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Schooling, Information and Non-Market Productivity: Contraceptive Use and Its Effectiveness

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SCHOOLING, INFORMATION AND NON-MARKET PRODUCTIVITY: CONTRACEPTIVE USE AND ITS EFFECTIVENESS

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Abstract

While the effects of schooling on market earnings have been well documented, the evidence on the returns to schooling in the nonmarket sector, particularly in activities associated with the household, is less clear. In this paper the technology associated with human reproduction is estimated to examine the influence of schooling on productivity in this household activity. Our results imply that schooling enhances couples' abilities (i) to decipher information about household inputs which require careful use and for which there is relatively little information and (ii) to learn about their own biological capacities or fecundity. In particular, we found that more educated couples were both more likely to know how to use and able to use more efficiently so called "ineffective" contraceptive methods than were less schooled couples, but the more educated did not obtain substantially higher efficiency compared to the less educated from contraceptives prescribed and/or installed by medical doctors, such as the pill or IUD, for which there is little scope for misuse. Moreover, our evidence indicated, based on estimates of couples' differing biological propensities to conceive and their contraceptive choice behavior, that more educated couples were better able than less educated couples to perceive these reproductive propensities, for which the market provides little direct information.

As a consequence of these different information skills associated with schooling, a difference in fecundity of one standard deviation among college graduates was associated with a difference of .7 unplanned conceptions, whereas a similar difference in fecundity among wives who were grade school graduates led to almost twice as large a difference in unplanned conceptions (1.3). The superior ability of the more educated couples to perceive their biological capacities to bear children and their wider knowledge of contraceptive methods helps explain why, despite the greater variability in their exposure to the risk of conception via marriage, the variability in the completed family size of more educated couples is less than that of similar couples with less schooling.

Our results suggest that the returns to schooling investment may be understated when such returns are measured in terms of only market outcomes. Moreover, in accord with studies of the returns to schooling and extension services in agriculture, we find that schooling and birth control information-dissemination programs are clearly substitutes, in the sense that the least-educated couples may gain the most from such programs.

Among the most widely observed empirical regularities are the positive associations between the schooling attainment of parents and their contraceptive knowledge and use, their demand for child health care, and measures of their children's health and survival (e.g., Michael (1973a, 1973b, 1982); Edwards and Grossman (1979); Cochrane, et al. (1982), Rosenzweig and Schultz (1982)). These patterns, evident in many countries of the world, suggest that schooling may be an important factor influencing nonmarket production processes associated with fertility and child health.[1] Economists have hypothesized that education has two potential roles in production (Welch, 1970)—(i) Schooling enhances the productivity of production inputs in use, and (ii) schooling lowers the cost or increases the efficiency of information acquisition, thereby improving the static and dynamic allocation of inputs, given prices and wages. When the productivity effects of education accrue within the non-market sector, and the household's output is "consumed" directly by the couple, tastes or preferences of the decision-makers are also relevant to production decisions, unlike in the market sector. Consequently, education may be assumed to modify fertility and child health investments merely by inducing a systematic change in tastes, holding constant prices, income and technology (Easterlin, Pollak and Wachter (1980)). To disentangle the potential efficiency, input allocation, and taste effects of education on household production therefore requires the identification of the household's production technology (Rosenzweig and Schultz (1983)). Insufficient information on this technology has slowed progress toward understanding precisely how education affects demographic outcomes (Michael (1982)).

Data enabling estimation of the technology characterizing nonmarket processes, however, are not sufficient to quantify the efficiency roles of schooling in nonmarket production. If schooling contributes to nonmarket efficiency, the technology and/or the environment in which those production processes take place must be such that there is scope for productivity variation. If all relevant information on input use and allocation has been disseminated completely across all agents, differences in schooling levels will have little relevance to the technologically-determined variability in non-market outputs. Rosenzweig and Schultz (1981), for example, could find no differences across mothers grouped by schooling in the effectiveness of prenatal medical care in influencing their child's birthweight or gestation. In this case, the inputs associated with prenatal medical care were presumably allocated under the advice of trained and specialized information providers, advice which may have effectively substituted for any information held by agents.

Schooling, to the extent that it improves skills in acquiring information, should exhibit its highest payoff in nonmarket activities where information is not readily available. Agent-specific information is least likely to be provided by the market. Differences across agents in biological endowments relevant to household production activities, such as inherent susceptibility to infection or propensity to conceive, are likely to be important determinants of the distribution of household outcomes. But this source of variation in such outcomes as child health and fertility will have a smaller impact among those agents who are better informed about their specific characteristics, as long as such technological or biological traits are uncorrelated with preferences.

In this paper we estimate the effects of schooling on the productivity of household inputs associated with the production of births (or conceptions) and on the abilities of couples to decode information on their individual inherent propensities to conceive based on their own fertility experience.[2] The reproduction process is a good candidate for the exploration of the nonmarket productivity effects of schooling, as the inputs used, i.e., contraceptives, are well-defined, interhousehold differences in the effectiveness in use of contraceptives are well-documented by demographers (Westoff and Ryder (1977)), and there appears to be significant inter-couple biological variability in underlying propensities to bear children given input allocations (Rosenzweig and Schultz (1985)). In particular, we test the hypotheses that (i) more schooled couples are able to use contraceptives more effectively than less schooled couples, (ii) schooling-related differences in contraceptive effectiveness will be greater for those contraceptives that are not prescribed or installed by health professionals, and (iii) more schooled couples are more able than less schooled couples to lessen the effects of biological traits or constraints on their fertility.

Economists have examined theoretically and empirically the association between schooling and contraceptive choice (Michael (1973), Michael and Willis (1975), Rosenzweig and Seiver (1982)). In these studies attention was principally paid to the hypothesis that more-educated couples would be more likely to adopt the new "superior" contraceptive technologies (circa 1960-70) because of schooling-induced information advantages. However, the absence of estimates of the reproductive technology prevented separation of the distinct potential effects of schooling on preferences for the timing of fertility and on the use-effectiveness of the techniques, and barred exploration of the interrelationships among schooling, fecundity and fertility.

Our hypothesis concerning how schooling augments the use-effectiveness of contraceptives not provided by professionals relative to that of the medically-provided techniques such as the pill, IUD, or diaphragm has implications (i) for the patterns of fertility as they have evolved over the past decades in the United States, (ii) for the distribution of the benefits from family planning programs, and (iii) for differences in fertility patterns by schooling. The first hypothesis implies that as information on the contraceptive pill and IUD becomes increasingly diffused, differences in levels of completed fertility should narrow, as fewer couples need to rely on the more variably-effective contraceptive methods, for which the more-educated have an advantage; the less-educated thus benefit more from family planning information dissemination, as we have found in Colombia (Rosenzweig and Schultz (1982)) and was hypothesized in earlier studies (Nelson, et al. (1970), Schultz (1971)).[3] Our second hypothesis concerning the effects of schooling on skills in deciphering couple-specific fertility experience implies that variability in fertility within schooling groups should decline with schooling attainment, given the independence of schooling and variability in fecundity.

Table 1 reports fertility levels and measures of fertility variability along with similar statistics for marital duration for four (female) schooling groups based on a probability sample of U.S. white women aged 40 to 48 in

Table 1

Levels and Variability of Fertility and Marriage Duration by Schooling Level, White

Once and Currently Married Fecund Women Aged 40 to 48 in 1975

Schooling Level (Sample size)	Mean Children-Ever-Born	Standard Deviation Children-Ever-Born	Coeff. of Var. Children-Ever-Born	Mean Marital Duration	Coeff. of Var. Marital Duration
Less than 12 years (n=73)	3.34	1.75	.523	22.3	.084
High school graduate (n=254)	3.37	1.72	.511	21.6	.097
Less than 16 years (n=99)	3.28	1.57	.477	21.3	.109
College graduate (n=89)	3.10	1.43	.461	20.3	.132

Source: 1975 National Fertility Survey

1975, from the 1975 National Fertility Survey (NFS), who were in intact marriages and had married only once by 1975. While fertility levels decline with schooling, the differences in mean levels of fertility by schooling are considerably narrower than those for similarly-aged white women in 1960 (Willis (1973)), when the pill and IUD were not widely available. What is most striking in Table 1, however, is the decline in the variability of fertility with schooling attainment, despite the marked rise in the variability of marital duration, and thus in the exposure to the risk of conception, with schooling. While the coefficient of variation for marital duration rises by over fifty percent from the lowest to the highest schooling group, the standard deviation of completed fertility declines by thirteen percent and the corresponding coefficient of variation declines by three percent.

