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Sources of Fertility Decline in Modern Economic Growth: Is Aggregate Evidence on the Demographic Transition Credible?

T. Paul Schultz

Economic Growth Center
Yale University

and

Senior Research Fellow
Institute for Policy Reform

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The large declines in total fertility rates that have occurred in many low income countries since 1960 are thought to have been caused by subsidized birth control and economic development, in roughly equal proportions. Studies of these issues are not generally guided by economic approaches to the determinants of fertility. Consequently, income is not disaggregated according to its sources, which according to some economic theories should exert different effects on fertility and child mortality. The assumed exogeneity of child mortality as a determinant of fertility has also not been subjected to statistical tests, and national family planning programs are assumed to occur independently of consumer demands for these services. Because of these statistical and economic shortcomings of the existing evidence on these issues, and the social significance of child mortality, fertility and population growth on a global scale, this paper analyzes the aggregate evidence and confirms many microeconomic findings about the determinants of child mortality and fertility. Based on data for 62 low income countries in 1972, 1982, and 1988, the educational attainment of adult women is the powerful engine of demographic change, associated with lower levels of child mortality and fertility, and on balance slower population growth. Factors that permit higher levels of calorie consumption per capita, given a country's education and income, are associated with lower levels of child mortality, and Wu-Hausman tests confirm that child mortality is endogenous in exerting its substantial positive effect on fertility. Male education is associated with higher levels of fertility. Male education is associated with higher levels of fertility, while income levels from nonhuman capital sources, compared on a purchasing power parity basis per adult, are associated with lower child mortality but higher fertility. Decreases in the share of the labor force employed in agriculture are associated with decreases in fertility. If family planning programs are assumed to be independent of parent demands for birth control and other unobserved variables affecting fertility, family planning exerts a significant, but quite small, effect on fertility. If family planning programs are more realistically treated as endogenously affected by transfers to a country by a major international donor agency (IPPF), the role of domestic family planning programs is an insignificant determinant of fertility.

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Executive Summary April 21, 1993

Sources of Fertility Decline in Modern Economic Growth: Is Aggregate Evidence on the Demographic Transition Credible?
T. Paul Schultz

Fertility has declined by a third in low income countries since 1960. Although the origins, dynamics, and ramifications of differences in lifetime fertility are not fully understood, certain empirical regularities in period rates of fertility are accounted for in this paper using a simple static economic model. Most empirical analysis of fertility has focused on cross sectional variation within a single country. Cross country comparisons have not frequently been guided by an economic framework, and few studies have tried to study fertility changes over time, either within (relatively closed) aggregates, such as nations, or within families between generations.

This paper examines national data for 62 low income countries from 1972, 1982 and 1988 to test some of the most elementary hypotheses regarding the economic demand for children, first with regard to the differences across countries at different stages of development and then based on the changes occurring within countries over time. The conclusions are in one sense similar to other studies, both family planning and development are associated with lower levels of fertility. However, development may involve different sources of economic growth in a particular country, and economic theory suggests that some income sources will be associated with decreasing fertility, such as women's education and earnings, whereas others, such as men's education and nonlabor income, may be associated with increasing fertility. Adult education averaged for men and women is, therefore, not a satisfactory variable for explaining fertility, according to such economic approaches to fertility determinants, and national income per capita is not a good indicator of development, unless GDP is first divided by adults who might produce that output, and then the composition of education between men and women is also held constant.

Child mortality does not appear to be exogenous to the economic endowments, preferences and conditions of the family, despite the importance for child survival of community health measures and local disease environments that the family has no control over. Statistical specification tests confirm that child mortality should be treated as endogenous to the process determining fertility and possibly measured with substantial error. The availability of calories per capita in a country is found to be associated with child mortality, but can be excluded from the proximate causes of fertility variation, and thus provide the basis for identifying child mortality's effect on fertility. The estimated effect of an endogenous decline in child mortality is to

produce a fully offsetting decline in fertility that is not associated in this time period with an increase in population growth.

Countries with higher incomes, given their human resource base measured by education and child mortality, have higher fertility. Interestingly, the effects of gender specific education and income on fertility are strengthened when several variables for religion are controlled. But when child mortality is treated as endogenous, the relatively higher levels of fertility in Islamic countries is accounted for by the lower levels of female education in these countries as well as the higher levels of child mortality.

Family planning programs are summarized by an index used in previous evaluation studies, but because this index includes proxies for the prevalence of contraceptive use, this index embodies both the "supply" effects of government subsidies and policies encouraging the spread and use of birth control, but also the parent "demand" for fertility (restriction). If this family planning index is treated as exogenous, a standard deviation change in the index is associated with a 4-5 percent decline in fertility. If this index is predicted as endogenous on the basis of all the variables in the demand model plus IPPF financial transfers to the country's family planning program, the estimated effect of family planning is no longer statistically significant. Only in the last year, 1988, is it possible in 58 countries to measure the actual price of a single form of contraception, the pill. As expected, increasing the price of this single contraceptive method increases total fertility, but the response is modest in size, for a doubling of price is associated with a five percent increase in fertility.

Finally, the fertility analysis shifts from the cross sectional levels to the more difficult to explain changes over time within countries, ignoring the countries initial level. The estimated effects of changes in women's and men's education and the proportion of the labor force in agriculture remain essentially the same as that based on the cross section, but the estimated impacts of income per adult and urbanization are no longer statistically significant in the time series analysis. The education of women is the most important factor associated with the decline in fertility in the cross section and over time. But since men's education has a weaker but countervailing effect on fertility, a critical dimension of development governing the timing of the demographic transition is the investment in schooling of women relative to men. Raising calorie availability at very low levels of nutrtition appears to be closely related to lowering child mortality and thereby contributes to declining fertility. Family planning does not emerge as a dominant factor determining fertility when the principal demand determinants are controlled, even when it is implausibly assumed to be exogenous to parent demand. Because of the complexity of the policy formation process, the lags between changes in constraints and dynamic adjustment of fertility

behavior, intercountry comparisons such as reported in this paper are not well suited to measure the cost effectiveness of social welfare programs, such as family planning. But these aggregate data do shed some light on the connections between the structure of modern economic growth and its consequences for the decline in child mortality and fertility.

1. Introduction

The decline in fertility in low income countries that has occurred since 1960 can be partly understood in terms of models of household demand behavior, as can variation across individuals and population aggregates. Although the origins, dynamics, and ramifications of differences in lifetime fertility are not fully understood, certain empirical regularities can be accounted for in simple static fertility models. Most recent economic research on fertility has been guided by the idea that the family coordinates many demographic and economic production and consumption activities. Money and time constraints on families are thought to influence potentially not only births, but also affect other forms of interdependent family behavior, including investments in human and nonhuman capital, inter- and intra-household transfers, marriage, migration, and savings behavior.

In many low income countries total fertility rates have declined by 50 percent or more since 1960. Cross country variation in the timing and pace of this demographic transition is striking and calls for a coherent quantitative explanation. However, most empirical analysis of fertility has focused on cross sectional variation within a single country, first across subnational regions, and then across individuals as household surveys have become more widely available. Changes in fertility over time are less frequently analyzed, either within (relatively closed) aggregates, such as nations, or within families between generations.

I will examine here national data from the last two decades to test some of the most elementary hypotheses regarding the demand for children that may help to account for the broad outlines of the contemporary demographic transition in low income countries. The lack of many <u>panel</u> household surveys in low income

countries limits the opportunities for testing empirically economic models of fertility change at the individual and intergenerational family level. This paucity of economic studies of the fertility transition may reflect more than a shortage of data, however. It may also reflect the widespread belief that this rapid change in fertility is not due to the changing economic constraints faced by families, but rather is credited to the subsidized provision of modern birth control technologies through organized family planning programs. The effectiveness of family planning to reduce fertility will, therefore, be considered in section 4, not because I think data for national aggregates can be decisive in this long-running debate, but because the existing analysis of such data is unsatisfactory and, I shall argue, misleading. First, several hypotheses are outlined and related to the cross-sectional evidence based on alternative model specifications. Econometric specification tests reported in Section 5 then lead to the reexamination of the data using generalized least squares and fixed-effect methods.

2. Hypotheses and Measurement of Variables

When models of individual behavior are estimated from variation in average behavior and average conditioning variables for large aggregates such as countries the properties of the estimates depend on many tenuous aggregation assumptions (Theil, 1954).[1] There are, however, potential offsetting advantages

[1]I am particularly concerned about variables that may exert a nonlinear effect on fertility, but which exhibit little variation at the aggregate level, such as age, but are subject to substantial variation at the individual level. In such cases, the estimation of the effect of such a variable as age on fertility from intercountry variation in average age could be misleading. Moreover, other demographic linkages between age composition (youthfulness of the population) and (high) fertility are expected as long as fertility patterns are

of these aggregate data for testing hypotheses. The same relationship can be estimated on the basis of cross sectional or time series variation or a pooled combination of both for the same sample of countries. It is then possible to assess whether the relationship observed across countries at various levels of development forecasts reasonably well changes occurring in countries over time.[2] As already noted, the principal empirical puzzle motivating this paper is why the timing of the decline in mortality and fertility differs across countries and over time.

