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Labor Market Activities and Fertility

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1. Introduction

In poor countries women tend to have high fertility and their children have high infant and child mortality rates. In rich countries, women tend to have low fertility and their children have low infant and child mortality rates. Thompson (1929) and Notestein (1945) described the change from the first state to the second as the "demographic transition," one of the most-studied ideas in the social sciences. Thompson's basic description is compelling: countries begin with high birth and death rates (Stage 1). At some point, death rates decline substantially, though birth rates do not (Stage 2). This stage involves substantial population growth. Then, birth rates also fall, and population growth begins to moderate (Stage 3). Stage 4 has both low birth and death rates.

What is more controversial is *why* this transition occurs, i.e. what causes each of the changes that Thompson described. Initial declines in mortality have been attributed to better health care; better sanitation; better, less variable food supplies; and better education and understanding of the causes of disease (especially among mothers). The ensuing decline in births has been attributed to the prior decline in mortality (if infant and child deaths are less likely, mothers do not need as many births to achieve a "target" number of children); to access to modern contraception; increased education (especially of women); urbanization; reduced reliance on subsistence agriculture (where children are productive hands); improved social insurance for retirees; changing norms about what constitutes a fulfilling life for women; improved status of women; increased power of women within families; and increased labor market opportunities for women. While each of these explanations has *prima facie* plausibility, their relevance to the demographic transition in any particular country is often hotly debated. For example, the demographic transition in Western Europe took place before the advent of either modern medicine or modern contraception. Yet both are surely important features of the transitions in today's developing countries.

Further complicating an interpretation of the demographic transition is that many of the factors cited are clearly inter-related, with plausible interpretations about causality running in both directions. For example, increased education for girls may help to reduce fertility for a variety of reasons: delayed onset of marriage and the first birth (in order to finish school); changed attitudes about what women should do (study and work rather than have many children); improved knowledge of health and birth control; etc. But it is also reasonable to suppose that reduced fertility, especially reduced teen pregnancies, increases girls' education by allowing them to stay in school. Untangling the many structural links between fertility, mortality, and poverty is complex both conceptually and empirically.

This paper focuses on one aspect of the demographic transition, women's labor market activity, and how it relates to the basic variables of fertility and poverty. Just as there are differences in fertility and mortality in rich and poor countries, there are differences in women's time use. In rich countries, women tend to work outside the home, usually in wage employment on a fixed hourly schedule. In poor countries, women tend to work at home or, especially in Africa, on their family's farm or at own-account activities where time use is more flexible. Understanding the relationship

between the demographic transition and these differences in time use is our main theme.

This topic is important for African policy makers interested in poverty reduction. Increasing employment opportunities for women, or increasing wages in existing employment opportunities, can lead to significant reductions in fertility as women chose to spend less time bearing and raising children and more time at work. Both of these effects lead to reduced poverty: the decline in fertility leads to "fewer mouths to feed," and the increase in labor market activity increases household incomes. It is important to note that this effect is probably stronger for improvements in *women's* employment and wages than it is for men's, for reasons that we discuss below. In a similar fashion, induced reductions in fertility, say, through improved access to reproductive health services, can lead to the same reallocation of time use for women, with similar results for poverty reduction.

2. Theory

2.1. The Work/Fertility Trade-Off

In general, women (and their families) choose both their fertility and their labor market activities. As such, both are endogenous variables, so it does not make sense to think of one causing the other in a reduced form sense -- both are determined by a larger set of constraints and circumstances. A simple model of a mother's choices[1] might have the form:

(1) max U(N,C) subject to
(2) $N = f(T_H,Z)$,
(3) $p_c \cdot C + p_z \cdot Z = w \cdot T_W + Y$,
(4) $T_W+T_H=T$.

Utility is a function of the number of children, N, and consumption, C. $f(T_H,Z)$ is a child production function with inputs T_H, the time spent raising children, and other purchased inputs Z. Total income is the sum of earned income -- the wage rate, w, times time worked (T_W)-- plus unearned income, Y. Income is spent on consumption and on inputs to the production of children. Finally, each mother faces a time constraint such that time spent raising children and working. For simplicity, we ignore leisure, both here and in the utility function.

