals and the cohort
response rates estimated here are unfortunately not possible, but magnitudes
are not dissimilar.

regressions on actual cumulative fertility, regression (3) Table 2, the

anticipated positive expectational response is evident only marginally for

women age 30 to 39.

Another approach for evaluating how mortality expectations might

influence fertility is to consider decisions that have a bearing on

fertility, but which occur before personal experience is gained of own-

child mortality and thus before replacement can occur. A study in

Taiwan found that the age at marriage across regions is closely asso-

ciated with the level of child mortality in that region and this pattern

was interpreted as consistent with the expectation hypothesis (Schultz, 1980).

To explore this possibility in Korea, Table 4 summarizes regressions of duration

of marriage on the same list of reduced-form explanatory variables included

in the fertility equation in Table 1.[13] Age at marriage is approximately the

mirror image of the duration of marriage within an age group as estimated

here. All of the regression coefficients on the community child mortality

ratio are positive, and all but one is significantly different from zero at

the five percent level. A change in the child mortality ratio as observed

between women age 45-49 and 30-34, or from .201 to .078, (Table A-1) would

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[13]Due to space limitation Table 4 reports coefficient estimates only for
the community and individual's child mortality rate variables. The co-
efficient estimates for other explanatory variables are reported in Table B-10
of Appendix B.

according to these regressions, be associated with a decrease of approximately one year in marriage duration. This effect represents about a third of the dramatic increase in age at marriage that actually occurred in Korea across these age cohorts. The individual's child mortality ratio may be interpreted in this context as a proxy for imperfect information that persons retain about their family-specific future health status; the regression coefficient on this individual variable (which is known with certainty only in the future) is significantly different from zero in only two out of the seven age groups of mothers, but in those instances it is positive (Table 4). These marriage duration regressions suggest that community level child mortality may influence the timing of marriage, probably through its effect on mortality expectations.

The other coefficients in the fertility equation are affected by the alternative specifications of child mortality,[14] even though modestly in many cases. The direct inclusion of the quadratic in the child mortality rate or the number of child deaths in previous research estimating fertility determination equations from household data may have produced biased estimates of the effect of other exogenous conditioning factors considered in those studies.

5. Conclusions

Household survey data on individuals are being used increasingly to estimate the preconditioning effects of personal and environmental

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[14] Given growing evidence of the association between own child mortality and mother's education, it was anticipated that the Wallace adjustment of fertility would reduce the partial association between this measure of fertility and the mother's education, by removing one way through which education is correlated with the parts of the expected value of fertility conditional on child mortality beyond its linear expansion.

variables. Among discrete demographic phenomena, however, empirical regu-
larities may represent spurious correlation in addition to causal asso-
ciation. This paper considered one such case, between a couple's inci-
dence of own child mortality and its cumulative lifetime fertility. The
problem arises because of the discrete nature of fertility and the condi-
tional effect of fertility on the frequency distribution of child deaths
and child death ratios.[15]

Our working hypothesis has been that child mortality is a random
variable whose expected value does not vary across women of the same age
with different numbers of children. The Korean data analyzed here are
internally consistent with this hypothesis for women age 40 to 49, but
for younger women a weak positive relationship is noted between r and C
across parity, which may suggest the need to reconsider this assumption
in subsequent work. If fertility is specified as a linear function of
the child mortality ratio, the fertility equation can be consistently esti-
mated directly, as shown in regression (3) of Table 2. If the correct
specification of the fertility equation is as a linear function of the
number of deceased children, then a consistent two-stage estimation pro-
cedure suggested by Olsen (1980) may be adopted, where the instrumental
variable is the child mortality ratio itself, r. Estimates of this
specification of the fertility equation are reported in regression (7).
In either specification the response derivative of fertility with

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[15] An analogous statistical-demographic problem arises in the inter-
pretation of a ratio measuring the proportion of children of one sex,
when it is treated as a conditioning variable in a fertility equation.
In this latter case of the sex ratio, a nonlinear response has also been
noted (Ben-Porath and Welch, 1972), and we would surmise that it also
embodies a spurious correlation as in the case dealt with here. DeTray
(1980) has also stressed the deficiency of this empirical specification
for measuring the strength of "son preference" from micro-demographic
regressions.

respect to child deaths is of about the same magnitude, ranging from .3

to .5, for the various five year age groups of women from age 20 to 49.

Alternatively, Wallace's (1979) procedure that adjusts fertility for the

spurious association between D and C and between a nonlinear function of

r and C implies estimates of the replacement response derivative that

are only half the size of those obtained by the two consistent methods.[16]

In addition to demonstrating the quantitative importance of the spurious

association problem for estimating from household data the fertility re-

placement response to own child mortality, we have also found that esti-

mates of the fertility effects of other conditioning variables may be

changed substantially by common errors in specifying the fertility

equation.