A static model of the demand for lifetime fertility has been outlined on several occasions, and suggests five empirical predictions (Schultz, 1973, 1981): (1) increased education of women raises the cost of childbearing and reduces fertility; (2) increased education of men may increase or decrease fertility, but in either case will reduce fertility less (algebraically) than will the education of women; (3) reduced child mortality, assuming the demand for surviving children is price inelastic, is associated with a decline in the demand for births (Schultz, 1981); (4) increased national income per adult that is not associated with adult education approximates the share of wealth and natural resource income in a society, and this income from nonhuman capital sources is expected to increase the demand for children, if they are a normal good. It is also widely conjectured that (5) the net cost of child rearing is greater for parents in urban than in rural areas, and the opportunities for children to work

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impacted by persistent unobserved variables.

[2]Omitted country-specific effects can bias cross sectional estimates if they are correlated with included variables (Hausman and Taylor, 1981). By first-differencing the data on levels, the estimated time series relationship is purged of any country-specific omitted factors that might influence fertility, such as culture, assuming that they do not change during the observational period.

productively in a context where they can be monitored by parents tend to be greater in an agricultural setting than in a nonagricultural one, and the cost of vocational training of a child appears greater for parents in urban than in rural environments as economic development proceeds.

To test these hypotheses associated with the micro economic model of fertility, a reduced-form demand equation for current births per woman (i.e. total fertility rate) is estimated that incorporates explanatory variables to measure effects of different sources of family income which embody different time-price effects (i.e. women's and men's wage or education, and property income), and other variables that represent exogenous sources of variation in the relative price of children: child mortality, rural/urban residence, and agricultural employment.[3] It can be argued, however, that child mortality, rural/urban residence and employment by sector are endogenous, because the allocation of family resources as modified by preferences may influence child mortality and interregional and intersectoral migration. Yet many researchers are inclined to interpret mortality and migration as predetermined for the purpose of evaluating the determinants of fertility. Here I will attempt to

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[3]Although the Total Fertility Rate (TFR) , the sum of current age specific birth rates often derived from periodic surveys reporting births in the last five years, represents a synthetic approximation for the average lifetime fertility of women, I would prefer to analyze the actual cumulative lifetime fertility of various birth cohorts, and relate this measure of cohort fertility to the lagged conditions prevailing when the cohort was likely to be making its fertility decisions. However, such cohort data is rarely available in low income countries and thus the common practice is to analyze TFRs. There may also be some improvement in model specification if the explanatory variables were lagged a few years to reflect biological time to conception and gestation (say two years) and the adjustment of expectations (unknown). Given the smooth evolution of many of these aggregate series, there may not be much to gain from introducing lags for those few variables that contain much annual variation, such as GDP. But such alternative model specification have not been compared empirically in cross country studies, to my knowledge.

explain only child mortality within the model and test its exogeneity.

The importance that society assigns to education, and specifically to the education of women compared with men, may itself reveal the relative value society assigns to women working at home and having a large number of children. One way to explore the role of such cultural value systems is to select features of the culture that are arguably fixed in the near term, and add them as controls in the fertility equation to test the robustness of the partial correlations between fertility and the conventional determinants of economic demands. Controls for religion are therefore included representing the proportion of the population that is reported to be Catholic, Protestant, and Muslim, where the remainder of the world's religions are absorbed into the overall intercept. An alternative set of controls might would allow for fertility values to differ by region, which would overlap considerably with religion, but appear more ad hoc.

Most of the core variables suggested by the demand model can be measured for most countries since 1970 (See Data appendix for details). However, it is not clear how income (GDP per adult) in constant local prices in different countries should be compared. The purchasing power (PP) of the local currency for a broad bundle of consumer goods may be used (Summers and Heston, 1991), or the nations's productivity in producing internationally tradeable commodities can be inferred from foreign exchange (FX) parities (World Bank Staff, 1992). Since much of personal income is spent on nontradeable goods, e.g. personal services and housing, the consumer purchasing power parity measure of national average income has more appeal for understanding how increasing productivity due to the accumulation of physical capital and natural resources (i.e. other than human capital) is related to household fertility choices. The results reported here

are based on the purchasing power parity equivalence, but our general conclusions are not affected if foreign exchange rates in 1980 are adopted as the basis of conversion.[4]

Information is not available on the shadow value of wages for all men and for all women in any country. Only a handful of countries report sex-specific wages, and then they are not standardized for education, age, or other productive characteristics. Nor are they available for the entire population but only the labor force in wage or salary employment in specific sectors, such as larger firms in manufacturing (ILO, Yearbook of Labour Statistics). There is no agreed upon methodology for using such data to infer the level of labor productivity or shadow wage for all men or women in a country.

An alternative approach is to estimate average educational attainment for men and women and use this as an instrument for proportional variation in wages across countries. Surveys and censuses are available for a growing number of countries that report the level of education attained by all men and women. Making plausible assumptions regarding the number of years that individuals have completed at each level of schooling in each country, it is possible to estimate the average number of years of education completed by men and women over the age of 15 in about 75 low income countries during the 1970s and 1980s (World Bank, 1991, supplementary data base). These estimates are related, but with a complex lag structure, to current school enrollment rates (Cf. Lichtenberg, 1992).

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[4]The variance of the logarithms of income per adult, the explanatory variable in the subsequent regressions, is smaller when income is compared on the basis of PP rather than FX (.67 versus .96). As expected, the elasticities of fertility and child mortality with respect to income are therefore estimated to be larger based on the less variable PP than FX income series. The statistical significance of the partial association between fertility and the PP and FX income series is nearly identical, i.e. t ratio.

Macroeconomic growth models have recently relied on current enrollment rates to proxy stocks of educational capital embodied in the national labor force (Mankiw, et al. 1992). This is not a promising solution (Denison, 1962). "Years" of adult education is a better predictor of the stock of educational capital embodied in the potential workforce, because it is highly correlated with the logarithm of the wage rate of individuals and groups.

National productivity is thus represented by three variables, an average logarithmic wage effect due to different levels of education of women and of men, and the logarithm of real GDP per adult. When the human capital effects of female and male education are held constant, the GDP variable in intended to capture the effects of physical capital and natural resource endowments per adult.[5] Child mortality, calorie availability, and labor force composition, are consolidated estimates of the Population Division of the United Nations, FAO, and ILO, respectively, based on periodic surveys or censuses, whereas several family planning variables are described later.

3. Empirical Findings

All developing countries (i.e. excluding OECD countries and centrally planned European countries) are analyzed for which data were available on total fertility rates (TFR) and years of education by sex , as well as (PP) income, child mortality, urbanization and share of male labor force in agriculture. The three years examined (1972, 1982 and 1988) are selected because information on family planning activity is available in each. The data appendix lists the

[5]Clearly future work is need to construct a directly observable measure of nonhuman capital and natural resources that explains the variation in national productivity.

countries in the sample and the source of data for each variable. Regression (1) in Table 1 is based on pooling of the three cross sections, providing a sample of 217 country-year observations. The significance tests are undoubtedly overstated in these initial pooled regressions, because the repeated cross sections are treated as independent observations. Alternative estimates are later reported based on alternative assumptions regarding the structure of the errors underlying this panel of 75 countries. The six core variables explain two-thirds of the variance (R^2) in the total fertility rate; all coefficients have the expected sign; and all are individually statistically significant at the 5 percent level, except for urbanization. Regression (2) allows the intercepts to shift for each period's cross section, although they are not jointly statistically significant at the 5 percent level. Three religion variables are also included, which are highly significant. All of the coefficients on the core economic variables increase in their statistical significance except income with the inclusion of the religion (or region, not reported) controls. Countries which have a greater share of their population affiliated with the Protestant, Catholic or Muslim religions have, as expected, higher fertility. The joint F test of the equality of all slope coefficients in the three cross sections is not rejected at the five percent level ($F(9,190)=1.28$, $p=.25$).[6] In sum, one obtains a similar relationship in each separate cross section. In this sixteen year period from 1972 to 1988 there is substantial stability in the multivariate

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[6]If the three cross sections are separately estimated, the effect of women's wage is significant in all three years but declines in value over time, as does urbanization, whereas the estimated effect of child mortality increases over time and the higher level of fertility associated with the Protestant faith increases in magnitude over time. As summarized by the Chow test, these slope coefficients are not statistically different over time at the 5 percent significance level.