Of course there are many possible explanations for the patterns displayed in Table 1; as noted, estimates of the reproduction technology are necessary to test precisely the schooling efficiency hypotheses. In Part 1 of the paper, we briefly set out an illustrative dynamic model of fertility and contraceptive choice incorporating the reproductive technology, heterogeneity in fecundity, information acquisition and uncertainty. The model is used to illustrate the problems associated with identifying the efficiency effects of schooling and in identifying the parameters of the birth technology given stochastic fecundity and optimizing behavior. In Part 2 the birth production function is estimated, based on couples' histories of conceptions, contraceptive use, and pregnancies from the 1975 NSF and location-specific price data. We use the estimates to measure the effects of schooling on the efficiency of different sets of contraceptive methods. These estimates of the birth technology are supplemented with estimates of the associations between subjective reports by women of their knowledge of the different methods, based on data from the 1973 National Survey of Family Growth. Both sets of estimates support the hypothesis that more schooled women and men use the so-called "less effective" contraceptive methods more efficiently than less schooled women or men and have greater knowledge of how they work, but there are no significant differences by schooling attainment in the effectiveness of the medically-prescribed methods or in rudimentary knowledge about them.

The estimates of couple-specific fecundity obtained using the parameter-estimates describing the reproductive technology are related in Part 3 to subjective reports by respondents of births they associate with contraceptive failures. Differences in the influence on these failures, or "excess fer-ility," of our measured fecundity variable by schooling attainment, conditional on endogenously-determined fertility plans, are estimated, as are the differences in the influence of fecundity by schooling level on the selection of contraceptive methods. Both estimates support the hypothesis that, given their desired fertility plans, more educated couples reduce the influence of biological constraints on their actual fertility; they thus exhibit significantly less variability as a group in "excess fertility" and in actual fertility than do less educated couples. Part 4 contains a summary and conclusions.

1. Fertility Control Choice, Information Acquisition and the Supply of Births

To specify concretely the interrelationships among the technology describing reproduction, the efficiency effects of schooling, information acquisition, and variability in technolgy and preferences, we consider a simple linear representation of the fertility technology in which there is only one form of fertility control. If the number of births to couple j in period i is N_{ij}, Z_{ij} are the resources devoted to fertility control, μ_j is the couple-specific, exogenously-given and time-invariant propensity to conceive (fecundity), and γ reflects period-effects, then

(1) $$N_{ij} = \mu_j + \varepsilon_{ij} + \gamma(i)_j - \beta_{ij}Z_{ij} ,$$

where we assume that ε_{ij} is an independently-distributed serially uncorrelated disturbance. β_j, which measures the degree to which given fertility control resources Z_{ij} reduce fertility (contraceptive "effectiveness"), is also specific to the couple, a function of its stock of information Λ_j; i.e.,

(2) $$\Lambda_j = \Lambda(e_j, \Omega) ,$$

and

(3) $$\beta_j = \delta\Lambda_j$$

where Ω is information freely available, e is education of the couple and if schooling increases information acquisition and the returns to information investments are lower the greater the amount of freely available information Ω, $\Lambda_e, \Lambda_\Omega > 0$, and $\Lambda_{\Omega e} < 0$.

Equations (1), (2) and (3) describe the couple-specific technological "supply" function of births (Rosenzweig and Schultz (1985)) and the technical efficiency effects of schooling and "public information" in reproduction.[4] The demand for births N_{ij} and thus the derived demand for contraceptive resources Z_{ij} depend on how the couple values fertility, its cumulated "stock" of children M_{ij} $(= \sum_t^i N_{tj})$, and other goods X_{ij}, on its resource constraints, and on the couple's information on the best use of contraceptive resources, as in (2), and on its own fecundity μ_j.

To see how schooling affects the demand for fertility control via the contraceptive efficiency effects embodied in equations (1) and (2) and through its role in improving the couple's knowledge about its own fecundity, assume that in each period of its reproductive life the couple maximizes the expected value of an intertemporally separable, linear-quadratic utility function. The parent's problem in period s, suppressing the j subscript, is

$$(4) \quad \max E \left[\sum_{i=s} \rho^{i-1} U_i \right]$$

where

$$(5) \quad U_i = \alpha_1 N_i - 0.5\, \alpha_2 N_i^2 + \alpha_3 M_i - 0.5\, \alpha_4 M_i^2 + \alpha_5 X_i - 0.5\, \alpha_6 X_i^2 ,$$

and $\alpha_1, \ldots, \alpha_6 > 0$, subject to the within-period budget constraint,

$$(6) \quad F_i = pZ_i + X_i + cM_i ,$$

where F_i = full income in period i, p is the fertility control cost and c is the cost per child.

The couple chooses in each period whether to use fertility control. The couple knows the outcomes of its past contraceptive decisions and the technologies of both birth production, in (1), and contraceptive effectiveness, from (2), but it does not know the fertility it will experience in each future period, although it may know the persistent component of fecundity .

While in dynamic problems such as (4) through (6) it is not generally feasible to derive analytically the decisions rules in each period, illustrative comparative statics can be performed for the final-period decisions, when the impact of current decisions on future decisions is irrelevant. The decision whether or not to use fertility control in the last period depends in that case only on the difference in final-period expected utilities associated with the two choices. Letting this difference be denoted as J_T^Z, the effect of a change in schooling level on the differential, where $J_T^Z>0$ indicates use of control, is:

$$\frac{dJ_T^Z}{de} = [-\alpha_1 + \alpha_2(\mu-\beta) - \alpha_3 + \alpha_4 (M_{T-1} + \mu-\beta) + \alpha_5 c$$

$$- \alpha_6 c (F - p - c(M_{T-1} + \mu-\beta))] \delta\Lambda_e \tag{7}$$

$$= \{c\frac{\partial E(U_T|Z_T=1)}{\partial X_T} - [\frac{\partial E(U_T|Z_T=1)}{\partial N_T} + \frac{\partial E(U_T|Z_T=1)}{\partial M_T}]\} \delta\Lambda_e .$$

As can be seen, whether or not more schooled couples are more likely to use fertility control in a particular life-cycle period, when schooling augments contraceptive efficiency, depends on the difference between the expected marginal utility of goods relative to the sum of the expected marginal utilities of fertility and children given that control is chosen. The patterns of <u>prior</u> fertility as well as preferences thus interact with the technological parameter $\delta\Lambda_e$ such that the relationship between schooling and the demand for contraceptives cannot be signed.

Differences in contraceptive demand behavior across schooling groups, the focus of prior studies, are thus not very revealing about the effects of schooling on contraceptive use-effectiveness. Indeed, it is not possible to identify the sign or magnitude of the technological relationship between schooling and contraceptive effectiveness from the observed contraceptive choices of different schooling groups at a given life cycle point, if patterns of income or preferences differ by schooling. Given the difficulty of estimating or controlling for unobservables associated with preferences, estimation of the technical parameter β_j by schooling group is therefore a preferable empirical research strategy to estimation of approximations to decision rules.

Estimation of the parameters describing the effects of contraceptive inputs and of other endogenous and exogenous observables (parity and age) on fertility is made difficult by the presence of the couple-specific fecundity term. Variation in the unobserved persistent components of the biological supply of births across couples, given behavior in accord with a model will be associated with inter-couple variation in contraceptive selection (Rosenzweig and Schultz (1985)) leading to biases in estimates of the effectiveness of contraceptives.

If such biases can be circumvented, however, estimates of β and γ combined with couples' contraceptive and fertility histories allow the measurement of couple-specific fecundity. Such estimates can be used to test the hypothesis that more educated couples are more knowledgeable than less educated couples about their own biological capacity to bear children. In particular, the responsiveness of contraceptive selection to fecundity variation will differ depending on how the forces generating the histories of birth outcomes net of contraceptive choices are attributed by the couple to purely random events and how much to their own persistent component of fertility supply, or fecundity.

To see how information about fecundity is reflected in contraceptive behavior, assume that educated couples are able to extract perfectly their own fecundity from their fertility experience. Among these couples, those with higher fecundity will be more likely to use fertillity control in the last period, as,

$$(8) \quad \frac{dJ_T^Z}{d\mu} = \beta[\alpha_2 + \alpha_4(1 + \frac{dM_{T-1}}{d\mu})] - \alpha_6 \ (p-\beta c) > 0 \quad ,$$

as long as the cost of control p is less than the expected cost of an averted child βc. Couples with higher fecundity are more likely to choose to control fertility both because they will have more children at the beginning of the period and because they can expect more children, net of control, in the future period.

Among couples totally uninformed about the persistence of their fecundity, the more fecund will still be more likely to contracept than the less fecund, because of their larger numbers of cumulated births. Because they assume that their future births are no more likely to be more numerous (or more likely) than other couples, however, they are less likely than the more informed (schooled) among the highly-fecund to contracept. For them,

$$(9) \quad \frac{dJ_T^Z}{d\mu} = \beta \ \alpha_4 \ (1 + \frac{dM_{T-1}}{d\mu}) - \alpha_6 \ (p-\beta c) > 0 \ .$$

The differential in the response of the probabilities of contracepting to higher fecundity, (8) minus (9), is $\beta\alpha_2$, which corresponds to the lower expected utility from an additional birth for the couple that anticipates higher future fertility net of control.