How do women's labor market opportunities affect time allocations, fertility, and poverty? In this simple model, the wage rate, w, offered to women captures "labor market opportunities," and we take it as exogenous.[2] If the wage rate on offer increases, there are three effects. First, there is the substitution effect to spend more time working for wages and less time producing children. Holding all else constant,

[1] Here, we abstract from family considerations and suppose that mothers alone bear and raise children.
[2] This is not a realistic assumption, since the wages that one earns depend on education and work experience, both of which may be, in turn, affect by fertility. But for now, the assumption suits our purpose of developing a simple model to illustrate some key points.

this would lead to less fertility, greater income, and less poverty (as measured by income per capita). But there is also an income effect: as long as $T_W \neq 0$, the wage increase makes women richer, which leads to greater demand for both consumption *and* children, assuming that both are normal goods. This, it seems that the effect on poverty is clear, but the effect on fertility and time allocation is less so. The ambiguity comes from the well-known backward bending labor supply curve in which, at sufficiently high wages, the income effect almost surely overcomes the substitution effect to produce less labor supply, T_W, as the wage rises. The corresponding increase in time spent producing children, T_H, would increase fertility, all else constant.

Empirically, we have long observed that an increase in women's wages is accompanied by lower fertility (De Tray, 1973), which suggests that the substitution effect dominates the income effect in this case. One reason for this may be that time spent working at wage labor cannot be chosen continuously, but is either zero or some fixed amount, like 40 hours per week. In that case, any reduction in hours has to be to zero, and so eliminates the income effect, since at zero hours, labor income is zero regardless of how high the wage rate is.

There is a third effect in this model that might allow increased wages to lead to increased fertility. As wages increase, even if time spent working increases and time spent producing children declines, that decline may be offset by greater purchases of the inputs Z, which are made possible by the increased income from a wage increase. This, too, runs counter to what we observe empirically, so we must ask why this effect does not seem to be too important. The technical reason is that T_H and Z must not be easily substituted for one another. To some extent, this is a biological imperative: to have children, mothers must spend an unavoidable minimum amount of time not working at wage labor. But that amount of time is relatively brief, and some (though certainly not all) countries enforce labor legislation that requires firms to provide maternity leave of a few weeks to a few months. However, in many cultures, there is a social expectation that mothers will spend considerably more than the biological minimum time raising their children. Such norms will make the work/fertility trade-off more severe, and increase the impact of wage changes, or labor market opportunities more generally, on fertility.

To be precise, we should say "certain types of work." As we have noted, in developed countries where much of this literature comes from, work for women means formal sector wage employment with fixed time schedules. Such jobs are incompatible with spending time raising children. In Africa, however, women do many types of work that are at least somewhat compatible with child care. For example, African women often do agricultural work accompanied by their children, with infants strapped to their back. It is also possible to undertake some kinds of informal self-employment like trading while simultaneously caring for children. This "joint production" clearly eases the time constraint and thus the trade-off between women's work and child care.[3]

Nevertheless, there are some types of work, particularly regular wage labor, for which joint production is difficult or impossible. Women cannot usually take their children

[3] Formally, a mathematical model would need to have a function for the joint production of children (N) and consumption goods (C) that is a function of time spent at the joint activities.

with them to factories, offices, plantations, or call centers. For these jobs, the trade-off between employment and fertility is real. And as it happens, these are the jobs most likely to be associated with economic development and poverty reduction. This helps to explain why it is that we tend observe high fertility with poverty and vice-versa. Again, we are not attributing causation to either factor. We simply note that the time constraint will force this correlation.