Either of the preferred specifications of the fertility equation

implies an estimate of the replacement response between one-third and

one-half. According to these estimates this fraction of the population

growth increasing effect of the decline in child mortality is offset by

the scaled down reproductive achievements of Korean parents. Although

this is only one of many factors behind the recent large reduction in

Korean fertility, it is far from negligible, and it might raise the priority

otherwise assigned to child health programs in a rapidly growing population.

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[16]Mauskopf and Wallace (1979) and Olsen (1930) indicate why this fer-
tility adjustment procedure should overcompensate for the spurious correla-
tion problem. Our empirical evidence confirms that this procedure can
underestimate substantially the replacement response derivative.

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Data Appendix Table A-1

Variable Definitions, Sample Means, and Standard Deviations:

Currently Married Korean Mothers, 1971*

Definition of Variable (and Symbol)	Age of Mother					
	20-24	25-29	30-34	35-39	40-44	45-49
Dependent Variables						
Children Ever Born (C)	1.51 (6.91)	2.40 (1.07)	3.78 (1.38)	4.93 (1.66)	5.88 (2.03)	6.54 (2.40)
Children Ever Born minus expected births given deaths $C** = C - E(C\|D)^1$	-.002 (.682)	-.003 (1.00)	-.003 (1.26)	-.001 (1.46)	.015 (1.72)	.043 (1.95)
Children Ever Born minus expected births given death ratio $C* = C - E(C\|r,r^2)^1$	-.008 (.650)	-.049 (.936)	-.062 (1.15)	-.046 (1.32)	.012 (1.62)	.182 (1.83)
Mortality Variables						
Number of Children Dead (C)	.063 (.263)	.158 (.430)	.337 (.633)	.541 (.857)	.951 (1.20)	1.42 (1.50)
Ratio of Children Dead to Born (r = D/C)	.037 (.162)	.052 (.147)	.078 (.152)	.096 (.149)	.144 (.170)	.201 (.200)
Community Child Death Ratio, all ages[2] (MICR)	.118 (.027)	.116 (.027)	.115 (.026)	.117 (.027)	.117 (.026)	.118 (.027)
Exogenous Variables						
*Mother's Schooling:**						
none (DHEDZ)	.093	.131	.229	.328	.476	.638
1-6 years (suppressed)	.557	.528	.517	.488	.406	.279
7-9 years (DWED69)	.199	.196	.134	.101	.064	.039
10-12 years (DWED912)	.131	.112	.102	.076	.045	.039
13+ years (DWED12U)	.020	.033	.019	.007	.009	.006
*Father's Schooling:**						
none (DHEDZ)	.035	.051	.081	.133	.259	.366
1-6 years (suppressed)	.345	.281	.319	.357	.358	.361
7-9 years (DHED69)	.229	.236	.191	.194	.169	.145
10-12 years (DHED912)	.290	.285	.258	.202	.140	.074
13+ years (DHED12U)	.101	.148	.151	.113	.073	.054
*Mother's Background:**[3]						
Urban (PBBSM1)	.171	.154	.152	.120	.073	.054
Town/Urban (PBSM2)	.108	.126	.102	.094	.090	.095
Village/Town (PBBSM3)	.249	.258	.229	.193	.194	.182
Village (suppressed)	.471	.463	.517	.593	.602	.610
Community Proportions:[2]						
Children age 14-19 in agricultural labor force (PPAGR)	.163 (.157)	.151 (.151)	.154 (.151)	.175 (.150)	.175 (.149)	.181 (.149)
Children age 14-19 in nonagricultural labor force (PPNAG)	1.75 (.109)	1.81 (.107)	1.78 (.106)	1.62 (.103)	1.63 (.101)	1.60 (.101)
Number of Women in Sample	397	1001	1132	1049	779	538

* Standard deviations are reported in parentheses beneath means, except for binary variables, such as categorical education and background variables, for which the standard deviation is $\sqrt{m(1-m)}$, where m is the relative frequency or mean of the binary variable.

[1] These transformations of the cumulative fertility variable for a woman are defined and discussed in the text. See also Wallace (1979).

[2] Community variables are derived from the public-use-file of the ten percent sample survey of the Korean Population Census of 1970. Of the 184 communities, the 1971 survey was clustered in 42: 7 wards (gu) in Seoul, 4 wards in Busan, 7 cities (shi) and 24 counties (gun). The child death ratio for women in age groups 25-29 to 45-49 are averaged to obtain the community child death ratio over all ages. The child labor force participation proportion is the average of the rates calculated in each community for girls and boys.

[3] Three regions are distinguished for each woman: birthplace, longest residence before and after marriage. According to the rural and village/town, city locations, the woman is allocated to one of the four urban-rural background categories. For further details see Lee, et al. (1978).