Of course, while the responses of fertility control to fecundity variation are signed by the theory, since expressions (8) and (9) contain in them the parameters describing preferences, observed differentials in such responses by schooling may be due to differences in preferences across schooling groups rather than, or in addition to, differences in informational skills. Tests of the information efficiency hypothesis based on fecundity-contraception associations must also attempt to account for preference differentials, as we do below.

Finally, we have assumed that the stock of contraceptive information held by the couple is exogenously-determined, solely a function of its schooling and the exogenously-determined information sources Ω in (3). If information is obtained jointly with the consumption of other goods--from reading newspapers or other periodicals, for example--the couple's knowledge Λ_j and thus β_j, will not be independent of its preferences. Indeed, couples may "optimally" allocate resources to information acquisition. Identification of the technology of reproduction is made more difficult in these cases as the "parameters" of the household technology will reflect preferences.[5] We test for the relationship between preferences and contraceptive knowledge below by including husband's income as a determinant of β_j and by examining the relationship between income, the demand for children and contraceptive knowledge.

2. Data and Estimation of Contraceptive Use-Effectiveness by Schooling and Method

a. Specification of the Reproductive Technology and Data

To estimate how schooling directly affects contraceptive effectiveness and to identify the couple-specific components of fertility supply, we substitute the efficiency and information equations (2) and (3) into the reproduction function (1), and use time-aggregated information on couples' contraceptive usage, pregnancies and conceptions. Aggregated over s reproductive periods and allowing multiple types of contraceptive methods Z_k, each of which is used in f_k of those periods, the equation we estimate is given by:

$$(10) \qquad n_j = \mu_j + \sum_{i=1}^{s} \frac{\varepsilon_{ij}}{s} + \gamma A_j - \sum_k (\beta_k + \delta_k e_j) z_{kj} ,$$

where $z_{kj} = f_{kj}/s$, $n_j = \sum_{i=1} N_{ij}/s$ = conception rate, and A = entry age in the period. Specification (10) assumes that the exogenous sources of method-specific information Ω are identical across all couples and are subsumed in the common method-specific slope term δ_k. These sources of information may differ across methods (but not across couples) such that, as hypothesized, the influence of schooling on contraceptive effectiveness may differ both across methods and across couples with different schooling.

A problem in estimating (10), as noted, is that z_{kj}, the fraction of the aggregated period the couple uses a specific fertility control method, will be correlated with the within-period shocks to fertility-supply ε_{ij} and to fecundity μ_j, which are unobserved, from (9). However, the z_{kj}, reflecting the couple's demand for children, will also be a function of prices, preferences and income, as noted. The usual set of fertility demand variables may thus serve as instruments for the contraceptive choice variables, as long as they are orthogonal to fecundity and to the random supply shock, and consistent estimates of the technological parameters can be obtained from (10).[6] We also assume initially that the personal characteristics of the couple influencing the demand for children, other than schooling, do not affect their information about contraception and thus do not enter directly in (3) or (10).

Data are drawn from a longitudinal sample of women from the 1970 National

Fertility Survey (NFS) who were reinterviewed in 1975. The 1970 sample was a national representative sample of ever-married women born since July 1, 1925. Two thousand three hundred sixty-one women of the original 1970 sample were reïnterviewed in 1975. Their selection was based on being in intact first marriages (for both spouses), where the wife's age at marriage was less than 25, and the duration of the marriage was less than twenty years at the time of the first interview in 1970. Only white couples were included in the 1970-1975 panel. A description of the 1970 NFS and an outline of the design of the 1975 resurvey are presented in Westoff and Ryder (1975).

The survey obtained a month-by-month calendar of contraceptive use, by technique, pregnancies, pregnancy outcomes and intercourse behavior of the couple (abstinence or not) from the 1970 to the interview date in 1975, as well as socioeconomic information in both 1970 and 1975. The residential location of the couples in 1970, which is assumed relevant for reproduction in the period, is also available.[7] Based on this latter information, a series of variables were appended to the micro data to describe the state or SMSA in which each couple resides, including local prices, labor market characteristics, and measures of the availability of public health and family planning services.

The dependent variable measuring fertility is the number of conceptions occurring between the interview dates divided by the months of exposure to the risk of conception, namely, the months in which the wife was not pregnant and/or in which the couple was not abstaining from intercourse. Equation (10) includes four fertility control variables, constructed based on the monthly calendar information: the proportions of the total exposure period between

1970 and 1975 (during which the woman was subject to the risk of conception) that the couple was (1) sterilized, (2) using the pill or IUD, (3) using the diaphragm or condom, (4) using only "ineffective" techniques (foam, jelly, rhythm, etc.).[8] The grouping of contraceptive methods is based on standard conventions and beliefs on the relative average effectiveness of such methods in the U.S. population (Vaughan, Trussell and Menken, (1977), Westoff and Ryder, (1977), Bongaarts and Potter (1983)).

Also included in the reproduction function as endogenous determinants of fecundity are the number of children born by 1970 and the couple's monthly frequency of intercourse. The monthly frequency of intercourse is reported in 1970 and 1975, and the average is assumed to apply uniformly throughout the period of exposure. Months of abstinence from intercourse during ther five-year period, as noted, are excluded from the period at risk.[9]

The set of instruments characterizing the couple's tastes, opportunities, and constraints is extensive; information is employed on the personal characteristics of the couples that were thought to be exogenous with respect to the fertility decision. These include, in addition to the schooling variables and the wife's age, the husband's earnings (not that of the wife's) and the husband's and wife's religious affiliation, and features of the residential area that influence employment opportunities and thus the relative costs of children and other goods, including medical and family planning infrastructure and services, and local sales taxes and prices (see Table 2 for full list).

The final sample with complete reproductive histories and sets of characteristics for couples who were capable of conceiving at the 1970

Table 2

Variable Definitions and Sample Characteristics: 1970-75 NFS

Variable	Definition	Mean	Standard Deviation
Endogenous Variables			
Average monthly conception rate, 1970-75.	Ratio of conceptions to the number of months of pregnancy risk (exposure period).[a]	.0128	.0181
Sterilization	Proportion of exposure period protected by sterilization.	.155	.277
Pill or IUD	Proportion of exposure period using the pill or IUD.	.408	.397
Diaphragm or condom	Proportion of exposure period using the diaphragm or condom.	.146	.304
Ineffective methods	Proportion of exposure period using jelly, foam, douche, withdrawal, rhythm or combinations of these methods.	.132	.281
Coital frequency	Average monthly coital frequency, 1970 and 1975.	8.65	4.91
Intended births, 1970	Number of additional children intended in 1970.	.768	1.06
Excess fertility	Number of pregnancies occuring earlier than desired and/or when no more children were wanted.	1.63	1.42
Exogenous Individual Characteristics			
Schooling-wife	Years of schooling completed by the wife.	12.7	2.00
Schooling-husband	Years of schooling completed by the husband.	13.2	2.53
Age	Age of wife in months in 1970.	329	69.3
Husband's income - 1970	Husband's earned income before taxes in 1970.	9420	3820
μ-fecundity	Actual conception rate of the couple minus the couple's predicted conception rate based on the couple's actual use of contraceptives averaged over the periods 1970-1972.5, 1972.5-1975.	.000460	.0188
Husband Protestant		.100	.241
Husband Catholic		.276	.200
Husband Jewish		.0169	.0166
Husband Morman		.0304	.0295

Table 2, continued

Exogenous Area Characteristics[b]			
Local family planning	Per-capita number of hospitals with family planning departments in 1969, at state of SMSA level ($x10^5$).	.286	.462
Health expenditures	Per-capita local government health and hospital expenditures in 1965 in thousands of dollars, at state of SMSA levels ($x10^2$).	.294	.119
Female unemployment rate	Proportion of women in labor force in 1970 aged 15-59 unemployed, at state level.	.0510	.00978
Population per M.D.	Number of persons per medical doctor, 1969, at state or SMSA level.	1630	1030
Obstetricians/ gynecologists	Per-capita number of obstetricians, gynecologists, at state of SMSA level ($x10^4$).	.755	.687
Hospital beds	Per-capita number of hospital beds, 1965, at state level ($x10^2$).	.480	.111
Metropolitan	= 1 if SMSA.	.538	.499
City size	Population in SMSA in 1970 ($x10^{-3}$).	1280	2460
Share of jobs in services	Percent of persons employed in services, 1970, at state levels (x10).	75.5	18.0
Share of jobs in sales	Percent of persons employed in sales, 1970, at state level (x10).	167	61.8
Share of jobs in government	Percent of persons employed in government, 1970, at state level (x10).	167	61.8

a. The period of exposure approximates the number of months between the two interviews that the woman is exposed to the risk of conception. Those months are excluded during which the couple abstains from intercourse and in which the woman is pregnant. The average period of exposure for the sample is 62 months, and if abstinent months were included, the average period of exposure would be increased by 1.3 percent.

b. Sources of the area characteristics are described in Rosenzweig and Schultz(1983). Where both state and SMSA characteristics are used, those individuals residing in an SMSA are attributed the characteristics for that SMSA, and those residing outside the SMSA are attributed the average characteristic for their state.

interview date contains 1753 couples. The average age of the wife was 27.4 years in 1970, and ranges from 15 to 42; the couples had on average 1.9 children in 1970 and had 2.5 children by the second interview in 1975. Descriptive statistics for the NFS sample and variable definitions are reported in Table 2.