In the model above, women choose an optimal number of hours to work outside the home, T_W. But most wage labor jobs have inflexible working hours, which may exacerbate the work/fertility trade-off. First, the time demands of child care are variable. During most days, it may be possible to work nine-to-five each day and still tend to one's children, but not when a child is sick, for example. But many wage jobs do not allow employees the flexibility to respond to these variable demands for child care by missing work. That, too, sharpens the wage work/fertility trade-off.

On the other hand, there are circumstances that can ease the trade-off. We have already mentioned joint production. For mothers employed in the formal sector, child care services provided either by the employer or the public sector, are sometimes available (though rarely in Africa). It may also be possible to purchase child care services by hiring a nanny. More likely, family members may substitute for the mother's time at child care. So we might want to rewrite the child production function as

$$N = f(T_H, T_O, Z)$$

Where T_H is mother's time spent with children, and T_O is the time of other family members spent at child care. This function may still have little or no substitution between time (the T_i's) and other inputs (Z), but substitution of different family members' time may be sufficient to allow women to pursue work outside the home while still having children.

At first glance, this possibility would seem to ease the work/fertility trade-off for women, and perhaps allow both increased incomes and fertility. However, other household members' time is not without its own opportunity costs. In particular, it is not unusual for older siblings, usually girls, to be charged with child care in families where mothers are unable to allocate sufficient time to that activity. If this means that they cannot attend school, it sets up a dynamic relationship between poverty and high fertility today and in the future. Girls from poor families with high fertility who do not finish school will have poor labor market opportunities (lower w in this model) and so be more likely to not participate in wage labor and to have high fertility themselves.

2.2. The Child "Quantity/Quality" Trade-Off

In the previous section, we saw that it is possible to develop a model of the fertility/work trade-off in which an increase in women's wages or wage employment opportunities yields a reduction in fertility, higher money incomes, and lower poverty. But that result is far from certain, requiring limited substitutability for a woman's time in the raising of her children and income effects that are not too strong. In a seminal paper, Becker and Lewis (1973) strengthen the argument that increases in women's

wages or wage employment opportunities will lead to lower fertility and higher incomes. They noted that parents care not only about the quantity of children that they have, but also each child's "quality," which we can interpret roughly has her/his human capital. Surprisingly, the Becker/Lewis model shows that the observed income effect for fertility may be negative even when children are a normal good. That is, when money income increases, even if it is not due to increased wages, it may cause a reduction in the number of children demanded.

To see why, add to the utility function above child quality, Q:

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

and ignore for the moment the labor supply decision.[4] Families maximize this utility subject to an income constraint:

$$I = N \cdot Q \cdot p + C \cdot p_C$$

where p is the price of N·Q (number of children times their quality) and p_C is the price of consumption goods. Note that this income constraint assumes that each child will be of the same quality Q, which is optimal of the quality production function has diminishing returns. The first order conditions for this problem are:

$$\delta U/\delta C = \lambda \cdot p_c$$
$$\delta U/\delta N = \lambda \cdot (Q \cdot p) = \lambda \cdot \pi_N$$
$$\delta U/\delta N = \lambda \cdot (N \cdot p) = \lambda \cdot \pi_Q$$

where λ is the marginal utility of income. The unusual thing about these results is that the marginal cost of N, or its shadow price, π_N, depends on Q, and vice-versa. In most cases, this marginal cost is the market price of a good, as it is for the consumption good C here. But for the quantity and quality of children, the marginal cost actually depends on the endogenous value of another choice variable because of their interaction in the budget constraint. This gives rise to two unusual results.

First, consider the effect of income on the number of children demanded (fertility). If we assume that children are "normal" goods, then the true income effect will be positive. However, the observed income effect can actually be negative. When income rises, it increases the demand for child quality, Q.[5] This increase in Q, in turn, increases the shadow price of child *quantity*, Q·p, which will decrease the demand for N. The overall observed effect of income on the demand for child quantity has two components: the usual income effect, assumed to be positive, and the induced effect that comes from greater demand for child quality, which is negative. There is no a priori reason to believe that either one of these effects dominates, though Becker and Lewis argue that the true income elasticity of demand for child quantity may be small. For our purposes, however, the key point is that the observed income elasticity of demand for child quantity could be negative. That would produce the often-observed correlation of higher incomes and lower fertility even if the increased income is not