Mean Child Death Ratio, P,

and Frequency Distribution of Births, g(C), by Age Groups of Korean Mothers

	Age Group of Mothers
	20-24	25-29	30-34	35-39	40-44	45-49
P	.0417	.0657	.0894	.1099	.1617	.2171
g(1)	.5895	.2058	.0442	.0276	.0231	.0186
g(2)	.3224	.3716	.1245	.0390	.0281	.0390
g(3)	.0755	.2768	.2606	.1163	.0719	.0669
g(4)	.0127	.1129	.2880	.2069	.1245	.0781
g(5)		.0290	.1838	.2469	.1566	.1059
g(6)		.0020	.0707	.2173	.2041	.1468
g(7)		.0010	.0221	.0858	.1849	.1989
g(8)		.0	.0053	.0420	.1220	.1375
g(9)		.0010	.0	.0114	.0424	.1208
g(10)			.0010	.0057	.0347	.0428
g(11)				.0010	.0064	.0297
g(12)					.0013	.0074
g(13)						.0056
g(14)						.0019
total	1.000	1.000	1.000	1.000	1.000	1.000

Table B-2

Calculated Values of $E(D|C)$ for Korean Mothers Age 20-24,

For Whom Child Death Probability is .0417

Number of Child Deaths, D	Number of Children Ever Born, C			
	1	2	3	4
0	.9583	.9183	.880	.8433
1	.0417	.0799	.1149	.1468
2		.0017	.0049	.0094
3			.00007	.0003
4				.000003

Expected Number of Children Born, $E(C|D)$,
Conditional on the Number of Child Deaths, by Mother's Age Group

Number of Child Deaths, D	Age Group of Mothers					
	20-24	25-29	30-34	35-39	40-44	45-49
0	1.471	2.328	3.601	4.608	5.147	5.122
1	1.799	2.771	4.108	5.201	5.966	6.239
2	2.585	3.466	4.601	5.774	6.677	7.174
3		4.364	5.298	6.370	7.321	7.936
4			6.038	7.040	7.989	8.635
5			6.923	7.789	8.573	9.348
6				8.572	9.191	10.10
7					9.772	10.90
8						11.67

Expected Number of Children Born, $E(C|r)$,

Conditional on the Child Mortality Ratio, by Mother's Age Group

	Age Group of Mother			
$r = D/C$	20-24	25-29	30-34	35-39
0	1.4915	2.3282	3.6021	4.5778
1/10				10.0
1/9				9.0
1/8			8.0	8.0
1/7			7.0	7.0
1/6			6.0	6.0
1/5		5.0	5.0137	5.0709
1/4	4.0	4.0	4.0342	4.3965
3/11				11.0
2/7			7.0	7.0
3/10				10.0
1/3	3.0	3.0082	3.2741	4.3984
3/8				8.0
2/5		5.0	5.0031	5.0206
3/7		7.0	7.0	7.0
4/9				9.0
1/2	2.0094	2.1067	2.8015	3.7490
5/9				9.0
4/7				7.0
3/5			5.0	5.0
5/8			8.0	
2/3		3.0005		
3/4			4.0003	
4/5			5.0	
1	1.0227	1.1162	1.2769	1.2406

Table B-5

Alternative Specifications of Fertility -- Child Mortality Regressions
Women Aged 20-24