Table 1

Cross Country Regressions of the Total Fertility Rate (TFR) and Child Mortality Rate to Age 5 (CMR)[a]

ependent Variable:	(1) Fertility (TFR)	(2) Fertility (TFR)	(3) Child Mortality (CMR)	(4) Fertility (TFR)	(5) Fertility (TFR) Reduced Form	(6) Means (Standard Deviations)
stimation Method:	OLS[c]	OLS	OLS	2SLS[c]	OLS	
xplanatory Variables:						
Years of Female Education[b]	-.447 (6.90)[a]	-.513 (7.35)	-13.2 (5.10)	-.225 (1.56)[a]	-.551 (8.37)	3.35 (2.21)[a]
Years of Male Education[b]	.138 (3.21)	.175 (4.01)	1.42 (.83)	.145 (2.51)	.179 (4.14)	5.10 (2.49)
Log of GDP per Adult (1988$, Purchasing Power Parity)	.491 (3.25)	.478 (2.98)	-25.7 (4.12)	1.16 (3.43)	.517 (3.32)	7.97 (.818)
Urban Percent of Population	-.0073 (1.44)	-.0117 (2.27)	.370 (1.80)	-.0175 (2.48)	-.0084 (1.61)	37.9 (21.5)
Percent of Male Labor Force in Agriculture	.0148 (3.15)	.0160 (3.49)	.861 (5.05)	-.0025 (.26)	.0190 (4.43)	50.9 (25.4)
Catholic Percent of Population		.0116 (5.03)	.261 (2.89)	.0050 (1.26)	.0115 (5.08)	34.8 (36.9)
Protestant Percent of Population		.0212 (3.97)	.540 (2.60)	.0103 (1.27)	.0239 (4.62)	8.87 (13.0)
Muslim Percent of Population		.0086 (2.84)	.645 (5.71)	-.0044 (.68)	.0119 (4.21)	26.1 (36.0)
Year 1982 Dummy		.023 (.16)	-9.09 (1.55)	.256 (1.19)	.0190 (.13)	.341
Year 1988 Dummy		.234 (1.43)	-12.7 (1.99)	.532 (2.19)	.202 (1.24)	.341
Calories consumed per capita per day			-.152 (2.07)		-.0035 (1.91)	2373. (367.)
Calories per capita squared $x10^{-3}$			.0238 (1.60)		.00053 (1.43)	5764. (2474)
International Planned Parenthood Federation (U.S.$/woman)					-.00036 (.34)	27.9 (60.4)
Child Mortality to age five (CMR)	.00635 (3.73)	.00460 (2.69)		.0251* (3.02)		136. (75.5)
Family Planning Activity Score (FPA)						34.6 (25.3)
Intercept	.885 (.66)	.454 (.33)	520. (5.29)	-6.90 (2.03)	5.79 (2.35)	5.35[d] (1.54)
2	.658	.710	.814		.722	
	67.3	45.6	74.5	27.3	40.5	

s: *Treated as endogenous with identification as implied by calories included in Col. (3). Sample size is 217.

absolute value of t ratios are reported beneath coefficients in parentheses in columns (1) through (3) and (5), asymptotic t ratios ol. (4) and standard deviations of variables in col. (6).

rs of education for female and male adults are estimated from The World Bank and UNESCO figures.

refers to ordinary least squares and 2SLS to two stage least squares.

ple mean and standard deviation in parentheses of the total fertility rate that is the dependent variable in columns 1, 2, 4 and

relationship across low income countries between total fertility rates and the core variables implied by the demand for children framework: women and men's education, nonhuman capital income, urbanization, agricultural employment, and child mortality.[7]

Similar factors, many of which are unobserved, affect both fertility and child mortality, introducing a simultaneous equation bias when child mortality is treated as exogenous for explaining fertility. It is also likely that high levels of fertility contribute to raising child mortality, introducing a reverse causal interpretation of the observed pattern. Finally, child mortality is probably subject to more errors in measurement than the other variables examined here, which would bias the coefficient on child mortality downward, if these errors were random. For all of these reasons, it is advisable to treat child mortality as endogenous and measured with error in a model seeking to explain fertility.

Statistical specification tests (Wu, 1973; Hausman, 1978) of whether child

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[7]According to regression (2) a country in which men and women both have one more year of education the total fertility rate is .34 child lower, or 6 percent lower than the sample mean of 5.4 children. If only men's education tends to be higher by one year, fertility is higher by .18 children. If only women's education increases one year fertility tends to decrease by .51 children. Doubling of GDP per adult, holding human capital constant, is associated with an increase in the total fertility rate of .33. A country that has half of its population in urban areas compared with one which has only 10 percent, which is roughly comparable to Latin America vis-a-vis Africa in this period, is associated with fertility being nearly one-half child (-.47) lower in the more urbanized country, holding these other strategic variables constant. Removing one-quarter of the male labor force from agriculture is associated with fertility decreasing by .4 children. A decline in infant mortality from 150 to 50 per thousand live births is associated with a decline in fertility of .46 children. These estimates cross multiplied by the changes from 1972 to 1988 in the conditioning variables leads to the expectation that fertility in the 66 countries common to both cross sections would have declined by 1.0, whereas fertility actually fell by only .78 in this subsample of countries.

mortality is exogenous to the fertility model can be implemented only if mortality is identified by the exclusion of a variable from the fertility equation that enters significantly into the determination of child mortality. Reductions in child mortality are often explained by availability of calories at the household and group level, most notably at very low levels of calories (Strauss, 1985; Fogel, 1990). Calorie consumption per capita is, therefore, specified as a determinant of child mortality, but the effect is allowed to vary by calorie level, through the inclusion, if significant, of a nonlinear quadratic term in calories.[8] Biological effects of nutrition on fecundity are widely believed to be negligible and are excluded here.[9] Other studies of child

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[8]It would also be desirable to include a measure of the within country variation in personal calorie consumption, because greater dispersion in individual consumption given the average level should be associated with higher child mortality. Unfortunately, I have found no indicators of the personal distribution of calories except those constructed by Fogel (1990) for 18th Century France and England. The FAO estimates of national calorie consumption are used here, from the World Bank World Development Reports of 1985 and 1991, and the figures for 1972 consumption are from the 1976 Food and Agricultural Organization Production Yearbook. A cubic approximation for the effect of average calories on average child mortality is not an improvement on the quadratic form reported here. The association of calories with mortality between a child's first and fifth birthday is particularly notable. Although only one-fourth of child deaths occur after infancy, they may be more sensitive to availability of calories because weaning is widespread by the second year of life. See nonlinear estimates of calorie effects on health and productivity in Brazil (Thomas and Strauss, 1992) and Strauss' (1985) overview of field. See also Dasgupta and Ray, 1987.

[9]It has been hypothesized that improvements in nutrition could also increase reproductive capacity (Frisch, 1978), but most evaluations of the evidence conclude that chronic malnutrition has at most a minor biological role in depressing fecundity (Trussell, 1978). If calories do increase somewhat fecundity in certain low income populations (e.g. Papau New Guinea) by increasing annovulatory cycles, lengthening the interval of menses, and increasing pregnancy wastage, this omission might mask some of the underlying positive relationship expected due to fertility responding to child mortality. Thus, the estimates reported below of the fertility response to endogenous child mortality are probably biased downward. Another over identifying variable was also included in the later analysis of only 1988 data: proportion of children immunized against

mortality and anthropometric indicators of child health, such as height for age and weight for height, suggest that a mother's education is the most important factor reducing child mortality. In addition, some studies find that working outside of agriculture and having a higher household income are also associated with improved child health outcomes (Strauss, 1985; Schultz, 1993).

In regression (3) of Table 1 the child mortality rate to age five is the dependent variable. The coefficients on the women's education and income are significant and negative, whereas agricultural employment is significantly related to higher child mortality, and the religion and time trend coefficients are also significant. As expected, the availability of more calories per capita in a country is associated with lower child mortality, and the nonlinear effect of calories is also jointly highly significant. The child health benefits from increased calories continue until a country reaches an average level of about 3200 calories per capita per day, or two standard deviations above the mean of the sample, 2373 calories.[10]

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polio or diphtheria, pertussin and tetanus (dpt). This variable might capture the effect of a variety child health programs across countries, and it is indeed negatively and significantly associated with child mortality. But its inclusion among the determinants of child mortality increases only slightly the two stage estimate of the effect of child mortality on fertility from .0205 to .0209 supporting the hypothesis that these are valid over identification restrictions conditional on the other restriction. However, the polio and dpt immunization variables are available for only 58 countries later examined in 1988 in Table 3. The other estimates in the fertility equation were very stable, whether identified by only the nonlinear calorie variable or the child immunization rates, but the effect of family planning on child mortality declines by 1988 when either child immunization variable is included.

[10]Because only four countries which contribute eight of the 217 observations have levels of calorie consumption that marginally exceed this daily per capita value of 3193, there is little reason to attach much precision to this estimate of the calorie level that would minimize child mortality. But developed market and centrally planned economies have on average exceeded this level for some time, and calorie shortages should therefore be a minor factor elevating the

Variation in calorie availability per capita, given the income, education, and agricultural employment of the population, is presumably due to international differences in the unobserved prices of nutrients, which may in turn be affected by trade and agricultural policies and poverty and famine alleviation programs, as well as the domestic composition of agricultural production. The effect of calories on child mortality may be attributed, thus, to a variety of domestic factors affecting the relative price of nutrients in national markets, and of course differences in the personal distribution of income, education, and prices that are not captured in the average levels of the observed aggregate variables.