[4] as do Becker and Lewis. Willis (1973) gives a model that considers labor supply, child quantity, and child quantity jointly.
[5] This assumes, quite reasonably, that child quality is a normal good.

coming from (women's) wages and thus does not involve the substitution effect for time allocations discussed in the previous section. Note that if we combine this model with the work/fertility model of the previous section, then an increase in women's wages (or labor market opportunities more generally) may cause reductions in fertility for two reasons: the standard substitution effect towards greater work, and this potentially negative income effect.

The second notable result of the Becker/Lewis model has to do with price effects. Suppose that family planning services become more affordable. We can interpret this as a rise in the price of child quantity (because it is a reduction in the cost of limiting that quantity). This has a pure substitution effect of reducing the demand for the number of children. But that demand will shift toward greater child quality unless quantity and quality are strongly complementary. The increased quality, in turn, increases the shadow price of child quantity, further reducing the demand for the number of children. At the same time, the reduced demand for the number of children reduces the shadow cost of child quality, inducing a further substitution toward greater quality. Thus, even though child quantity and quality may not be closer substitutes than either is for other goods, C, the observed cross-price elasticities between these two goods will be stronger than their cross-price elasticities to consumption. This presents the possibility that relatively small changes in the prices of child quantity or quality will induce large changes in fertility.

2.3. Summary

If we combine the arguments in the previous two sections, we have a model with three endogenous variables: women's labor supply, fertility (child quantity), and investments in children's human capital (child quality). Willis (1973) analyzes this model in detail. While these variables are jointly determined, and thus it does not make sense to think about causation among them, there are important feedback loops between them, and exogenous variables like the availability of family planning services will affect each of the three variables as women adjust their time use, fertility, and investments in their children to changing circumstances.