Explanatory Variables	1) C		2) C*		3) C		4) C*		5) C		6) C**		7) C	
	b	t	b	t	b	t	b	t	b	t	b	t	b	t
Intercept	1.240	(4.35)	-.192	(- .70)	1.244	(4.25)	-.193	(- .70)	1.156	(3.98)	-.353	(-1.21)	1.242	(4.24)
DA1	.066	(.44)	.116	(.80)	.018	(.12)	.130	(.90)	.038	(.25)	.031	(.21)	.019	(/13)
DA2	.268	(1.97)	.291	(2.21)	.223	(1.60)	.304	(2.31)	.201	(1.46)	.192	(1.39)	.224	(1.61)
DA3	.411	(3.20)	.440	(3.53)	.416	(3.15)	.439	(3.52)	.412	(3.15)	.411	(3.14)	.416	(3.16)
DA4	.515	(4.14)	.552	(4.58)	.499	(3.91)	.557	(4.62)	.496	(3.92)	.496	(3.91)	.500	(3.93)
DWEDZ	.513	(4.31)	.553	(4.80)	.478	(3.92)	.564	(4.90)	.462	(3.99)	.467	(3.83)	.478	(3.93)
DWED69	-.268	(-2.85)	-.272	(-2.98)	-.283	(-2.93)	-.267	(-2.93)	-.271	(-2.83)	-.275	(-2.87)	-.283	(-.294)
DWED912	-.349	(-2.63)	-.357	(-2.78)	-.361	(-2.65)	-.353	(-2.75)	-.355	(-2.63)	-.358	(-2.65)	-.361	(-2.66)
DWED12U	-.269	(- .99)	-.281	(-1.08)	-.284	(-1.02)	-.277	(-1.06)	-.269	(-1.02)	-.263	(-1.02)	-.284	(-1.03)
DHEDZ	.209	(1.11)	-.013	(- .07)	.384	(2.04)	-.066	(- .37)	.324	(1.72)	.351	(1.86)	.379	(2.00)
DHED69	-.129	(-1.45)	-.141	(-1.63)	-.142	(-1.55)	-.137	(-1.59)	-.131	(-1.45)	-.131	(-1.44)	-.141	(-1.55)
DHED912	.009	(.10)	.008	(.08)	none	none	.010	(.11)	.020	(.20)	.019	(.19)	.000	(.00)
DHED12U	-.134	(- .83)	-.131	(- .84)	-.138	(- .84)	-.130	(- .84)	-.121	(- .74)	-.123	(- .75)	-.137	(-.84)
r	3.152	(4.40)	-.971	(-1.40)	.058	(.29)	-.029	(- .15)						
r2	-3.574	(-4.48)	1.089	(1.41)										
D									.303	(2.48)	-.075	(- .61)	.039	(.29)
PBBSM1	-.129	(-1.05)	-.136	(-1.14)	-.171	(-1.35)	-.123	(-1.04)	-.167	(-1.34)	-.164	(-1.31)	-.169	(-1.35)
PBBSM2	-.132	(-1.07)	-.139	(-1.17)	-.183	(-1.46)	-.124	(-1.04)	-.185	(-1.48)	-.181	(-1.45)	-.181	(-1.45)
PBBSM3	-.124	(-1.25)	-.107	(-1.12)	-.146	(-1.44)	-.100	(-1.05)	-.154	(-1.54)	-.148	(-1.47)	-.144	(-1.43)
MICR	-.209	(- .15)	-.421	(- .31)	.429	(.30)	-.615	(- .45)	.506	(.36)	.621	(.44)	.420	(.29)
PPAGR	.081	(.18)	-.113	(- .27)	-.095	(- .21)	-.060	(- .14)	.029	(.07)	.042	(.10)	-.089	(-.20)
PPNAG	.341	(.51)	.159	(.25)	.389	(.57)	.144	(.22)	.595	(.88)	.625	(.92)	.390	(.57)
R^2 (F)	.296		.254		.258		.250		.270		.246		(6.93)	

Note: DA1, DA2, DA3 and DA4 are dummy variables with suffixes denoting the deviation of the mother's age
from the youngest age in the five-year-age-interval. For example, DA1 has a value 1 in age group 20-24
if the mother's age is 21.

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TABLE 8-6

Alternative Specifications of Fertility -- Child Mortality Regressions
Women Aged 25-29