Because the exposure period is relatively short--a maximum of five years--and the overall demand for children among U.S. couples is low, a large proportion of the sample had no conceptions (53 percent). As a consequence, we employ two-stage maximum likelihood tobit. To test the robustness of our results to the normality assumptions imposed by the tobit procedure, we also employ two-stage least squares in a linear specification. For the latter, we use the White (1980) heteroscedasticity procedure to eliminate the inconsistency in the coefficient standard errors caused by the concentration of the dependent variables at the zero value.

b. Estimates of Method-Specific Contraceptive Use-Effectiveness

Table 3 reports the two-stage tobit and the heteroscedasticity-corrected-two stage least squares (2SLS) estimates of variants of the specification of the reproductive technology given by (10). In the first column, the schooling of the wife is included as a linear variable. The schooling coefficient sign indicates that couples in which the wife is more educated have higher fertility when not using contraceptives, suggesting that the more educated may be better able to increase fertility when higher fertility is desired. Use of each of the contraceptives groups, however, appears to reduce the conception rate, with sterilization reducing the rate the most and the condon/diaphragm

Table 3

Two-Stage Tobit and Heteroscedasticity-Corrected Two-Stage Least Squares Estimates of the Reproductive Technology: Schooling, Income and Contraceptive Use-Effectiveness

Estimation method Variable:	ML Two-Stage Tobit (1)	(2)	(3)	Corrected-2SLS[a] (4)	(5)
Proportion of exposure period protected by:					
Sterilization[b]	-.0538	-.0604	-.0676	-.0521	-.0568
	(2.44)[c]	(2.64)	(2.34)	(4.31)	(4.02)
Pill or IUD[b]	-.0397	.231	.235	.116	.101
	(2.29)	(1.95)	(1.14)	(1.54)	(1.08)
Pill/IUD × schooling[b]	-	-.0218	-.0228	-.0129	-.0111
		(2.31)	(1.34)	(2.01)	(1.32)
Pill/IUD × income[b] ($X10^{-5}$)	-	-	.183	-	-0.465
			(0.42)		(0.20)
Diaphragm or condom[b]	-.0335	.270	.264	.0650	.0880
	(1.76)	(1.24)	(1.16)	(0.55)	(0.70)
Dia./Cond. × schooling[b]	-	-.0232	-.0344	-.00732	-.0152
		(1.47)	(1.65)	(0.84)	(1.26)
Dia./cond. × income[b] ($X10^{-4}$)	-	-	.104	-	.0501
			(0.98)		(1.01)
Ineffective methods[b]	-.0344	.494	.704	.206	.275
	(1.31)	(2.51)	(2.75)	(2.04)	(2.07)
Ineff. × schooling[b]	-	-.0412	-.0489	-.0208	-.0305
		(2.65)	(1.86)	(2.55)	(2.08)
Ineff. × income[b] ($X10^{-5}$)	-	-	-.613	-	-.590
			(0.37)		(0.72)
Age ($X10^{-3}$)	-.270	-.295	-.292	-.128	-.113
	(6.07)	(6.58)	(5.50)	(5.20)	(3.85)
Coital frequency[b] ($X10^{-4}$)	2.63	.451	1.52	1.85	9.23
	(0.19)	(0.03)	(0.07)	(0.24)	(0.74)
Wife's schooling	.00172	.0192	.0224	.00978	.0113
	(3.81)	(3.26)	(2.63)	(2.43)	(2.27)
Husband/s income ($X10^{-5}$)	-	-	-.142	-	-.127
			(0.36)		(0.67)
Intercept	.102	-.112	-.144	-.0276	-.0477
	(4.39)	(1.41)	(1.33)	(0.57)	(0.83)
Sigma	.0270	.0269	.0269	-	-
lnlikelihood	1320.1	1324.9	1326.2	-	-

a. Corrected for heteroscedasticity (White, 1978). Breush-Pagan test indicates heteroscedasticity (chi-square, .01 level).

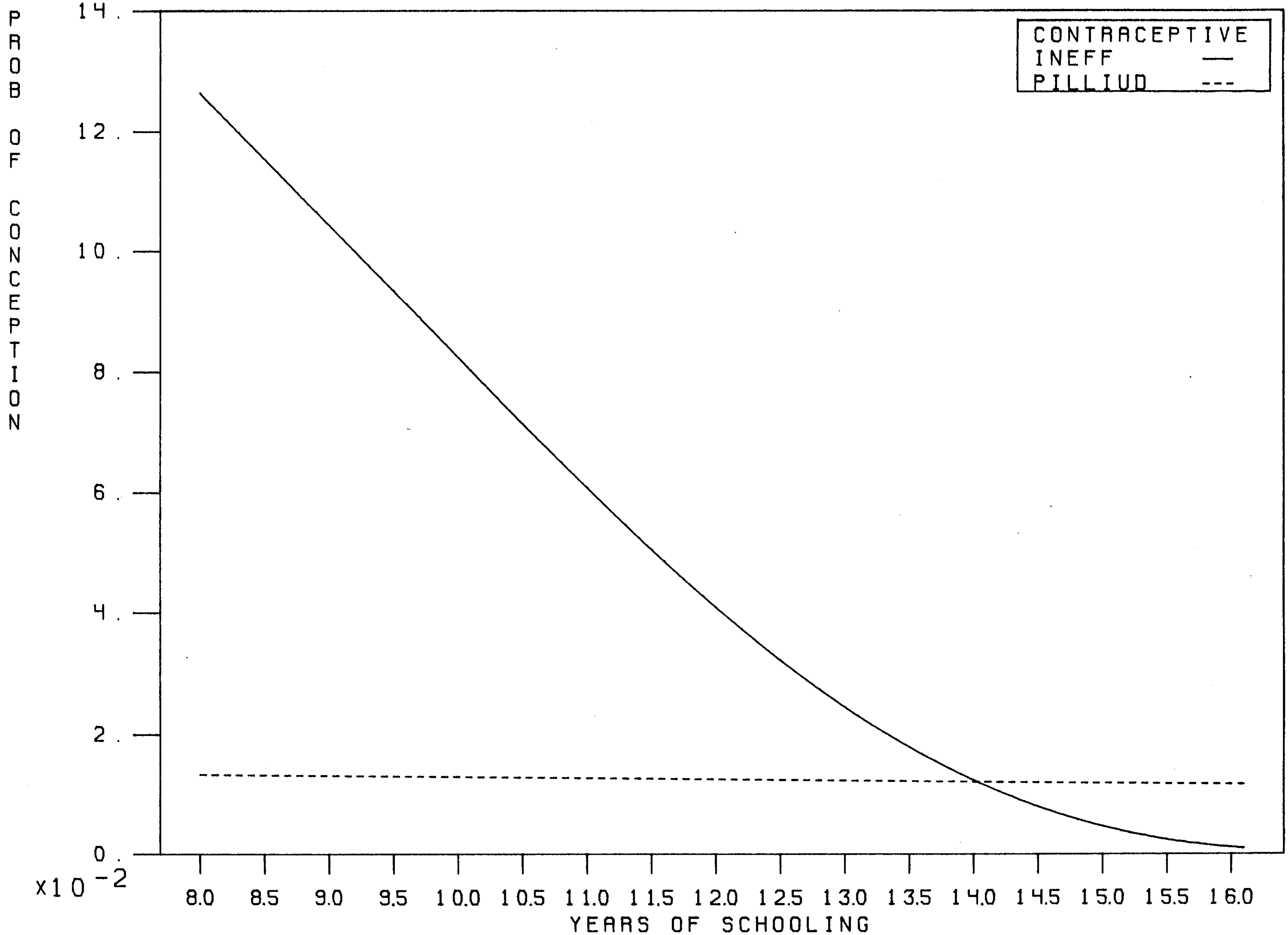
b. Endogenous variable.

c. Absolute values of asymptotic t-ratios in parentheses.

and ineffective methods, on average across couples, the least. Coital frequency has the expected sign, but its effect on the conception rate is trivial.