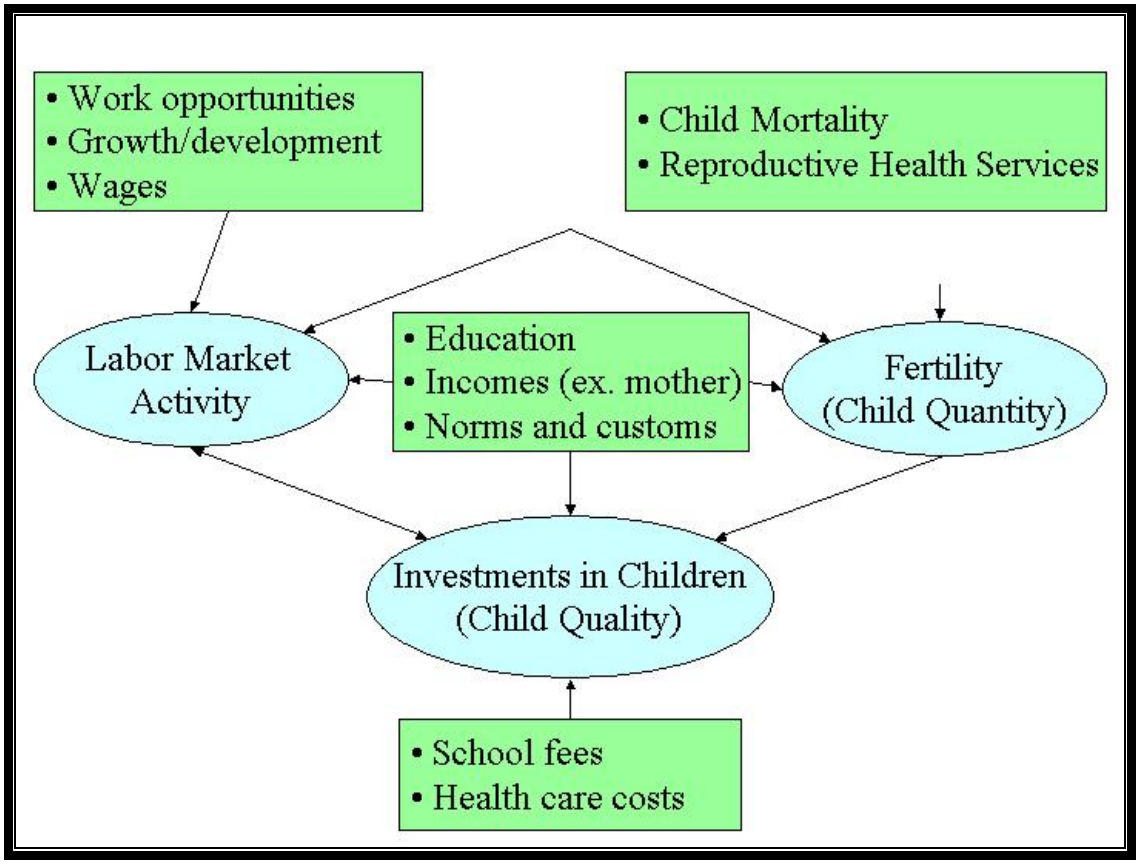

Figure 1 - Modeling Labor Market, Fertility, and Child Investment Choices

To fix ideas, consider Figure 1. The ovals are the three endogenous variables that we have been discussing, and the boxes are exogenous variables, including public policies, that may affect them. The exogenous variables are divided into four somewhat artificial groups. There are factors that seem most obviously associated with the labor market, like wages and employment opportunities. There are those mostly associated with fertility, like access to reproductive health care or child mortality probabilities. There are those most associated with investments in children, like school fees. And there are some factors that condition all of these effects, most notably education, income from sources other than the mother, and attitudes or norms.

2.3.1. Labor Market Opportunities

We have already discussed the possible impacts of increases in wages for women in some detail. For a variety of reasons -- discontinuities in hours worked, child rearing being considered "women's work," and the unusual interaction of child quantity and quality in the opportunity cost of the other -- increased wages for women are likely to generate greater labor supply, lower fertility, greater demand for child "quality," greater money incomes for women. Further, the latter two effects will yield lower poverty.

It is worth noting here that education levels (in the center box) will interact with the general structure of wage rates in determining labor supply, fertility, and investments

in children. Better educated women will earn higher wages and so have a greater incentive to work, reduce fertility, and increase investments in their children. This helps to explain why education is consistently correlated with lower fertility.

While economists love to analyze prices, in this particular case, job opportunities, especially opportunities for the kind of formal sector wage employment that is least compatible with fertility, are probably more important. Here, the prognosis for Africa is discouraging. Very few people have formal sector employment in Africa, and such employment is more common for men than women. Especially in rural areas, women's opportunities for formal wage work are almost non-existent, making wage rates irrelevant. There are simply no jobs of this type available. Nevertheless, there are examples of economic development that requires wage employment and at least one of the most common industries, textiles and garments, appears to have a preference for female employees. The same is true of the emerging cut flower industry and (perhaps) call centers. Introduction of these industries would produce the same sort of effects that we have seen for wage increases. By increasing the demand for (women's) labor, we can reasonably expect that this type of labor-intensive economic development will lead to lower fertility, greater investments in children, and less poverty.

2.3.2. Direct Influences on Fertility

Turning now to the factors that are directly linked with fertility decisions, children's mortality probabilities played a central role in the original ideas about the demographic transition. The basic idea is that parents have a desired number of children that they would like to see grow to adulthood. If they know that the probability of infant and child deaths is high, then they will have more children to account for that possibility. But once they are convinced that the mortality probabilities are low, they will also reduce fertility. On this view, the interpretation of the demographic transition is one in which infant and child mortality first fall, but it takes time for parents to recognize this and take it into account in their fertility decisions. Once they do, fertility also declines, and the transition is complete.