	Dependent Variables												
	1) C		2) C*		3) C		4) C*		5) C		6) C**		7)C	
	b	t	b	t	b	t	b	t	b	t	b	t	b	t
Intercept	2.057	(8.30)	-.232	(-.97)	2.034	(7.81)	-.230	(-.96)	2.085	(8.38)	-.230	(-.92)	2.058	(8.17)
DA1	.126	(1.36)	.114	(1.28)	.114	(1.17)	.115	(1.29)	.114	(1.22)	.111	(1.19)	.111	(1.18)
DA2	.258	(2.84)	.273	(3.13)	.269	(2.83)	.272	(3.12)	.253	(2.78)	.248	(2.72)	.258	(2.80)
DA3	.578	(6.25)	.510	(5.74)	.575	(5.92)	.510	(5.74)	.556	(5.99)	.554	(5.96)	.566	(6.01)
DA4	.863	(9.54)	.731	(8.41)	.913	(9.62)	.727	(8.38)	.826	(9.06)	.823	(9.02)	.880	(9.52)
DWEDZ	.034	(.37)	.001	(.01)	.025	(.26)	.002	(.26)	.033	(.35)	.042	(.45)	.035	(.37)
DWED69	-.217	(-2.48)	-.224	(-2.67)	-.249	(-2.71)	-.221	(-2.64)	-.229	(-2.60)	-.227	(-2.59)	-.238	(-2.67)
DWED912	-.195	(-1.51)	-.216	(-1.74)	-.237	(-1.74)	-.213	(-1.71)	-.240	(-1.86)	-.236	(-1.81)	-.221	(-1.68)
DWED12U	-.460	(-2.35)	-.465	(-2.47)	-.533	(-2.60)	-.458	(-2.44)	-.501	(-2.55)	-.502	(-2.56)	-.516	(-2.60)
DHEDZ	.318	(2.28)	.169	(1.26)	.319	(2.18)	.169	(1.26)	.245	(1.75)	.228	(1.62)	.288	(2.03)
DHED69	-.266	(-3.35)	-.284	(-3.72)	-.280	(-3.36)	-.282	(-3.70)	-.285	(-3.57)	-.286	(-3.58)	-.282	(-3.49)
DHED912	-.337	(-3.80)	-.353	(-4.15)	-.356	(-3.83)	-.352	(-4.13)	-.343	(-3.85)	-.346	(-3.88)	-.356	(-3.96)
DHED12U	-.376	(-2.86)	-.364	(-2.88)	-.347	(-2.51)	-.366	(-2.90)	-.343	(-2.59)	-.344	(-2.60)	-.354	(-2.64)
r	5.168	(11.52)	-.209	(-.48)	1.063	(5.30)	.149	(.81)						
r^2	-6.867	(-10.11)	.598	(.92)										
D									.735	(11.07)	.206	(3.11)	.412	(5.48)
PBBSM1	-.117	(-1.10)	-.095	(-.93)	-.091	(- .81)	-.098	(- .96)	-.070	(- .65)	-.075	(- .70)	-.102	(-.95)
PBBSM2	-.075	(- .74)	-.080	(-.82)	-.086	(- .80)	-.079	(-.81)	-.061	(- .60)	-.065	(- .64)	-.088	(-.85)
PBBSM3	-.056	(- .68)	-.041	(-.52)	-.039	(- .45)	-.043	(-.54)	-.033	(- .40)	-.036	(- .43)	-.047	(-.56)
MICR	.705	(.56)	.773	(.64)	1.497	(1.14)	.704	(.59)	.904	(.72)	.895	(.71)	1.322	(1.04)
PPAGR	.661	(1.70)	.512	(1.37)	.627	(1.54)	.515	(1.38)	.548	(1.41)	.533	(1.37)	.596	(1.51)
PPNAG	-.054	(- .09)	-.017	(-.03)	-.151	(- .24)	-.009	(-.02)	-.246	(- .41)	-.245	(- .41)	-.125	(-.21)
R^2 (F)	.343		.212		.275		.211		.337		.248		(20.89)	

Table B-7

Alternative Specifications of Fertility -- Child Mortality Regressions
Women Aged 35-39

	Dependent Variables													
	1) C		2) C*		3) C		4) C*		5) C		6) C**		7) C	
	b	t	b	t	b	t	b	t	b	t	b	t	b	t
Intercept	3.195	(9.16)	-1.023	(-3.21)	3.310	(8.90)	-1.011	(-3.17)	3.447	(10.35)	-1.154	(-3.46)	3.472	(10.1)
DA1	.203	(1.56)	.247	(2.07)	.290	(2.09)	.256	(2.15)	.226	(1.82)	.225	(1.81)	.265	(2.07)
DA2	.362	(2.88)	.258	(2.24)	.511	(3.82)	.274	(2.39)	.434	(3.62)	.435	(3.63)	.465	(3.77)
DA3	.416	(3.01)	.273	(2.16)	.615	(4.21)	.294	(2.35)	.464	(3.53)	.468	(3.56)	.549	(4.06)
DA4	.691	(5.34)	.441	(3.73)	.844	(6.15)	.457	(3.89)	.689	(5.57)	.692	(5.60)	.779	(6.12)
DWEDZ	.207	(1.96)	.054	(.56)	.267	(2.37)	.060	(.62)	.149	(1.47)	.147	(1.45)	.421	(2.12)
DWED69	-.508	(- 3.24)	-.472	(- 3.30)	-.552	(-3.30)	-.477	(-3.33)	-.487	(-3.25)	-.488	(-3.26)	-.514	(-3.33)
DWED912	-.502	(- 2.30)	-.661	(- 3.32)	-.511	(-2.20)	-.662	(-3.33)	-.498	(-2.39)	-.499	(-2.39)	-.525	(-2.45)
DWED12U	-.090	(- .16)	-.382	(- .76)	-.106	(- .18)	-.384	(- .76)	-.091	(- .17)	-.093	(- .18)	-.164	(-.30)
DHEDZ	.201	(1.43)	.076	(.59)	.295	(1.96)	.086	(.67)	.251	(1.86)	.255	(1.89)	.261	(1.89)
DHED69	-.054	(- .44)	-.084	(- .75)	.006	(.04)	-.077	(- .69)	.047	(.41)	.047	(.41)	-.012	(-.09)
DHED912	-.164	(- 1.29)	-.031	(- .27)	-.125	(- .93)	-.027	(- .23)	-.106	(- .88)	-.104	(- .86)	-.137	(-1.10)
DHED12U	-.202	(- 1.06)	-.039	(- .23)	-.172	(- .84)	-.036	(- .21)	-.063	(- .34)	-.064	(- .35)	-.165	(-.88)
$\dot{r}$	8.076	(14.75)	1.863	(3.73)	2.519	(8.31)	1.270	(4.89)						
r^2	-11.161	(-11.87)	-1.190	(- 1.39)										
D									.876	(18.27)	.278	(5.79)	.514	(9.01)
PBBSM1	-.392	(- 2.32)	-.275	(- 1.79)	-.508	(-2.83)	-.287	(-1.87)	-.381	(-2.36)	-.380	(-2.36)	-.428	(-2.59)
PBBSM2	-.388	(- 2.33)	-.328	(- 2.16)	-.430	(-2.42)	-.332	(-2.19)	-.313	(-1.97)	-.314	(-1.97)	-.385	(-2.35)
PBBSM3	-.226	(- 1.79)	-.164	(- 1.42)	-.277	(-2.06)	-.170	(-1.47)	-.195	(-1.61)	-.195	(-1.61)	-.243	(-1.95)
MICR	3.141	(1.81)	1.279	(.81)	3.058	(1.65)	1.270	(.80)	1.688	(1.01)	1.669	(1.00)	2.477	(1.45)
PPAGR	2.729	(4.72)	2.141	(4.06)	2.607	(4.23)	2.128	(4.03)	2.397	(4.34)	2.390	(4.32)	2.442	(4.30)
PPNAG	2.001	(2.26)	1.649	(2.04)	1.778	(1.88)	1.625	(2.01)	1.055	(1.24)	1.044	(1.23)	1.401	(1.61)
R^2 (F)	.365		.167		.277		.166		.418		.243		(24.46)	