According to the interactive specification involving the wife's schooling in column (2), use-effectiveness increases with wife's schooling. Moreover, the effectiveness of the "ineffective" methods appears to vary most with the schooling of the wife, while that of the pill/IUD varies least. These findings are consistent with the widespread dissemination of information about the more effective techniques and suggest that this information is delivered relatively uniformly across schooling groups by health professionals, with less need for individual agents to decode instructions or interpret circumstances surrounding their use. Figure 1 depicts how conception rates associated with the pill/IUD and ineffective methods vary with the wife's schooling, based on the tobit estimates of column (2) of Table 3. As can be seen, while the conception rate for the pill/IUD at the mean schooling level of the wife, 12.7 years, is lower than that associated with the use of ineffective methods, this differential in effectiveness disappears among women with more than 14 years of schooling. On the other hand, the conception rate associated with the use of the pill or IUD is less than one-quarter that associated with the use of ineffective methods among women with 10 years of schooling. Similar patterns obtain for the husband's schooling (not reported): schooling differentials in the use-effectiveness of the pill/IUD are less than those for the ineffective methods, but the differentials are smaller.

In column (3) we test the hypothesis that (husband's) income also



PROB OF CONCEPTION
14.
12.
10.
8.
6.
4.
2.
0.
x10 -2
CONTRACEPTIVE
INEFF
PILLIUD
8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0
YEARS OF SCHOOLING

affects, directly or indirectly, contraceptive use-effectiveness by interacting the three contraception groups with husband's income. The addition of these terms does not importantly alter the magnitudes and ordering of the schooling effects on contraception effectiveness; moreover, while income does not appear to increase use-effectiveness for either the pill/IUD or condom/diaphragm, it does appear to augment the effectiveness of the ineffective techniques.

The heteroscedasticity-corrected two-stage least squares estimates of the reproductive technology, in columns (4) and (5), generally replicate the tobit results--the increase in contraceptive effectiveness with the wife's schooling is more than 1.6 times higher for the ineffective techniques than for the pill/IUD. However, in these estimates, schooling does not appear to significantly affect the efficiency of the condom or diaphragm methods. The results also reject the hypothesis that husband's income influences the use-effectiveness of any of the contraceptive methods. Skills in information acquisition, associated with schooling, rather than the demand for information or for goods incidentally providing information, associated with income, therefore appear to be important in determining differences among couples in contraceptive use-effectiveness.

c. Contraceptive Knowledge, Schooling and the Demand for Children

While the results obtained from the direct estimates of the birth supply technology conform to the hypothesis that more educated couples are able to use more effectively contraceptive methods for which information is less available, it is possible that the estimates are an artifact of the linear specification of the technology or result from the more educated caring more about fertility "mistakes." Indeed, although our two-stage procedure is designed to separate out preferences from technology, as noted, information acquisition concerning contraceptives may in part reflect the demand for children. If so, all variables relevant to demand, not just income and schooling, should in principle be included in the reproduction function as determinants of the β_{kj}.

The 1973 National Survey of Family Growth NSFG ascertained from a probability sample of ever-married U.S. women of childbearing age in 1973 information on the women's knowledge about how specific contraceptives were used, as well as socioeconomic and demographic information, similar to that in the 1970-75 NFS. In Table 4, we present two-stage estimates of the determinants of the total number of methods that the women understood how to use (out of 18), and the probability that each of eight major methods was understood by her, including withdrawal, the rhythm temperature method (T), the rhythm calendar method (C), condom, diaphragm, foam, IUD, and the contraceptive pill. In order to test the hypothesis that the demand for children influences contraceptive knowledge, we also included in these equations the total birth intentions of the women as an endogenous variable, in addition to the schooling attainment of the husband and wife, the wife's age and the husband's income and religious affiliation.

The results in Table 4 concerning differentials by schooling in method specific use-knowledge are consistent with our findings concerning schooling differentials in use-effectiveness based on estimates of the reproduction function--the positive associations between the wife's schooling and the

Table 4

Determinants of Method-Specific Contraceptive Knowledge

Dependent variable:	Total Methods Understood[a] TSLS	Withdrawal Probit	Rhythm(T) Probit	Rhythm(C) Probit	Condom Probit	Diaphragm Probit	Foam Probit	IUD Probit	Pill Probit
Mean of Dependent Variable	13.1	.854	.793	.843	.961	.852	.869	.834	.987
Schooling-Wife	.522	.260	.262	.265	.0807	.118	.0767	.0848	.145
	(2.86)[b]	(3.36)	(3.64)	(3.53)	(0.69)	(1.51)	(0.96)	(1.11)	(0.86)
Schooling-Husband	.231	.0926	.118	.101	.0666	.0649	.0794	.0345	.0863
	(4.87)	(4.55)	(6.12)	(5.06)	(2.22)	(3.17)	(3.77)	(1.74)	(2.06)
Income-Husband ($x10^{-4}$)	.293	.205	.242	.222	.172	.0691	.0984	.106	.183
	(2.48)	(3.20)	(4.23)	(3.63)	(1.77)	(1.16)	(1.59)	(1.80)	(1.27)
Birth Intentions[a]	1.61	1.05	1.26	1.26	-.0916	-.152	-.0910	-.580	.578
	(1.03)	(1.60)	(2.05)	(1.96)	(0.09)	(0.23)	(0.13)	(0.88)	(0.40)
Age of Wife ($x10^{-2}$)	.706	.985	.576	.485	-.543	-.416	.00659	.203	-.627
	(0.63)	(2.08)	(1.30)	(1.04)	(0.74)	(0.87)	(2.33)	(0.44)	(0.54)
Age of Wife Squared ($x10^{-4}$)	-.215	-.192	-.149	-.142	.0576	.0703	-.107	-.0176	-.000592
	(0.92)	(1.93)	(1.61)	(1.46)	(0.38)	(0.70)	(1.03)	(0.18)	(0.01)
Husband Protestant	.479	.0936	.320	.182	-.338	-.0322	.111	-.127	-.306
	(1.72)	(0.74)	(2.89)	(1.53)	(1.46)	(0.25)	(0.87)	(0.99)	(0.80)
Husband Catholic	-.112	-.292	-.00859	-.0730	-.443	-.0451	.0437	.255	-.610
	(0.23)	(1.40)	(0.04)	(0.36)	(1.26)	(0.21)	(0.20)	(1.20)	(1.13)
Husband Jew	.223	.577	.00348	.0359	4.84	.508	-.259	.0382	4.93
	(0.38)	(1.32)	(0.01)	(0.13)	(0.01)	(1.13)	(0.90)	(0.17)	(0.14)
Constant	-.444	-6.92	-7.41	-6.69	1.60	-.309	-1.60	.402	.673
	(0.07)	(2.45)	(2.82)	(2.43)	(0.37)	(0.11)	(0.54)	0.14	(0.11)
F/X^2	40.8	294.9	354.5	273.9	120.9	258.5	256.6	339.7	68.0
d.f.	2829	2829	2829	2829	2829	2829	2829	2829	2829

a. Endogenous variable. Instruments are: born in Southern state, wife's parents living, husband lived with parents at age 14, wife lived on farm.

b. Absolute values of asymptotic t-ratios in parentheses.

likelihood that she knows how to use the allegedly ineffective methods (e.g., withdrawal, rhythm) are substantially stronger than the associations between the wife's schooling and the likelihood that she is knowledgeable about the use of either the condom, diaphragm, foam, IUD or the contraceptive pill. These patterns are somewhat less strong for the husband's schooling, as in our use-effectiveness results. The weak association between knowledge of how to use the pill and schooling in part arises from the pervasiveness of knowledge about its use--less than two percent of couples were evidently ignorant of how to use the contraceptive pill. In contrast, more than 20 percent of couples did not know how to use the rhythm temperature method.

The point estimates indicate that a one-year difference in the wife's schooling is associated with a 7 to 9 percent differential in the likelihood that she knows how to use one of the three ineffective methods, while a similar difference in schooling is associated with only a 1 to 3.5 percent differential in knowledge of the other techniques. Note that, since the rhythm methods can be used to increase fertility as well as to decrease it, the higher level of knowledge of these techniques characterizing the more educated couples is consistent with our finding in Table 3 that more educated couples exhibit higher fertility when no attempt is made to limit conceptions. Indeed, it is only in the two rhythm equations that the set of fertility demand variables, exclusive of husband's income, is statistically significant, with knowledge of use of rhythm more likely if the couple intends to have a larger family.