The Wu-Hausman specification test rejects the null hypothesis that child mortality is exogenous to the fertility equation, at $p < .01$. Regression (4) in Table 1 is therefore estimated by two-stage least squares with endogenous child mortality identified as in regression (3). Most notably, the estimated effect of endogenous child mortality on fertility is five times as large as the estimate based on the rejected hypothesis that mortality is exogenous (Cf. regressions (4) and (2)). The direct effect of the woman's wage on fertility is decreased by half (regression (4)), but by solving out for the implied reduced-form relationship, one can confirm that more than half of the total effect of the women's wage on fertility now operates through its indirect child mortality reducing effect (i.e. .59= (-13.2)*(.0251)/(-.225+(-13.2)*.0251). The positive

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levels of child mortality in the high income world. According to regression (3), a country where the average calorie consumption is one standard deviation above the sample mean (i.e. 2373+367) the expected child mortality rate is 11 per thousand lower than the sample mean, or 8 percent lower. Had calories been a standard deviation below the sample average, as many African countries were, (i.e. 2373-367) the regression implies child mortality rates are expected to be 13 percent higher, other things equal. Adjustments of caloric availability for the biological needs associated with the age and sex composition of national population in 1988 did not change these estimates noticeably.

effect of income on fertility, given endogenous child mortality, more than doubles in magnitude, and the religion variables are no longer jointly statistically significant in the fertility equation, but they are significant in raising child mortality. The unrestricted reduced-form equation is estimated, excluding child mortality, in regression (5), for comparison with the structural effects solved from regressions (3) and (4).

4. Family Planning

Another factor that may influence fertility is the cost of birth control. One element of the cost of birth control is the variable monetary and psychic cost associated with using a specific method. Another cost involves deciphering a new technology of control, evaluating it against alternatives, adopting the best method, and using it effectively. This second element is a search cost which is essentially fixed, as long as technology and family constraints are unchanging. But these search costs may reoccur in a dynamic setting as new technologies are introduced or improved, such as the IUD and pill in the 1960s, and subsequent improvements in injections and sterilization, or a new method becomes worthy of consideration because desired levels of fertility change. Decreases in the cost of birth control are expected to help individuals have fewer unwanted births. It is also likely that beyond reducing unwanted births, such a decrease in the cost of birth control would encourage people to switch to birth control from other less satisfactory arrangements for controlling their reproductive potential, such as delaying marriage, reducing the frequency of intercourse, or relying on abortion or even infanticide. This second source of

welfare gain is more difficult to evaluate than that associated here with the decline in fertility (Schultz, 1988).

All countries do not provide their populations with access to all forms of birth control, or necessarily provide these technological options at the same price. Educational and outreach programs are mixed in many combinations, with a variety of subsidized family planning service systems. It has been argued that countries which support more diversified and seemingly effective family planning programs (FPA) and legislate facilitating population policies had by the 1970s lower total fertility rates (TFR) (e.g. Mauldin and Berelson, 1978; Lapham and Mauldin, 1985). Declines in TFR are also linked with strengthening family planning programs in recent years (Bongaarts et al., 1990). To interpret these partial correlations between TFR and FPA as a measure of the causal effectiveness of these programs, researchers have implicitly assumed that family planning programs occur independently of other fertility determinants. Since family planning activity is related to observed determinants of fertility, such as income, education and religion, it is reasonable to conjecture that family planning activity is also related to unobserved determinants of fertility, such as parents' preferences or cultural receptiveness to the "idea" of family planning or omitted measures of economic constraints that are responsible for shifting parent demands for children. Political support for the state to provide family planning services is therefore likely to build as an increasing share of a population demands fewer children, and hence better methods of birth control. The error or unexplained variation in the equation for fertility would then, almost certainly, be correlated with family planning activities, and the partial correlation between fertility and family planning, even controlling statistically

for other observed fertility determinants, would be biased and inconsistent. Despite these recognized limitations of correlational analysis to answer this policy question, agencies involved in evaluating and funding family planning have presented evidence in this form to show the effectiveness of such programs (Mauldin and Berelson, 1978; Bongaarts et al., 1990; World Bank, 1991).

Activities of family planning programs are summarized by an index that has been frequently used to evaluate the contribution of family planning to fertility declines (e.g. Mauldin and Berelson, 1978; Ross, et al., 1988, Table 18). This "effort score" has a mean in my sample of 34 and ranges from zero to 84, depending on the country's commitment to family planning services and population policies.[11] Although the components in the series are not precisely the same in every year, the indicator has been standardized for comparative purposes over time. Two model specifications are estimated: the first assumes the Family Planning score is exogenous (Regressions 1-3, Table 2), and the second seeks to endogenize it within the overall model (Regressions 4-6, Table 2). In regression

[11]In 1982 and 1988 the index is based on 30 pieces of information in four groupings: policies and program organizational support, range of services provided, record keeping for improving services, supplies of birth control services (Lapham and Mauldin, 1985). The 1972 index is based on fewer series, but is offered as compatible (Mauldin and Berelson, 1978). Aside from the subjective nature of much of the information, the major limitation of the index is that it includes contraceptive supplies. A dominant source of variation in fertility in the world is use of birth control, which is the result of both the supply of such services and the demand for them. Thus the index does not represent only the "supply" price of birth control services, but the quantity used which also embodies the effect of factors affecting the "demand" for children. It is not possible to eliminate the contraceptive prevalence components in the index for the purposes of this analysis. See Entwisle (1989) for an analysis that decomposes this effort score into its more and less justifiably exogenous components. For a further discussion of how the proximate determinants of fertility framework that seeks to measure the fertility effect of contraceptive use can be integrated into a statistical analysis within the household demand model see Schultz (1992).

15a

Table 2

Cross Country Regressions of the Total Fertility Rate (TFR) and Child Mortality Rate to Age 5 (CMR)[a]

Dependent Variable:	(1) Child Mortality	(2) Fertility	(3) Fertility	(4) Child Mortality	(5) Family Planning Activity	(6) Fertility
Estimation Method:	(CMR)	(TFR)	(TFR) Reduced Form	(CMR)	(FPA)	(TFR)
	OLS[c]	2SLS[c]	OLS	OLS	OLS	2SLS
Explanatory Variables:						
Years of Female Education[b]	-11.3 (4.30)[a]	-.161 (1.21)	-.450 (7.46)	-13.0 (4.93)[a]	4.72 (3.24)	-.238 (1.32)[a]
Years of Male Education[b]	1.67 (.99)	.152 (2.60)	.195 (5.03)	1.33 (.77)	1.06 (1.11)	.144 (2.39)
Log of GDP per Adult (1988$, Purchasing Power Parity)	-24.7 (4.03)	1.20 (3.64)	.567 (4.03)	-25.5 (4.09)	2.28 (.66)	1.15 (3.36)
Urban Percent of Population	.321 (1.58)	-.0194 (2.79)	-.0108 (2.33)	.355 (1.70)	-.0869 (.75)	-.0172 (2.18)
Percent of Male Labor Force in Agriculture	.821 (4.88)	-.0042 (.47)	.0168 (4.37)	.854 (4.98)	-.0923 (.98)	-.0022 (.22)
Catholic Percent of Population	.196 (2.13)	.0030 (.80)	.0078 (3.70)	.264 (2.90)	-.201 (4.01)	.0054 (1.01)
Protestant Percent of Population	.422 (2.02)	.0065 (.03)	.0173 (3.62)	.545 (2.62)	-.364 (3.18)	.0111 (1.04)
Muslim Percent of Population	.602 (5.37)	-.0062 (1.01)	.0095 (3.69)	.644 (5.68)	-.119 (1.92)	-.0040 (.57)
Year 1982 Dummy	-8.49 (1.47)	.278 (1.31)	.063 (.48)	-9.61 (1.60)	3.70 (1.12)	.252 (1.16)
Year 1988 Dummy	-8.22 (1.13)	.673 (2.89)	.465 (3.13)	-13.3 (2.04)	15.3 (4.24)	.503 (1.43)
Calories consumed per capita per day	-.140 (1.94)		-.0028 (1.69)	-.154 (2.09)	.0428 (1.05)	
Calories per capita squared $x10^{-3}$	.0211 (1.44)		.00037 (1.10)	.0243 (1.63)	-.0098 (1.20)	
International Planned Parenthood Federation (¢/woman)				-.0174 (.41)	.0653 (2.80)	
Child Mortality to age five (CMR)		.0257* (3.15)				.0250* (3.01)
Family Planning Activity Score (FPA)	-.343 (2.80)	-.0102 (2.08)	-.0192 (6.82)			.0022* (.11)
Intercept	511. (5.28)	-6.97 (2.06)	5.23 (2.36)	523. (5.30)	-36.4 (.67)	-6.91 (2.02)
R^2	.821	-	.773	.814	.498	-
	71.7	26.8	53.3	68.5	15.5	24.6

Notes: See Table 1. Sample size is 217.