Table B-8

Alternative Specifications of Fertility -- Child Mortality Regressions

Women Aged 40-44

	1) C		2) C		3) C		4) C*		5) C		6) C**		7) C	
	b	t	b	t	b	t	b	t	b	t	b	t	b	t
Intercept	4.670	(8.63)	-.367	(-.77)	5.089	(9.08)	-.451	(-.95)	5.149	(10.34)	-.066	(-.13)	5.173	(10.1)
DA1	.097	(.52)	-.001	(-.0)	.028	(.14)	.013	(.08)	-.012	(-.07)	-.001	(-.01)	.010	(.05)
DA2	.223	(1.15)	.225	(1.32)	.228	(1.13)	.224	(1.31)	.232	(1.30)	.234	(1.31)	.229	(1.24)
DA3	.488	(2.47)	.281	(1.62)	.401	(1.95)	.298	(1.72)	.390	(2.14)	.396	(2.17)	.414	(2.20)
DA4	.342	(1.78)	.202	(1.20)	.337	(1.69)	.203	(1.20)	.348	(1.96)	.344	(1.94)	.353	(1.92)
DWEDZ	.424	(2.66)	.177	(1.26)	.393	(2.36)	.184	(1.30)	.321	(2.17)	.321	(2.17)	.369	(2.42)
DWED69	.047	(.17)	-.068	(-.27)	.107	(.36)	-.080	(-.32)	.114	(.44)	.115	(.44)	.070	(.26)
DWED912	-.993	(-2.71)	-.795	(-2.47)	-.965	(-2.53)	-.800	(-2.48)	-.898	(-2.65)	-.891	(-2.63)	-.939	(-2.68)
DWED12U	-.975	(-1.38)	-.952	(-1.53)	-1.054	(-1.43)	-.936	(-1.50)	-.917	(-1.40)	-.897	(-1.37)	-1.032	(-1.53)
DHEDZ	.105	(.62)	.245	(1.64)	.141	(.80)	.238	(1.59)	.067	(.43)	.067	(.43)	.118	(.729)
DHED69	-.371	(-1.94)	-.193	(-1.14)	-.436	(-2.18)	-.180	(-1.06)	-.302	(-1.70)	-.294	(-1.65)	-.401	(-2.18)
DHED912	-.308	(-1.41)	-.197	(-1.02)	-.429	(-1.89)	-.172	(-.90)	-.204	(-1.01)	-.195	(-.97)	-.385	(-1.85)
DHED12U	-.136	(-.43)	-.040	(-.14)	-.258	(-.78)	-.016	(-.06)	-.062	(-.21)	-.047	(-.16)	-.244	(-.80)
r_2	8.891	(10.63)	.136	(.18)	2.849	(7.36)	1.350	(4.11)						
r^2	-12.00	(-8.07)	2.411	(1.84)										
D									.816	(16.45)	.103	(2.09)	.460	(8.01)
PBBSM1	-.043	(-.17)	.019	(.09)	-.168	(-.64)	.044	(.20)	-.096	(-.41)	-.092	(-.40)	-.108	(-.45)
PBBSM2	-.464	(-1.82)	-.133	(-.59)	-.449	(-1.69)	-.136	(-.60)	-.362	(-1.54)	-.367	(-1.56)	-.368	(-1.51)
PBBSM3	-.419	(-2.16)	-.137	(-.80)	-.435	(-2.15)	-.134	(-.78)	-.420	(-2.35)	-.421	(-2.35)	-.385	(-2.08)
MICR	.373	(.14)	-1.100	(-.46)	-.407	(-.14)	-.943	(-.39)	-3.194	(-1.27)	-3.003	(-1.19)	-1.268	(-.48)
PPAGR	1.987	(2.30)	1.746	(2.30)	2.192	(2.44)	1.705	(2.24)	1.960	(2.46)	1.932	(2.42)	2.129	(2.58)
PPNAG	-.076	(- .06)	-.414	(-.36)	-.108	(-.08)	-.408	(-.36)	-.661	(-.55)	-.665	(-.55)	-.229	(.19)
R^2 (F)	.311		.151		.251		.148		.409		.174		(15.92)	