Generally, except for the rhythm methods, knowledge of how to use contraceptive methods does not appear to be directly related to a couple's demand for children. The significant, positive association between income and contraceptive knowledge for all methods, despite the insignificant effect of birth intentions, is consistent, however, with the hypothesis that such knowledge may be in part a joint or incidental product of activities (reading) which become more prevalent as income rises. However, income, unlike schooling, did not appear to affect actual use-effectiveness.

3. Fecundity, Excess Fertility and Schooling Attainment

As noted, the two-stage estimates of the effects of contraception on the monthly probability of conception not only yield estimates of differentials in method-specific use-effectiveness, but enable the separation of the behavioral and biological components of fertility. Differentials by schooling in the effects of fecundity variation for contraceptive use and fertility can thus be assessed. The two-stage estimates provide a consistent prediction for each couple of its fertility (conception rate) based on its actual choice of contraceptives and the effectiveness with which it used those methods. The difference between this consistent prediction, based on the actual methods used by the couple and their use-effectiveness, and the couple's actual conception rate contains the couple-specific persistent and random components of fertility that are beyond the couple's control, namely, unexplained deviations in fertility supply. These prediction "errors" can be computed for different segments of the life cycle in order to decompose the fertility supply errors into their persistent and random parts.

Because of the truncation at zero of the conception probability, and hence the use of the tobit estimation procedure, the predicted or expected value of the conception rate n^e_{ij} for each couple j in period i is computed from the formula:

$$(11) \qquad n^e_{ij} = E(n_{ij}) = \Phi_{ij} B' z_{ij} + \sigma\phi_{ij} \; ,$$

where B' is the vector of estimated (two-stage) tobit index coefficients, is the vector of actual input values for couple j in period i, Φ and ϕ are the cumulative normal and normal density values evaluated on the basis of the couples' actual input values, and σ is the estimated tobit standard error. A consistent (i.e., as i goes to infinity) estimate of the persistent or fixed component of fertility supply (fecundity) for a couple j for whom fertility, net of inputs, is computed for each of s periods, from (11), is:[10]

$$(12) \qquad \xi_j = \sum_{i=1}^{s} (n_{ij} - n^e_{ij})/s \; .$$

To compute the couple-specific fecundity measure from our data, we divided the five-year period containing the calendar information from which the reproduction technology was estimated into two equal two and one-half year segments. While a greater number of interval segments might be desirable for estimating the permanent component of fertility supply, short intervals provide little information about fecundity in a setting where the average level of contraceptive effectiveness is high, as in our sample. Our measure of fecundity is thus likely to be "noisy." However, if the measure of fecundity based on the average of the two intervals from 1970-75 captures that component of fertility supply that is persistent, then, given costly fertility control, variations in our measure of fecundity should explain a significant proportion of the variance not only in total fertility but also in respondents' perceptions of the number of unplanned or "excess" births they had experienced. Moreover, since the fecundity measure is denominated as a conception rate, its effect on cumulated excess births should increase over the life-cycle.[11]

The 1970-75 NFS elicited information from respondents on the number of pregnancies that they had experienced earlier than desired and/or that had occurred when no more children were wanted. While 38 percent of couples reported no "excess" pregnancies, the mean number of such pregnancies was 1.6, more than 65 percent of the total pregnancies per couple.[12] Columns (1) and (4) of Table 5 report tobit estimates of the effects of our estimated couple-specific measure of fecundity, of age and of the usual fertility demand variables on this subjectively ascertained measure of "excess" fertility. As expected, if (12) approximates fecundity, couples that we estimate to have a higher biological propensity to conceive, net of their efforts to reduce conceptions, report increasingly higher numbers of excess pregnancies as they age. The estimates indicate that a couple with fecundity one-standard deviation above the mean experiences .26 additional excess pregnancies when the wife is aged 25 and .77 additional excess pregnancies when she reaches age 40 compared to otherwise identical couples with fecundity at the sample mean.

In columns (2) and (4) in Table 5, estimates are reported from specifications in which an interaction term involving schooling and the fecundity measure, for the wife and husband respectively, is added to the excess fertility specification to test the hypothesis that fecundity variation influences the number of excess births less for the more educated than for the less educated, as a consequence of the more educated being better aware of their own biological capacities. This is confirmed at the five percent level

Table 5

Effects of Fecundity and Schooling on "Excess Fertilty:" Tobit Estimates

Specification Variable:	Wife's Schooling (1)	(2)	Husband's Schooling (1)	(2)
μ - fecundity	-30.9 (2.10)	-12.8 (0.70)	-29.3 (1.99)	-12.3 (0.68)
μ x age	.167 (4.00)	.183 (4.28)	.162 (3.88)	.167 (3.97)
Schooling	-.0599 (2.77)	-.0574 (2.65)	-.0018 (0.10)	-.00037 (0.21)
μ x schooling	--	-1.84 (1.68)	--	-1.39 (1.59)
Age	.0255 (4.01)	.0256 (4.03)	.0242 (3.81)	.0246 (3.86)
Age squared (x 10^{-4})	-.271 (3.47)	-.272 (3.49)	-.255 (3.27)	-.259 (3.32)
Local family planning	-7493 (0.88)	-7919 (0.93)	-7767 (o.91)	-8476 (0.99)
Husband Protestant	.0692 (0.45)	.0695 (0.45)	.0863 (0.56)	.0935 (0.61)
Husband Catholic	.454 (2.76)	.457 (2.79)	.491 (2.99)	.504 (3.07)
Husband Jewish	.125 (0.37)	.132 (0.39)	.0618 (0.18)	.0866 (.25)
Husband Mormon	.402 (1.49)	.413 (1.53)	.410 (1.51)	.427 (1.57)
Husband's income - 1970 (x10^{-4})	.129 (0.92)	.135 (0.96)	.0987 (0.70)	.0961 (0.68)
Husband's income - 1975 (x10^{-4})	.00028 (0.01)	-.00186 (0.03)	-.0329 (0.51)	-.0297 (0.46)
Health expenditures	40.8 (1.15)	42.8 (1.21)	46.9 (1.32)	45.3 (1.28)
Female unemployment rate	-.526 (0.12)	-.547 (0.13)	-.992 (0.23)	-.917 (0.212)
Intercept	-3.88 (3.02)	-3.93 (3.07)	-4.29 (3.32)	-4.38 (3.39)
Sigma	1.60 (52.5)	1.59 (52.5)	1.60 (52.5)	1.60 (52.4)
lnlikelihood	2873.5	2872.1	2877.3	2876.1

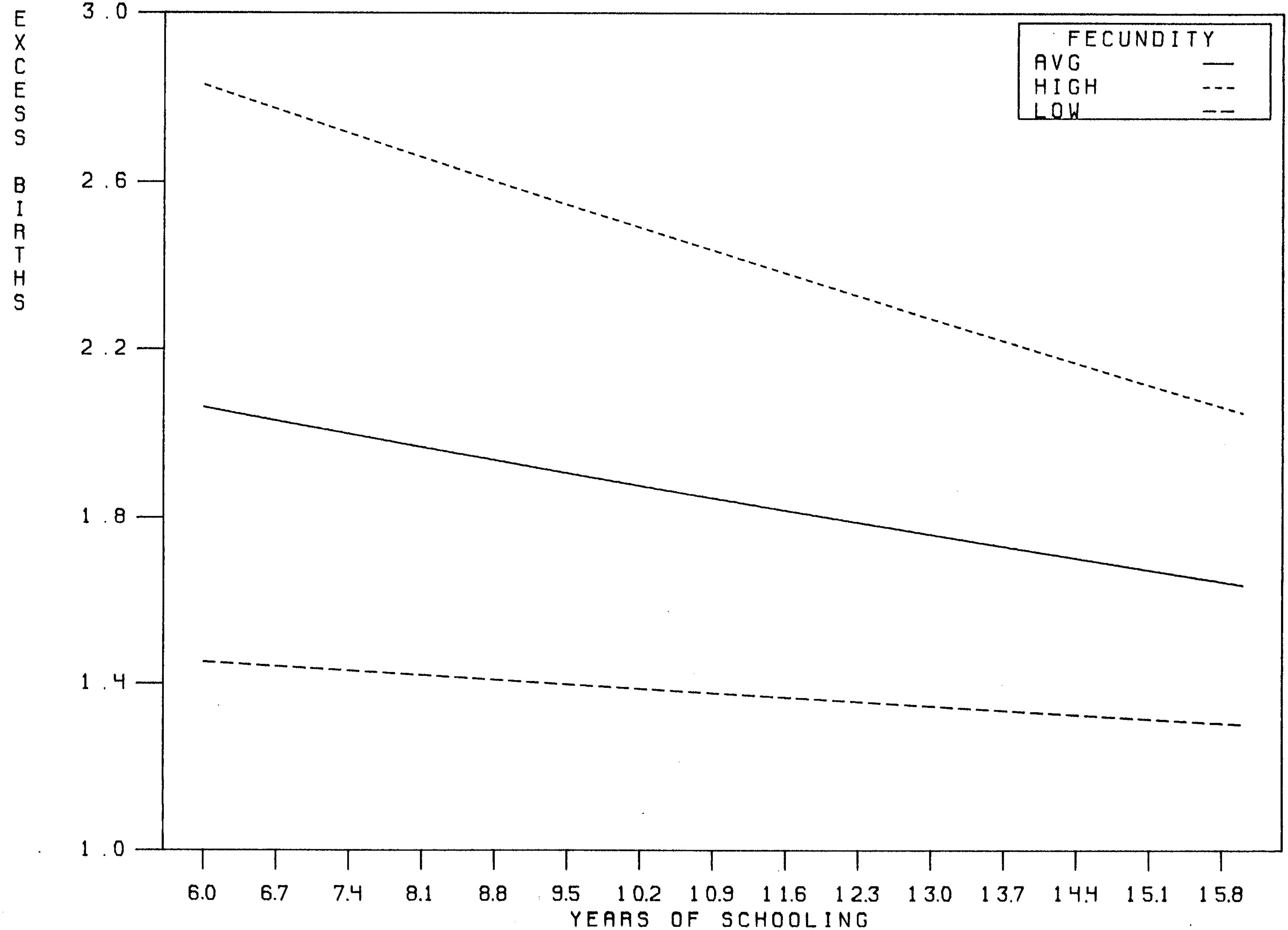
[a] Absolute values of asymptotic t-ratios beneath coefficients.