(1) of Table 2 the child mortality rate is regressed on the variables included in Table 1, Col. (3), plus the measure of family planning activities, assuming it is exogenous. The total fertility rate is then estimated again by 2SLS in regression (2) treating child mortality as endogenous, as the Wu-Hausman test rejects its exogeneity. The result confirms previous research that family planning, if it is exogenous, is negatively associated with total fertility rates. There are few substantial changes in the other regression coefficients with and without the inclusion of family planning.[12]

In regression (1) of Table 2, family planning is associated with lower child mortality. A standard deviation increase in the family planning score, of 25 points, is associated with a decrease in child mortality of 6 percent, or 8.6 per thousand births. Half of the effect of family planning on fertility is therefore through its impact on child mortality, which then leads to lower

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[12]Several studies have sought to summarize development (or social setting) and family planning into two index variables to account for fertility. They find that there is a statistically significant interaction between them (Mauldin and Berelson, 1978; Bongaarts, et al. 1990). In other words, the effect of a strong family planning program is greater in advanced social settings and smaller in less advanced social settings. This synergistic relationship between family planning and development can be investigated here for each dimension of development. Interaction variables are constructed between the family planning activity score variable and all of the other demand variables. None is statistically significant in explaining fertility levels except the child mortality rate. Whether child mortality is assumed to be exogenous or treated as an endogenous variable, the coefficient on the interaction of child mortality and family planning is statistically significant and positive, suggesting family planning has its greatest effect on fertility in an environment where child mortality is low and vice versa. In the pooled cross section (sample n= 217) the three variables have the following coefficients (Cf. Regression (3) Table 2):

$$\underset{}{TFR} = \underset{(4.37)}{.0182\ CMR} - \underset{(3.26)}{.0198\ FPA} + \underset{(2.23)}{.0000843(CMR*FPA)} + \ldots \qquad R^2 = .77$$

These results indicate that programs that reduce child mortality and those that foster family planning are complements so far as they reinforce each other in achieving the goal of reducing fertility.

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fertility (-.343* .025 = -.088). In other words, the total effect (as in the reduced form in regression (3) Table 2) of family planning on fertility is about twice as large as the direct effect estimated in regression (2), with the remainder of its effect being transmitted through child mortality.[13] A synergistic reinforcing effect of family planning and maternal-child health programs on fertility has been hypothesized (Berelson and Taylor, 1968), and estimated from individual data for Colombia and India (Rosenzweig and Schultz, 1982; Rosenzweig and Wolpin, 1982). Nonetheless, it is possible that family planning programs are more effective when they are geared toward the single objective of reducing birth rates, and not integrated with programs that foster allied objectives of improving child health and women's education. One reason the prospects of policies that go "beyond family planning" are said to be bleak is the comparative ineffectiveness and high cost of child health and women's education initiatives (Berelson, 1969). These pooled cross country estimates suggest that both family planning and women's education programs exert half of their total effect on fertility through their intermediary role of reducing child mortality.

If as discussed earlier, family planning effort is in part a government response to parent demands for children, what measurable sources of variation in family planning would be independent of fertility "demands" and thereby allow the

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[13]Bongaarts et al., (1990) has drawn attention to the anomaly that if family planning programs reduce fertility they would also increase the proportion of first births and possibly shorten birth intervals. In most populations the incidence of child mortality is higher for first births than subsequent ones, probably for biological reasons. Consequently, this birth-order composition effect of family planning could increase child mortality. But the empirical evidence presented here suggests that this effect is swamped by the mortality reducing effects of the mix of programs and policies measured by the family planning effort score.

researcher to identify how independent variations in the "supply" of family planning effort impacts on fertility? The meaning of any estimate of the effect of endogenous family planning on fertility depends on this choice of identification restriction. Only one variable could be found: the annual allocation of centrally provided family planning funds by country by the International Planned Parenthood Federation (IPPF). These external subsidies in 1988 (FX) dollars to another country's family planning program are divided by the number of women in that country of childbearing age, 15-45, and used to help explain the family planning effort index in regression (5) Table 2. IPPF transfers represent in the sample only 28 U.S. cents per woman per year on average, and they are zero in 18 countries. The estimated effect of IPPF transfers on family planning activities is positive with the t of 2.80, suggesting IPPF may be a satisfactory instrument for FPA (regression 5). International transfers from other donor agencies, such as from USAID, UNFPA, World Bank, etc. (avoiding, of course, any double counting) could not be found by country overtime. It may be noted in regression (5) that family planning activities are also stronger in countries with fewer Christians and Muslims, and with more highly educated women. The Wu-Hausman test rejects again the null hypothesis that child mortality is exogenous, which has been accordingly estimated as an endogenous variable in regression (6) in Table 2. But when family planning activity is treated as endogenous and identified by IPPF transfers, the Wu-Hausman t statistic is only 1.34 for the family planning variable, which is only significantly different from zero for a two tailed test at the 20 percent level. This specification test suggests that one cannot reject the null hypothesis that family planning is, contrary to expectation, exogenous.

The standard errors of equations (2) and (6) with predicted variables are appropriately adjusted.

When family planning is nonetheless treated as endogenous in regression (6) of Table 2 along with endogenous child mortality, the estimate of the effect of family planning is not significantly different from zero. Given the limited information I have for identifying the endogenous effects of family planning on fertility, there is no reason to conclude that family planning has affected fertility. If one treats the family planning variable as exogenous in regression (2), in accord with the Wu-Hausman test, a one standard deviation increase in the family planning policy variable from 34 to 59 is associated with a five percent decrease in fertility, or of about .26 children or 5 percent. From family planning's effects on child mortality another .23 child reduction in fertility may be expected. If family planning is treated as endogenous neither of these effects are statistically significant or substantial.

In terms of the fraction of the sample variation in fertility explained, or in terms of the change in fertility associated with a standard deviation in the conditioning variable, family planning program effort is no more "important" a determinant of fertility than women's and men's education, property income, urbanization, and arguably, child mortality. The dilemma with these findings is that they do not provide us with a strong empirical basis on which to identify without simultaneous equation bias a parameter of interest: the effectiveness of family planning to reduce fertility[14].

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[14]There are clear conceptual problems in regarding as exogenous some of the data series aggregated into the family planning effort index (Lapham and Mauldin, 1985). This index appears to measure contraceptive prevalence (Entwisle, 1989), and is thus certainly endogenous to a model of fertility determination (Schultz, 1992a).

Prices of Contraception

Among specific forms of birth control, prices for oral contraceptives are available from the largest number of low income countries. In 1988, 58 low-income countries report such prices (Population Crisis Committee). The sample average price for an annual supply of 13 cycles of oral contraceptives is $38.60. This is reported to be the method used by 12 percent of the contracepting couples in low income countries, the third most popular method after the IUD (24 percent) and sterilization (45 percent) (United Nations, 1989). Whether the price of oral contraceptives is a reasonable proxy for the prices of other methods in each country, is not known. Family planning programs may subsidize pills or make them available at less than market price because they are provided by international doner agencies who in turn purchase them in bulk. Although the average price of pills may be affected by demand driven population policies, it is more reasonable to assume that this price variable is uncorrelated with other unobserved determinants of fertility and can therefore be treated here as exogenous.

In Table 3, the price of oral contraceptives replaces the family planning index for the smaller sample of 58 countries in 1988 for which prices are available. Estimates of child immunization are also available for these countries, reflecting progress of a major international campaign to increase child survival. The percentage of children receiving dpt (diphtheria, pertussin and tetanus) vaccine by their first birthday is included as a determinant of child mortality in regression (1). Regression (2) reports the two-stage least square (2SLS) estimates, based on the Wu-Hausman test that child mortality is not exogenous. Regression (3) Table 3 is the reduced form for fertility that omits child mortality but includes calorie consumption and dpt immunization. These

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Table 3

Cross Country Regressions for 1988, with Child Immunization for Diptheria/pertussin/tetanus (dpt) and Prices of Oral Contraceptives[a]

Dependent Variable: Estimation Method:	(1) Child Mortality (CMR) OLS	(2) Fertility (TFR) 2SLS[c]	(3) Fertility (TFR) OLS	(4) Means (Standard Deviations)
Explanatory Variables:				
Years of Female Education[b]	-12.1 (3.34)	-.249 (1.28)	-5.00 (3.82)	4.53 (2.29)
Years of Male Education[b]	.263 (.11)	.231 (2.35)	.237 (2.79)	6.30 (2.44)
Log of GDP per Adult (1988$, Purchasing Power Parity)	-12.2 (1.14)	.608 (1.21)	.354 (.92)	8.08 (.794)
Urban Percent of Population	-.012 (.05)	-.0134 (1.23)	-.0135 (1.41)	45.6 (22.4)
Percent Male Labor Force in Agriculture	.251 (1.02)	.0087 (.84)	.0139 (1.57)	44.0 (26.6)
Catholic Percent of Population	.325 (2.54)	.005 (.89)	.012 (2.64)	39.2 (38.6)
Protestant Percent of Population	.810 (2.50)	.014 (.94)	.031 (2.67)	8.50 (12.4)
Muslim Percent of Population	.548 (3.25)	-.000 (.02)	.011 (1.87)	24.4 (35.7)
Calories consumed per capita per day	-.282 (2.29)	-	-.0054 (1.22)	2475. (398.)
Calories per capita squared $x10^{-3}$	.0489 (2.04)	-	.00093 (1.08)	6281. (2004)
Percent Children age one immunized for dpt (1990)	-.282 (2.29)	-	-.0149 (1.69)	75.2 (17.0)
Price of Oral Contraceptives ($/year)	-.0663 (.68)	.0066 (1.70)	.0533 (1.51)	40.4 (39.7)
Child Mortality Rate to age five (CMR)		.0207* (2.37)		107. (65.9)
Intercept	661. (4.20)	-2.97 (.63)	10.2 (1.81)	4.86[d] (1.63)
R^2	.895	-	.779	
F	32.0	11.8	13.2	

Notes: See Table 1. Sample size is 58.

estimates are similar to those reported in Regression (5) Table 1. Increasing child immunization for dpt by 17 percentage points, or a standard deviation, is associated with a reduction in child mortality of five per thousand births. The oral contraceptive price has the expected positive effect on fertility and it is statistically significant at the .05 level one-tailed test. A standard deviation increase in the annual price of oral contraceptives from $40 per year to $80, is associated with an increase in the total fertility rate of .26 children, or by 5 percent. In short, these estimates confirm that the elasticity of fertility with respect to the price of one form of widely marketed contraception is positive but only about .05.