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Table B-9

Alternative Specifications of Fertility -- Child Mortality Regressions
Women Aged 45-49

	1) C b	1) C t	2) C* b	2) C* t	3) C b	3) C t	4) C* b	4) C* t	5) C b	5) C t	6) C** b	6) C** t	7) C b	7) C t
Intercept	6.318	(7.92)	.673	(.99)	7.521	(8.75)	.730	(1.08)	7.214	(10.11)	1.991	(2.80)	7.322	(9.53)
DA1	-.082	(-.30)	-.002	(-.01)	.071	(.24)	.006	(.02)	.186	(.75)	-.137	(.55)	.093	(.35)
DA2	-.046	(-.16)	-.302	(-1.25)	.052	(.17)	-.297	(-1.24)	.154	(.61)	.132	(.52)	.043	(.16)
DA3	.165	(.56)	-.255	(-1.01)	.229	(.71)	-.252	(-1.00)	.254	(.95)	.209	(.79)	.228	(.80)
DA4	-.226	(-.80)	-.303	(-1.26)	-.160	(-.52)	-.300	(-1.25)	-.387	(-1.53)	-.430	(-1.70)	-.156	(-.57)
DWEDZ	.245	(1.01)	.395	(1.91)	.186	(.71)	.392	(1.90)	-.059	(-.27)	-.070	(- .32)	.188	(.80)
DWED69	.055	(.11)	.133	(.30)	.019	(.03)	.131	(.30)	-.078	(-.17)	-.100	(- .22)	.045	(.09)
DWED912	-.004	(-.01)	.168	(.36)	-.015	(-.02)	.167	(.36)	-.059	(-.12)	-.062	(- .13)	-.031	(-.06)
DWED12U	-.888	(-.70)	-.603	(-.56)	-.683	(-.50)	-.594	(-.55)	-.718	(-.63)	-.798	(- .70)	-.657	(-.53)
DHEDZ	-.393	(-1.75)	-.300	(-1.57)	-.423	(-1.73)	-.301	(-1.57)	-.478	(-2.36)	-.489	(-2.42)	-.409	(-1.87)
DHED69	-1.206	(-3.99)	-.582	(-2.25)	-1.278	(-3.88)	-.585	(-2.26)	-1.088	(-3.98)	-1.121	(-4.11)	-1.138	(-3.86)
DHED912	-.341	(-.85)	.108	(.32)	-.303	(-.69)	.110	(.32)	-.224	(-.62)	-.239	(- .66)	.273	(-.69)
DHED12U	-.973	(-1.99)	-.509	(-1.22)	-1.236	(-2.32)	-.521	(-1.25)	-.802	(-1.81)	-.798	(-1.81)	1.093	(-2.29)
r_2	11.996	(11.30)	1.421	(1.56)	2.576	(4.98)	.977	(2.41)						
r	-15.293	(-9.91)	-.721	(-.55)										
D									.931	(16.41)	.060	(1.07)	.414	(5.57)
PBBSM1	-.435	(-1.13)	-.317	(-.96)	-.451	(-1.07)	-.317	(-.96)	-.212	(-.61)	-.230	(- .66)	-.344	(-.91)
PBBSM2	-.192	(-.54)	-.158	(-.52)	-.248	(-.64)	-.160	(-.53)	-.280	(-.88)	-.270	(- .85)	-.229	(-.66)
PBBSM3	-.832	(-2.83)	-.463	(-1.84)	-1.034	(-3.23)	-.472	(-1.88)	-.790	(-2.98)	-.798	(-3.01)	-.891	(-3.12)
MICR	-1.854	(-.47)	-1.052	(-.31)	-3.377	(-.78)	-1.124	(-.33)	-5.778	(-1.61)	-5.593	(-1.56)	-3.423	(-.88)
PPAGR	-.360	(-.28)	-.292	(-.27)	-1.131	(-.81)	-.328	(-.30)	-1.012	(-.87)	-1.107	(- .96)	-.819	(-.66)
PPNAG	-1.078	(-.56)	-1.822	(-1.11)	-2.173	(-1.04)	-1.874	(-1.15)	-3.269	(-1.89)	-3.247	(-1.88)	2.174	(1.17)
R^2 (F)	.272		.084		.133		.083		.402		.101		(5.42)	