(one-tail test) for the wife's schooling and at the six percent level for the husband's schooling.

Figure 2 plots the associations between the wife's schooling and the number of excess births, based on the Table 5, column (2) estimates, for couples with average fecundity and for couples with fecundity one standard deviation above (high fecundity) and below (low fecundity) the sample mean. As can be seen, with an increase in the wife's schooling, the numbers of excess births for the above- and below-average fecundity couples approach that of the couples with average fecundity; differentials in excess fertility associated with fecundity variation narrow as schooling attainment rises.

The results in Table 5 thus suggest that at least part of the negative association betweem the variability of completed fertility and the wife's schooling level, exhibited in Table 1, is accounted for by the reduced impact of fecundity on unplanned or excess fertility among more educated couples. The point estimates indicate that among couples in which the wife has 16 years of schooling, the difference in excess births between the high- and low-fecundity couples is only 0.7 conceptions, while among couples in which the wife has 8 years of schooling, the differential is almost twice as large, namely, 1.3 unplanned conceptions.

The decline in "excess" birth differentials with increased schooling attainment, despite heterogeneity in fecundity, is consistent with the hypotheses that: (i) among more educated couples those with higher fecundity contracept more efficiently through the selection of more efficient contraceptive methods than do couples with lower fecundity and (ii) among highly-fecund couples the more educated choose more efficient contraceptive methods


FECUNDITY
AVG
HIGH
LOW
EXCESS BIRTHS
3.0
2.6
2.2
1.8
1.4
1.0
6.0
6.7
7.4
8.1
8.8
9.5
10.2
10.9
11.6
12.3
13.0
13.7
14.4
15.1
15.8
YEARS OF SCHOOLING

than the less-educated, because of their superior ability to discern more precisely their innately higher propensity to conceive. To test these propositions more directly, we construct two measures of each couple's contraceptive method choice over the 2.5-year period following the first interview in 1970, based on our estimates of the reproduction function. The first measures contraceptive "choice" efficiency (E_c) by weighting the actual set of methods z_{kj} used by the couple over the period by the sample average use-effectiveness of each method; i.e.,

(13) $$E_{cj} = \text{abs}[\Phi_j \beta_k z_{kj} + \phi_j \sigma] ,$$

where abs[ ] indicates absolute value. This measure corresponds to that used by Michael (1973) and Rosenzweig and Seiver (1982) in their studies of the demand for contraceptives, except that the β_k are obtained from our own consistent estimates of average use-effectiveness, reported in column (1) in Table 3, rather than from estimates provided in other studies which employed methods that did not take into account heterogeneity. E_{cu} will differ across couples only if couples select different mixes of methods.

We also construct a measure of contraceptive effectiveness that incorporates both the contraceptive method choice of the couple and couple-specific use-effectiveness, based on the wife's schooling, using the results reported in Table 3, column (3). This measure, given by:

(14) $$E_{cuj} = \text{abs}[\Phi_j (\beta_k + \delta_{kj} e_j) \; z_{kj} + \phi_j \sigma] ,$$

differs across couples because of differences in both method choice and in method use-effectiveness (by schooling).

We test the following hypotheses:

1. Both E_c and E_{cu} increase with fecundity, as in (8) or (9); namely,

more fecund couples choose to control fertility more efficiently.

2. Schooling will be more strongly related to E_{cu} than to E_c, since our estimates of the technology (10) imply that differences in use-effectiveness across methods are smaller for more educated couples than for less educated couples.

3. Among couples with high fecundity, both E_c and E_{cu} will be higher for the more educated than for the less educated.

As indicated, a couple's demand for contraceptives, and thus measured choice-and choice-plus-use-effectiveness, will depend on its preferences for family size, which may be correlated with schooling attainment. To "control for" heterogeneity in preferences associated with schooling, we use reports by the respondents in our NFS sample of their future birth intentions in 1970, that is, in the year prior to the 2.5-year period over which we measure contraceptive effectiveness. We estimate the determinants of couples' average choice- and choice-plus-use-effectiveness, conditional on their birth intentions, as functions of their measured fecundity, schooling, age, husband's income in 1970, and 1975, husband's religious affiliation and the local-area variables listed in Table 2.

Since unobserved factors associated with preferences for children would influence both birth intentions and contraceptive selection, leading to biased estimates, we treat birth intentions as an endogenous variable, as in Rosenzweig and Seiver (1982). The set of instruments (see Table 4, note a) we use to identify the contraception demand equation conditional on birth intentions characterizes the family background of the wife, which is assumed to affect her family size preferences but not, given those preferences, her choice of contraceptive methods.

Table 6 reports the two stage least squares estimates of the determinants of both E_c and E_{cu}. We report the results only for the wife's schooling; estimates using the husband's schooling attainment are essentially identical. In the first, linear, specification for each effectiveness measure, we see confirmation of hypotheses one and two; more fecund couples choose techniques with higher average effectiveness (given birth intentions) than do less fecund couples, and differences by the wife's schooling in contraceptive effectiveness associated solely with method selection (weighted by average use-effectiveness) are substantially smaller than differences in overall use-effectiveness, given birth intentions. The point estimates in the linear specifications imply that a one year increase in the wife's schooling is associated with a 2.2 percent increase in contraceptive effectiveness as a result of method choice but is associated with a substantial change in actual (choice plus use) effectiveness of 8-9 percent. The estimates also confirm that a couple's contraceptive efficiency depends inversely on its birth intentions.

In the second specification we allow the response of method selection to fecundity to differ (1) by the wife's schooling and (2) by birth intentions. We also allow the effects of birth intentions on the couple's selection of contraceptive effectiveness to vary by the wife's schooling. These estimates confirm hypothesis three for either measure of effectiveness. <u>For given birth intentions</u>, more fecund couples select more efficient methods of contraception when the wife is more educated than when she is less educated, presumably because the more educated can anticipate better their higher future likelihood

Table 6

Effects of Fecundity and Wife's Schooling on Contraceptive Effectiveness($x10^2$): Two-Stage Least Squares Estimates