5. Time Series Changes within Countries

Data are available on all variables except the "price" of contraceptives and child immunization for 66 low income countries in 1972, 1982, and 1988, a period during which the total fertility rates declined on average by .78, or 13 percent. The same model may therefore be estimated from the cross country or within country variation in this panel, or based on a more realistic specification of the stochastic term. In shifting from cross sectional estimates of a behavioral relationship to estimates based on time series variation, dynamic model limitations tend to become more salient (Kuh, 1959; Nerlove, 1965; Hausman and Taylor, 1981). Assume, as I have, that fertility of country i at time t, F_{it}, is a linear function of a set of concurrent conditioning variables, X_{it}, and a family planning program variable, P_{it} :

$$F_{it} = \alpha_o + \alpha_1 P_{it} + \sum_{j=2}^{n} \alpha_j X_{jit} + u_i + e_{it} , \qquad (1)$$

where it is now assumed that the error has two components, one associated with the country, u_i , either random or persistent over time, and another independently distributed error, uncorrelated across time or countries, e_{it}.

First, a Lagrange multiplier (LM) test is performed to assess whether ordinary least squares (OLS) estimates based on the pooling of the panel data are consistent, or whether the country specific component should be incorporated into the estimation by a suitable procedure, such as Generalized Least Squares (GLS).[15] The next to the last row in Table 4 reports this specification test for the single equation (reduced-form) models indicating whether the OLS estimates should be rejected in favor of either a random-effects model for u_i, and estimated efficiently by GLS, or a time invariant model estimated by fixed-effects (FE). The FE model, however, is less efficient in the sense that it does not use any information from the cross country variation in the panel. The Hausman and Taylor (1981) specification test is then reported in the bottom row of Table 4 for the null hypothesis that the X_{ji} and u_i are uncorrelated. If the null is rejected, both OLS and GLS estimates are inconsistent, and fixed effects estimate is preferred. The fixed-effect estimates of equation (1) may be thought of as based on first differences in all the variables over time (T) within countries, where the confounding of regressors with each country's fixed effect is swept out, if the u_i are as assumed time invariant, and one obtains:

$$F_{it} - F_{it-T} = \alpha_1(P_{it} - P_{it-T}) + \sum_{j=2}^{n} \alpha_j(X_{jit} - X_{jit-T}) + (e_{it} - e_{it}). \qquad (2)$$

[15]Missing data from the panel is assumed to be randomly missing, in which case including single observations in the GLS estimates is possible and the entire sample of 217 country-year observations is retained for GLS, but only 198 observations are used for FE estimates (Hsiao, 1986).

Table 4

Generalized Least Squares Estimates from the Panel of 1972, 1978 and 1988 Assuming Random Error Structure

Dependent Variable: Estimation Method:	(1) Fertility (FPA Endogenous) (TFR)	(2) Fertility (FPA Exogenous) (TFR)	(3) Child Mortality (CMR)	(4) Family Planning (FPA)
Explanatory Variables: Years of Female Education[b]	-.454 (6.51)[a]	-.456 (6.78)	-3.21 (1.25)	-.378 (.26)
Years of Male Education[b]	.180 (3.43)	.204 (4.12)	-3.40 (1.68)	3.97 (3.52)
Log of GDP per Adult (1988$, Purchasing Power Parity)	.118 (.86)	.265 (1.91)	-16.8 (3.38)	6.50 (2.41)
Urban Percent of Population	-.0017 (.30)	-.0049 (.93)	-.282 (1.35)	-.139 (1.17)
Percent of Male Labor Force in Agriculture	.0210 (4.70)	.0190 (4.39)	.817 (4.99)	.0540 (.57)
Percent of Catholic Population	.0127 (3.86)	.0104 (3.56)	.269 (2.02)	-.204 (2.79)
Percent of Protestant Population	.0256 (3.35)	.0217 (3.26)	.561 (1.82)	-.377 (2.20)
Percent of Islam Population	.0165 (4.25)	.0134 (3.88)	.794 (5.09)	-.216 (2.51)
Calories Consumed per capita per day ($x10^3$)	-.742 (3.89)	-.815 (4.13)	-12.2 (1.80)	-4.35 (1.10)
IPPF expenditures	-.0113 (.14)	-	-	.100 (5.83)
Family Planning Activity (FPA)	-	-.0101 (3.67)	-.212 (2.17)	-
1982 Year Dummy	-.0417 (.47)	.0078 (.09)	-12.0 (3.85)	5.61 (3.06)
1988 Year Dummy	.0230 (.21)	.231 (1.92)	-14.9 (3.42)	19.9 (8.52)
Constant	4.63 (3.91)	4.23 (1.71)	278. (6.39)	-17.0 (.68)
Pseudo-R^2	.704	.753	.775	.458
Lagrange Multiplier (LM) test rejecting OLS pooled for GLS or fixed effects model specification (confidence level)	85.02 (.0000)	49.78 (.0000)	96.69 (.0000)	70.09 (.0000)
Hausman test for fixed effects model versus GLS (confidence vel)	(.589)	(.029)	(.000)	(.686)

It is commonly assumed that the errors, e_{it}, are normal and independently and identically distributed, and then the differences in errors over time are also normal and iid. If the conditioning variables do not change in the short run (T), such as with religion, their coefficients cannot be estimated from the fixed effects framework. The intercept, α_0, vanishes if there is no time trend, or if there is a time trend, it is estimated as an intercept in (2).[16]

The fixed effect specification draws attention to the rudimentary dynamics in the "static" fertility behavioral model (2). Fertility at time t is assumed to be only a function of P and X's at t, rather than depend on a more complex history of these variables that may be used by people to form their expectations about the future. In the cross section one may be approximating long-run equilibrium tendencies in behavior (Kuh, 1959), but from the first differences it becomes obvious that the "dynamic" adjustment process places inordinate weight on one episode of change in the conditioning variables to explain the concurrent movement of fertility to what is presumably a new equilibrium.[17] By extending

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[16]It is unclear whether the time trend should be restricted to zero or not. In the original fertility regressions (2) and (5) in Table 1, that are estimated by OLS, there is no statistically significant difference in the intercepts for the three cross sections, or no marked time trend. However, with the structural estimates with child mortality endogenized in regression (4) in Table 1 or (2) in Table 2, an unexplained positive shift in 1988 TFR is notable. Child mortality decreases over time more rapidly than explained in regression (4) in Table 2, and family planning activity increases more rapidly than explained in regression (5) in Table 2. In the results reported in Table 5 the time trend is allowed to vary for each interval. Results are not sensitive to restricting the trend to zero in the reduced form specification (1).

[17]If one maintained this hypothesis it would also imply the desirability of measuring fertility and conditioning variables for cohorts. Rather than relying on period measures of fertility, such as the total fertility rate, cohort measures of children ever born should be analyzed in the future, with possible corrections for censoring by age for cohorts under age 45. Unfortunately, there are few countries for which these more suitable cohort data on fertility exist, and if one also required child mortality and education by sex and income by

the length of time between the first differenced observations (T) to a decade, it may be more plausible, despite the inadequacies of the static framework, to gain insight from this approach into the factors that determine fertility. However, the task of endogenizing child mortality rates and family planning program activity is undoubtedly more difficult to implement in the first-differenced specification than in the levels of the variables. A cautious approach is to rely on the reduced-form specification based on fixed effects that is less dependent on knowledge of the dynamics of the full structural model.[18]

In Table 4 GLS estimates are reported for four single equation models that do not contain endogenous explanatory variables. The LM tests uniformly reject the OLS estimates in preference to these GLS or FE estimates. Regression (1) omits child mortality and family planning as potentially endogenous, and because the quadratic in calories is no longer statistically significant, the linear approximation is adopted with these panel analyses. The coefficients on the core

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cohort, there might not be any low income countries left in the working sample.