Table B-10

Reduced Form Regressions of the Duration of Marriage Equation

by Age Group of Mothers

Explanatory Variables[a]	Age Group of Mothers						
	20–24	25–29	30–34	35–39	40–44	45–49	50 54
MICR	6.39 (1.78)	8.46 (2.61)	12.2 (3.70)	8.76 (2.98)	2.15 (.55)	8.47 (2.40)	14.6 (3.60)
r	-.194 (.39)	.851 (1.71)	.755 (1.58)	.329 (.68)	1.63 (3.06)	.513 (1.22)	-.0684 (.15)
DA1	.247 (.64)	.499 (2.06)	1.11 (4.72)	1.84 (8.35)	1.31 (4.90)	1.29 (5.31)	1.31 (5.06)
DA2	.811 (2.33)	1.11 (4.70)	2.19 (9.73)	2.92 (13.8)	2.28 (8.27)	1.49 (5.97)	1.78 (6.38)
DA3	1.32 (3.99)	1.76 (7.34)	3.21 (14.1)	4.28 (18.5)	3.84 (13.6)	2.57 (9.87)	3.25 (11.8)
DA4	2.02 (6.33)	3.28 (13.9)	4.41 (19.5)	5.51 (25.3)	4.66 (17.0)	4.10 (16.5)	3.93 (13.1)
DWED2	.931 (3.05)	.844 (3.52)	.324 (1.63)	.441 (2.46)	.491 (2.15)	.773 (3.61)	-.0052 (.02)
DWED69	-.567 (2.34)	-.753 (3.31)	-.720 (2.88)	-.527 (1.99)	-.182 (.45)	.089 (.19)	-.246 (.31)
DWED912	-.570 (1.67)	-.658 (1.95)	-1.94 (5.83)	-1.36 (3.68)	-1.20 (2.29)	-1.23 (2.55)	-1.69 (2.11)
DWED12U	-.958 (1.38)	-1.78 (3.50)	-2.83 (4.66)	-.644 (.69)	-3.25 (3.22)	-5.98 (5.35)	-3.24 (2.43)
DHED2	1.24 (2.63)	.224 (.62)	.479 (1.64)	.603 (2.53)	.485 (2.01)	.480 (2.42)	.535 (2.49)
DHED69	-.496 (2.18)	-.725 (3.50)	-.658 (3.05)	-.571 (2.77)	-.467 (1.71)	-.449 (1.67)	-.342 (.95)
DHED912	-.358 (1.42)	-.950 (4.12)	-1.04 (4.82)	-.874 (4.08)	-.892 (2.87)	-.015 (.04)	-.220 (.53)
DHED12U	-.802 (1.95)	1.53 (4.47)	-1.14 (3.67)	-1.61 (4.97)	-.754 (1.66)	-.788 (1.82)	-.358 (.63)
PBBSM1	-.241 (.76)	-.105 (.38)	.400 (1.41)	-.849 (2.98)	-1.14 (3.19)	-1.08 (3.16)	-.228 (.52)
PBBSM2	-.540 (1.71)	-.363 (1.37)	.723 (2.59)	-1.27 (-4.52)	-.803 (2.21)	-.843 (2.69)	-.556 (1.05)
PBBSM3	-.458 (1.80)	-.346 (1.61)	-.406 (1.89)	-.156 (.73)	-.949 (3.42)	-.248 (.95)	-.0691 (.21)
PPAGR	-1.06 (.95)	1.41 (1.39)	-.185 (.18)	.238 (.24)	.518 (.42)	-.352 (.31)	2.15 (1.71)
PPNAG	.979 (.57)	1.51 (.98)	-1.23 (.82)	-.167 (.11)	-2.38 (1.29)	1.32 (.78)	2.64 (1.33)
Intercept	1.72	4.23	9.13	14.70	21.51	26.71	30.92
R^2	.3061	.3654	.4646	.5432	.4619	.5271	.4938
Mean Dependent Variable	3.18	6.19	11.57	17.91	24.39	29.99	35.27
Mean Age- at Marriage	19.3	21.3	20.9	19.6	18.1	17.5	17.3
Sample Size	397	1001	1132	1048	779	538	387

[a] See Table A-1 and note to Table B-5 for variable definitions.