Specification	Choice-Effectiveness (1)	Choice-Effectiveness (2)	Choice + Use-Effectiveness (1)	Choice + Use-Effectiveness (2)
Schooling	.0239	-.00526	.636	.672
	(1.86)[b]	(0.35)	(21.8)	(5.01)
μ-fecundity	4.97	.857	8.40	6.88
	(4.45)	(0.15)	(3.32)	(0.61)
μ × schooling	-	1.56	-	2.24
		(4.08)		(2.92)
Intended births[a]	-.326	.0838	-.692	.0863
	(2.72)	(0.57)	(2.56)	(0.26)
Intended births × schooling × μ[a]	-	-.895	-	-.825
		(6.59)		(3.04)
Age	.00279	.00662	-.0246	-.0213
	(1.05)	(2.26)	(4.10)	(3.63)
Age squared ($x10^{-6}$)	-5.94	-6.72	8.27	7.63
	(1.87)	(1.89)	(1.15)	(1.07)
Husband's income - 1970 ($x10^{-6}$)	-8.60	-6.44	-44.5	-34.1
	(1.12)	(0.75)	(2.55)	(2.00)
Husband's income - 1975 ($x10^{-6}$)	5.61	3.32	.966	1.30
	(2.15)	(1.27)	(0.16)	(0.24)
Husband Protestant	-.0651	-.0947	-.114	-.138
	(1.02)	(1.33)	(0.80)	(0.96)
Husband Catholic	-.114	-.234	-.0234	-.0725
	(1.46)	(2.58)	(0.13)	(0.40)
Husband Jewish	-.129	-.256	-.0364	-.158
	(0.91)	(1.67)	(0.11)	(0.51)
Husband Mormon	-.0231	-.199	-.107	-.200
	(0.13)	(1.02)	(0.27)	(0.51)
Local family planning ($x10^2$)	56.8	76.2	57.2	39.6
	(1.56)	(1.88)	(0.70)	(0.50)
Health expenditures	4.40	15.0	11.7	4.79
	(0.30)	(0.99)	(0.35)	(0.16)
Female unemployment rate	2.30	1.47	1.06	1.73
	(1.30)	(0.74)	(0.27)	(0.44)
Constant	.810	-.981	2.38	.579
	(1.40)	(1.16)	(1.82)	(0.34)
F	5.41	5.92	107.6	90.0
d.f.	1728	1726	1728	1726

a. Endogenous variable. Instruments: wife's birth order, sibling sex-ratio, parents' occupational standing, origin family structure, region of residence and farm residence when age fourteen.

b. Absolute values of asymptotic t-ratios beneath coefficients.

of conceiving, for any given method choice. The findings also suggest that the degree to which birth intentions influence contraceptive selection varies by schooling level: couples with a more educated wife increase their contraceptive efficiency more when they demand fewer additional children. The estimates suggest that among couples whose fecundity is one standard-deviation above the sample mean, contraceptive effectiveness is 24 percent higher for wives with sixteen years of schooling than it is for wives with twelve years of schooling due to differences in the methods selected and is 21 percent higher when schooling differentials in method-specific use-effectiveness are also taken into account.

4. Conclusion

While the effects of schooling on labor market outcomes have been well documented, the evidence on the returns to schooling in the nonmarket sector, particularly in activities associated with the household, is less clear. In this paper we have estimated the technology associated with human reproduction to examine the influence of schooling on productivity in household activities. Our results implied that schooling enhances couples' abilities (i) to decipher information about household inputs which require careful use and for which there is relatively little information and (ii) to learn about their own biological capacities. In particular, we found that more educated couples were both more likely to know how to use and able to use more efficiently so-called ineffective contraceptive methods than were less schooled couples, but the more educated did not obtain substantially higher efficiency in contraception compared to the less educated from contraceptives prescribed and/or installed by medical doctors and for which there is little scope for misuse. Moreover, our evidence indicated, based on estimates of couples' differing biological propensities to conceive and their contraceptive choice behavior, that more educated couples were better able than less educated couples to perceive these propensities, for which the market provides little direct information.

As a consequence of these different informational skills associated with schooling, (i) the difference in the contraceptive methods chosen by college as opposed to high-school graduates with the same fecundity and birth intentions was relatively small (8 percent) and substantially weaker than the difference in the overall effectiveness of their contraceptive control (32 percent), and (ii) a difference in fecundity of one standard deviation among college graduates was associated with a difference of .7 unplanned conceptions, whereas a similar difference in fecundity among wives who were grade school graduates led to almost twice as large a difference in unplanned conceptions (1.3). The superior ability of the more educated couples to perceive their biological capacities to bear children and their wider knowledge of contraceptive methods helps explain why, despite the greater variability in their exposure via marriage to the risk of conception, the variability in the completed family size of more educated couples is less than that of similar couples with less schooling.

Our results thus imply that the returns to schooling investment may be significantly understated when such returns are measured in terms of only market outcomes. This does not imply, of course, that more public expenditures on schooling are warranted. However, our findings suggest, in accord with studies of the returns to schooling and extension services in agriculture (Huffman (1974)), that schooling and birth control information-dissemination programs are substitutes and that therefore the least-educated may gain the most from such programs. In addition, to the extent that exogenously-induced fertility variation affects the quantity of resources allocated to children (Becker and Lewis (1973); Rosenzweig and Wolpin (1980)), the superior ability of the more educated to realize and therefore accommodate their biological capacities implies that uniform increases in the overall levels of schooling would appear to not only increase per-capita resource flows from parents to children but to decrease the variance in such intergenerational flows, thereby reducing inequalities in endowments for the next generation.

Footnotes

1. In United Nations (1983), analyses of data from 22 developing countries in which World Fertility Surveys were recently collected provide a basis for forming generalizations concerning the relationship between the educational attainment of women and their reproductive behavior. Marital fertility in the last five years, children ever born and knowledge and use (ever) of contraceptives were each regressed on four schooling levels, with no schooling as the omitted category and with controls for mother's age and age at marriage. Schooling is found to be negatively related to both measures of fertility in 20 of the 22 countries, although in a few fertility falls monotonically with schooling only after four years of schooling are completed. Schooling of the mother is highly positively correlated with contraceptive knowledge and use in every country and between every pair of schooling levels. These UN regressions do not control for husband's income, earnings or assets, which often exhibit a positive partial correlation with fertility (Schultz (1973)). Since these income variables tend to be positively correlated with wife's schooling, their exclusion in the fertility regressions weakens the inverse mother's schooling-fertility link reported.

2. We do not explore the possibility that schooling merely proxies preexistent informational skills; we are only concerned with documenting that schooling is associated with nonmarket productivity differentials just as they are in the market sector.

3. The UN study discussed in note 1 (United Nations (1983)), concludes that as "...other communication channels than the educational system become available, education becomes relatively less important in determining

contraceptive ... knowledge and practice."

4. The supply of births may also be influenced by other factors than in (1), including couples' consumption patterns, although it is widely believed that while fecundity varies substantially among couples, reproductive potential is not importantly affected by socioeconomic conditions, at least in high-income countries (Bongaarts and Mencken (1983)). The existence of joint production complicates the model but poses no impediment to identification of the technological parameters as long as at least one of the reproduction inputs does not directly influence couple welfare. In estimating the reproduction technology below we assume that one endogenous consumption good, prior cumulated births, affects current reproductive capacity and in Rosenzweig and Schultz we explore the biological effects of smoking by the mother on fertility supply. See also Rosenzweig and Schultz (1983) for a fuller discussion of identification issues associated with production jointness in the household.

5. Joint production, the existence of goods which jointly and directly affect production and family welfare, noted in note 3 above, is distinct from the problem that the <u>effects</u> of the inputs on output may be influenced by the couple's consumption patterns, and thus by its preferences, through information acquisition.

6. Given contemporaneously non-separable preferences, inclusive of fertility, income and prices of all goods consumed as well as input prices will influence the demand for the reproductive inputs. The use of prices of consumption goods that do not affect fertility supply directly as instruments results in overidentification of the household technology without resort to functional

form assumptions.

7. The merged 1970/75 NFS, besides providing a detailed history of reproductive input use and fertility outcomes, also provides direct, but subjectively ascertained, information on couples' demand for children and their fertility supply. We use this information below to ascertain whether couples' perceptions of their own fecundity are associated with our estimates of exogenous, couple-specific fertility supply and to condition contraceptive demand equations for fertility preferences.

8. While months of abstinence are excluded from the measured exposure periods, sterilization is treated as a contraceptive method which, unlike abstinence, has a failure rate.

9. For a discussion of experiments with functional form, use of additional exogenous and endogenous inputs such as father's age, breastfeeding, smoking by the mother, and sensitivity tests invoving differing specifications of the effects of postpartum amenorrhea, see Rosenzweig and Schultz (1985).

10. Because of the non-linearity of the tobit specification, ξ_j does not correspond to μ_j in (1). Expression (12), however, measures those conceptions which occur (or do not occur) net of the attempts by the couple to control fertility and thus is independent of their preferences for children. Use of the heteroscedasticity-corrected linear estimates to measure μ_j yields almost identical results to those reported in subsequent tables where ξ_j is used to measure fertility supply.

11. The positive association between our measure of exogenous fertility supply for a couple and its "excess" cumulated births would also be consistent with an interpretation of our estimated fecundity variable as measure of

fertility demand due, say, to omitted inputs in (10). However, the number of births that the couple intended to have in the future, reported in 1970, is <u>negatively</u> and significantly associated with our fecundity variable, measured between 1970 and 1975. This finding supports the hypothesis that couples adjust their fertility intentions downward (fertility control upward) in response to higher fecundity, as implied by expressions (8) and (9) obtained from the model, and is inconsistent with the hypothesis that our residual measure of fecundity from (12) merely captures unexplained fertility demand.

12. Almost one-quarter of all births are reported as "unwanted" by the respondents in 1975, although only 27 percent of couples reported any unwanted children.

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