[18]Some studies of changes in TFRs (e.g. Bongaarts, et al. 1990) have regressed current fertility on lagged values of fertility and reported ordinary least squares (OLS) estimates. Clearly, country specific unobserved factors affecting fertility will persist to some degree over the period of analysis, and such serial correlation in errors embodied in fertility violates the assumptions under which OLS estimates are unbiased. Therefore, lagged fertility must be generally treated as endogenous and the model estimated by simultaneous equation methods. Schultz (1980) used province data for Taiwan in 1967 and 1971 to fit a stock adjustment model for fertility, which leads to a specification where the lagged fertility rate is an explanatory variable for current fertility. In this study the lagged variable is identified with lagged exogenous variables serving as instruments. A first differenced specification, as estimated here, is used by Schultz (1974) to analyze district level age-specific birth rates and age-standardized birth rates for Taiwan in the 1960s. None of the conditioning variables in this study, however, was treated as endogenous, and therefore the cross sectional (between) and first differenced (within) estimates are basically of a common reduced form specification, and both sets of estimates are quite similar in magnitudes.

variables are similar to the pooled cross section reduced-form OLS regression (5) in Table 1 , except that income and urbanization have lost their explanatory effect. Regression (2) is based on the assumption that family planning activity is exogenous, in which case the GLS estimates suggest a standard deviation increase in FPA is still associated with a five percent decline in fertility, as obtained in regression (2) in Table 2. Regression (3) in Table 4 explaining child mortality assigns different weights to women's and men's education in lowering child mortality than in the OLS pooled results reported in regression (1) Table 2. Finally, regression (4) for family planning activity differs from OLS estimates in regression (5) in Table 2.

The Hausman-Taylor test for whether the fixed-effect specification should be adopted is mixed (bottom row of Table 4). If family planning is endogenous and only IPPF expenditures are included, the GLS estimates are accepted and preferred because of their efficiency. But if FPA is exogenous, the GLS estimates are rejected in favor of the FE estimates. The Hausman test also rejects the GLS estimates for the child mortality equation, but accepts them for family planning activities.

Table 5 reports the fixed effect model estimates based solely on changes over time within countries. The estimated effects of female and male education and agricultural employment remain similar to those obtained by OLS, whereas the estimated effects of income and urbanization loose statistical significance and decline in magnitude as they did in the GLS estimates.[19] Family planning

[19] That the effect of urbanization is insignificant in the first-differenced specification is not surprising, since these changes are probably dominated by projections of trends, and are probably not greatly affected by actual current rates of rural-urban migration that might contain some information relevant to the economic model. Income effects in short periods are obviously noisy sources

Table 5

Regressions on Changes Within Countries from 1972 to 1988
or Fixed Effect Estimates[a]

Dependent Variable:	(1) Fertility (TFR)	(2) Fertility (TFR)	(3) Child Mortality (CMR)	(4) Fertility (TFR)	(5) Family Planning Activity (FPA)	(6) Fertility (TFR)
Estimation Method:	Reduced Form OLS[c]	Reduced Form OLS	OLS	2SLS[c]	OLS	2SLS
Explanatory Variables:						
Years of Female Education[b]	-.447 (3.91)[a]	-.478 (4.26)	13.8 (4.71)	-2.35 (.95)[a]	-3.89 (1.50)	-1.72 (1.09)
Years of Male Education[b]	.259 (2.75)	.291 (2.97)	-11.8 (4.40)	1.82 (.90)	7.20 (3.35)	1.20 (.98)
Log of GDP per Adult (1988$, Purchasing Power Parity)	-.0811 (.41)	-.0545 (.28)	3.60 (.70)	-.541 (.60)	6.51 (1.46)	-.707 (.81)
Urban Percent of Population	-.00215 (.20)	-.00248 (.23)	.0610 (.21)	-.0107 (.26)	-.310 (1.23)	-.00191 (.05)
Percent of Male Labor Force in Agriculture	.0274 (3.95)	.0278 (4.03)	.342 (1.89)	-.0185 (.26)	.0654 (.42)	.0127 (.23)
Calories consumed per capita per day ($x10^{-3}$)	-.652 (2.79)	-.668 (2.87)	-4.94 (.81)	-	-2.32 (.44)	-
IPPF expenditures per woman in (1988$)	.0316 (.27)	-	-	-	.110 (4.19)	-
Child Mortality to age five (CMR)	-	-	-	.135* (.77)	-	.108* (.87)
Family Planning Activity Score (FPA)	-	-.00323 (.89)	.0505 (.53)	-.0107 (.62)	-	.0271* (.69)
1982 Intercept	-.0866 (.62)	-.0662 (.47)	-31.3 (8.48)	4.17 (.75)	6.90 (2.18)	3.07 (.81)
1988 Intercept	-.719 (.36)	.310 (.01)	-48.0 (8.45)	6.50 (.76)	22.5 (4.58)	4.36 (.80)
F (80, 129)	25.9	26.1	99.5	38.3	13.6	1.17

Notes: See Table 1. Sample size is 210, but minus 72 country fixed effects the actual degrees of freedom is only 139.
*Endogenous variable.

activity, even when assumed exogenous, exerts no significant effect on fertility in the fixed effect model, and the magnitude of the coefficient declines two thirds. A standard deviation increase in family planning of 25 is associated over time with less than a two percent decline in fertility.

Regression (3) in Table 5 for child mortality rates yields a relationship that is not consistent with those estimated from levels (regression (1) Table 2), suggesting that the dynamics of this relationship are not being captured in these ten and six year periods. Regression (4) treats the child mortality rate as endogenous, and the FE estimates for female and male wage variables remain negative and positive, but become larger in absolute magnitude than previously estimated. Regression (5) in Table 5 seeks to explain changes over time in family planning activity, so as to treat family planning as endogenous. The two-stage FE estimates of the fertility equation in regression (6) imply no significant relationship between changes in family planning activity and changes in fertility. Only the reduced-form FE estimates in regression (1) appear to provide a plausible interpretation of fertility changes: the effort to include child mortality or family planning as endogenous does not yield convincing FE estimates of the structural models.

Evaluating the effects of social intervention programs, such as family planning, is rarely possible with country level data, though such data may appear useful for testing general hypotheses about the cons quences of different patterns of development and suggest linkages that warrant further study. Family planning, health and education programs often differ substantially across a

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of signal on lifetime constraints facing couples that should be relevant to their fertility goals and behavior.

national population and this variation can provide scope to estimate the behavioral impact of various mixes of program activities. Controlling for demand determinants of fertility may improve further efforts to evaluate family planning programs in such a quasi-experimental setting, because the demand factors and program activities may themselves be intercorrelated and the omission of one factor will bias estimates of the effect of the other. Studies of Bangladesh, Taiwan, Thailand and China have used econometric methods to estimate the effects of family planning activity on birth rates (Foster, 1992; Gertler, et al., 1992; Schultz, 1974, 1980, 1992a; Casterline and Montgomery, 1991; Schultz and Zeng, 1992). They have shown the diminishing returns to scale of such activity, and the substitutability between family planning outreach activities and the education of the women being served by such programs (Schultz, 1988). These studies also provide the means to estimate more than the magnitude of the program's effect on birth rates. The distribution of program benefits are readily estimated from the coefficients on interaction variables, defined as the product of the program's regional inputs and each distinguished individual exogenous group identifier (Schultz, 1992a). The policymaker is thus informed of the distribution of the program's benefits by such socioeconomic groups in the population, defined by such characteristics as age, ethnicity, education, and region of residence.

6. Conclusions

A series of studies have found that both family planning and development are associated across low income countries with lower levels of fertility. I have also found such patterns. What distinguishes the approach followed here and

how do the findings differ from those referred to earlier?

First, simple static theory is used to conceptualize the constraints imposed on (not chosen by) individuals that may influence their demand for children. Development may involve a different mix of structural changes in each country, some associated with declines in fertility and others with increases. Unless we get beyond the search for a single "index of development", and focus on measuring the dimensions of modern economic growth that have theoretically prescribed effects on fertility, the search for empirical regularities between development and fertility is unlikely to be informative. Fertility should be statistically interpreted in terms of these multiple theoretical constraints, allowing their independent effects to be nonlinear and to interact. Procedures that collapse the diversity of development into a single index seem archaic and counterproductive.[20]

Second, most prior studies have included education as a demand or development indicator, but none, to my knowledge, distinguish between the education of men and women. This practice continues despite the clear prediction of the earliest economic models of fertility that the effect of female education will be more negative than the effect of male education (Schultz, 1973).

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[20] The United Nations (1987) proposed that an index of development be constructed as the average of four series: GNP per capita, gross school enrollment ratio, infant mortality rate, and per capita number of radios, Tvs, and cars. Bongaarts, et al. (1990) use this index for their portrayal of the demographic effect of family planning. As with and Mauldin and Berelson (1978), and Lapham and Mauldin (1987) countries are displayed on a two way grid of the development index and the family planning effort index. The most recent Bongaarts et al. (1990) paper concludes that the absence of family planning programs worldwide would have led to a total fertility rate for low income countries that would be 1.2 children higher in 1980-85, or the TFR would have been 5.4 rather than 4.2. As a comparison, the pooled cross sections (Table 2, regression (2)) suggest that if the mean level of family planning score had not been 34 but zero, the associated TFR would have been .3 lower (34* (-.0089)).

Disaggregation of adult education by sex as a proxy for the value of time and wage rates of women and men is absolutely essential to explore the relevance of the micro economic model of fertility. This interpretation of women's education is also compatible with other interpretations of education as empowering women and thereby contributing to fertility declines, or Caldwell's (1982) view that mass education provides women with the capacity for decisionmaking in the family.

Third, child mortality is arguably not exogenous to the economic endowments, preferences, and conditions of the family, despite the likely importance of some community health measures and local disease environments in affecting child deaths. But the family's resources are also important, such as the educational attainment of a mother that explains empirically the probability of survival for her children. Consequently, either child mortality must itself be studied within the same conceptual framework as fertility, or a reduced-form equation for fertility should be estimated where child mortality has been implicitly solved out of this relationship. The availability of calories per capita is specified in this paper as a determinant of child mortality, but excluded from the fertility equation. The estimated effect of endogenous child mortality on fertility appears to be several times larger than when child mortality is viewed, as in prior studies, as if it were exogenous and measured without error. According to the estimates confirmed by specification tests that treat child mortality as endogenous, declines in the level of child mortality in developing countries are not associated with increases in population growth, because fertility declines fully offset this demographic effect of improvements in child health and nutrition.

Fourth, countries that have higher permanent incomes in the cross section,

given their human resource base, have higher fertility. This can be readily accommodated in the demand model of fertility. If the level of income is due to physical capital and natural resources, such as petroleum, which may have only a modest short run effect on the productivity of the time of men and women, then increment in income will not be offset by an increase in the opportunity cost of the time of parents. A higher level of GDP per adult, that is not associated with higher male and female education or lower child mortality, can be expected to increase demands for children. Interestingly, the effects of gender-specific education and income on fertility are strengthened when several variables for religion are controlled, such as Christianity and Islam. For example, the relatively high levels of fertility in Islamic countries are explained here in terms of the underlying economic constraints on the population, including past educational investments in women. One does not have to resort to ad hoc cultural variables to explain most of the variation in fertility across low income countries (Cf. Table 1, regressions (1) and (2), or Table 2, regression (6)).

Fifth, family planning programs are summarized by an index used in a series of influential articles buttressing the idea that family planning is responsible for much of the reduction in fertility in low income countries. If this family planning were an experimental treatment administered randomly to different countries, it could be argued that these programs are as implicitly claimed exogenous to the preexisting development and demand factors in these countries. Under this working hypothesis, family planning as an exogenous conditioning variable is related to lower levels of fertility in the cross section. A standard deviation increase in the family planning index from 34 to 59 is associated with a five percent decline in fertility. But if family planning

effort is explained within the model and endogenized, the relationship between it and fertility becomes statistically insignificant. Nevertheless, when the price of oral contraceptives is treated as an exogenous price of birth control, this more defensible exogenous policy variable accounts for a significant, though small, share of the variance in fertility, with a doubling of the price of birth control being associated with fertility being five percent higher.

Sixth, when the fertility analysis shifts from cross sectional levels to the more difficult to explain changes over time within countries, from 1972 to 1988, it is possible to estimate with confidence only a reduced-form specification of the same fertility model, without explicitly including child mortality. Based on fixed effect estimates where family planning is treated as exogenous, the impact of family planning on fertility is only one-third as large as when estimated by OLS or GLS. No effect of family planning is found when these programs are endogenized and estimated by fixed effects. Female and male education and agricultural employment exhibit significant estimated effects on fertility of roughly the same magnitude whether estimated by OLS, GLS or fixed effects.

Seventh, the Bucharest World Population Conference in 1974 first asked whether fertility declines are promoted by development or by organized family planning activities? This question may be poorly framed, for both are certainly relevant. But the thrust of this analysis is that the level and sex composition of human capital, the decline of agricultural employment, and the basic nutrition of the population explain most of the variation in the levels of total fertility rates and their changes over time, whereas family planning explains relatively little of either cross sectional or time series variation in fertility. Some

changes associated generally with modern economic growth raise fertility, such as male education, nonhuman capital returns, and the decline in agricultural employment, whereas others such as improved female education, urbanization, increased availability of food, and a resulting decline in child mortality, are associated with fertility declines. The specific mix of these sources of growth and development in any particular country will then influence whether its development is pronatal or antinatal. No single path must be followed: Libya and Kuwait appear to have developed differently than Korea and Singapore.

The education of women is the dominant empirical factor associated with the decline in fertility in the cross section and over time. But since male education has a weaker but countervailing effect on fertility, a critical dimension of development is likely to be the investment in schooling of females relative to males. Growth in income alone lowers child mortality but has little total (reduced-form) effect on fertility. Raising calorie availability at very low levels appears to be strongly related to lowering child mortality and thereby contributes to declining fertility at early stages in the development process.

In the changes over time, family planning effort does not emerge as an important determinant of fertility. Because of the complexity of the policy formation process, and the lags between changes in the constraints on individuals and dynamic adjustments in their fertility, intercountry comparisons are not well suited to provide definitive answers on the cost effectiveness of social welfare programs, such as family planning. Program evaluation studies are more promising when conducted within individual countries, in those cases where administrative regions have implemented distinctively different policy packages without regard to socioeconomic development of the regions. When individual household survey

data are then combined with administrative information on program expenditures or activities by small service region, convincing evidence can be constructed on the contribution to fertility declines of family planning programs (or lack of it), holding constant for the principal household demand factors. Even in these cases the first differencing of data by region helps to purge from the analysis potentially misleading correlations between region fixed effects and program inputs. Aggregate data for countries may not provide a credible answer to the question: how much difference has organized family planning made? But models for cross country differences and change within countries may still shed light on the connections between the sources of modern economic growth and their consequences for the decline in child mortality and fertility in this century.

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Data Appendix

Variable Definition	Sources
1. Total Fertility Rate	United Nations, 1990, World Development Prospects and Demographic Yearbook.
2. Child Mortality Rate per thousand births	United Nations, 1988, Mortality of Children Under Age 5, 1980.
3. Years of Schooling Completed by Adult Population by Sex.	World Bank, diskette Soual data, 1992. UNESCO, Statistical Yearbooks.
4.a Real GDP per adult in U.S. 1988 $ using foreign exchange rates (in logarithms).	World Bank, 1991, World Tables, WDR 1990, UN Statistical Yearbook and IMF International Financial Statistics Yearbook.
4.b Real GDP per adult in 1985 international prices (PWT5) or purchasing power parity (in logarithms)	R. Summer and A. Heston, 1991, Expanded Set of International Comparisons 1950-1988," Quarterly Journal of Economics 104:2 (May) 327.
5. Urban Population Share (percent)	UN Demographic Yearbook, 1991, World Tables, 1990 World Urbanization Prospects.
6. Percent of male labor force in agriculture, forestry, and fishing.	International Labor Office, Yearbook of Labour Statistics, various issues.
7. Religious composition as of 1980 (percent professing).	D. Barrett, 1982, World Christian Encyclopedia.
8. Calories per capita per day	Food and Agricultural Organization, 1976, FAO Production Yearbook, 1985 and 1991 WDR.
9. Family Planning Effort score	1972 scores in B. Berelson and W.P. Mauldin, 1978, "Conditions of Fertility Decline in Developing Countries, 1965-1975," Studies in Family Planning 9:5, 84-148. 1982 and 1989 scores in Ross et al., 1991, Family Planning and Child Survival Programs.
10. International Planned Parenthood Federation Expenditures in U.S. ¢ 1988 per woman age 15-45.	1989-90, IPPF Annual Report; 1973/74, 1983/84, 1988/89 Inventory of Population Projects, UN Population Fund.
11. Oral Contraceptive Price 13 cycles (one year) in U.S. $ 1990.	Access to Affordable Contraception, 1991, Report on World Progress toward Population Stabilization, Population Crisis Committee, Washington, D.C.
12. DPT immunization percent of children at first birthday	UNICEF, expanded childhood Immunization Campaign.

LIST OF COUNTRIES AND YEARS IN SAMPLE. UNLESS OTHERWISE NOTED 1972, 1982 and 1988

Algeria, Argentina (1988), Bangladesh, Barbados (1972), Benin, Bolivia, Botswana (1982 and 1988), Brazil, Burkina Faso, Burundi, Cameroon, Central African Republic (1982 and 1988), Chile, China, Colombia, Congo, Costa Rica, Cuba (1972 and 1982), Cyprus (1982), Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Fiji (1972 and 1982), Gabon (1988), Ghana, Guatemala, Guyana (1982 and 1988), Haiti, Honduras, Hong Kong (1982), India, Indonesia, Iran, Iraq, Ivory Coast, Jamaica, Kenya, Kuwait, Lesotho, Liberia, Libya (1972 and 1982), Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Morocco, Myanmar, Nepal, Nicaragua (1972 and 1982), Nigeria, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Republic of Korea, Rwanda, Senegal, Singapore, South Africa (1988), Sri Lanka, Sudan, Syria, Tanzania, Thailand, Togo, Trinidad & Tobago, Tunisia, Turkey, Uganda, Uruguay (1988), Venezuela, Zaire, Zambia, and Zimbabwe (1982 and 1988)