One problem with this interpretation is that people in poor countries seem to want far more children than are necessary to compensate for high child mortality levels. Even in very poor countries, child mortality is rarely higher than 20 percent, so parents wanting only two children to survive to adulthood -- the number necessary for long-run population stability -- would only need to have 2.4 births on average. Yet survey respondents usually report much higher desired fertility levels in Africa. Of course, not every parent's children suffer the average rate of mortality. If the risks of having few or no children survive are high, then parents might have very high desired fertility to offset those risks. But they would need to be extremely risk averse to justify the desired fertility rates observed in Africa. Nevertheless, reductions in child mortality should be expected to have some impact on fertility. Thus, improvements in health care services and public health more generally, including clean water and sanitation, are important variables.

Access to and cost of reproductive health services are also obvious determinants of fertility, women's employment decisions, and investments in children. It should be

noted, however, that reproductive health services can lower fertility only if families actually *want* fewer children, which is not always the case, as we have noted. Reduced costs of reproductive health services, however, may have an effect, especially for the poor, for whom the typical costs of birth control are a significant share of disposable income.

Finally, possibilities for provision of child care by someone besides the (possibly working) mother is an important consideration. As we have noted, in some instances, the extended family may help to ease the work/fertility trade-off by substituting for the mother in child care. More important for policy makers is the issue of public provision of child care. This remains rare in Africa, but is increasingly the norm in other parts of the world, including many developing countries.

2.3.3. Costs of Child Quality

The most obvious exogenous influences on child quality are the costs of education and child health services. In this regard, an interesting possibility for research is the experience of many African countries that have recently eliminated school fees. Several studies document the impact of this policy change on school enrolments in Africa, but not that I know of look beyond this impact to examine the effects on fertility or women's labor force choices, both important questions for policymakers.

2.3.4. Other Conditional Factors

Women's educational attainment is almost always highly correlated with lower fertility, greater labor force participation, and increased investments in their children. Economists usually interpret this effect as operating through wages: greater education means that women can earn higher wages, increasing the incentives for greater labor force participation and lower fertility along the lines described above. But there is also a sociological argument that education affects girls' attitudes and preferences in ways that encourage lower fertility.

It is tempting to take these correlations as causal, and many empirical studies do so. However, there are two reasons to be cautious on this count. First, if girls and their parents are forward-looking, then they will make decisions about education that take into account the implications for future employment, fertility, and child quality of pursuing more education. If this is the case, then we would have to view education as jointly determined with the other three variables, rather than as an exogenous determinant of them. A second reservation comes from the observation that, in many cultures, a girl who becomes pregnant cannot continue to study. If that is the case, then fertility (perhaps unplanned) would be causing educational attainment, rather than the other way around.

We have discussed the income and substitution effects of changes in *women's* wages and labor market opportunities, but not other household members' incomes, including unearned income and wealth. Here, there is only an income effect, so we might expect economic development and poverty reduction along these lines to have a positive effect on fertility. However, Becker and Lewis show why this is probably not the

case, again noting that the interaction of child quantity and quality implies that even a pure increase in income will induce a (negative) substitution effect in this case. Butz and Ward (1979) is an early empirical test that supports this argument, albeit for U.S. data.

Economists tend not to pay much attention to attitudes, norms, and customs -- what we would call preferences -- but they are an important area of interest for other social scientists. If women's view of what they should be and do changes in the course of modernization, then that is consistent with changing demands for children and changing labor supply. Such attitudes may have important interaction effects with the other causal forces that I have considered here. For example, if custom dictates that women are not supposed to work outside the home, then increased employment opportunities or wages may not induce any change in labor supply or fertility.

3. Empirical Work

Most empirical work on labor supply, fertility, and poverty done by economists and economic demographers falls into three broad types of study. The first and most common in the recent literature uses household survey data to study some subset of the relations laid out in Figure 1 at the individual or household level. We will call these "micro-level studies." A second type of study, more common in the earlier literature, uses cross-country (or cross-region) data to test relationships between national averages of the variables found in Figure 1. And finally, a recent strand of literature uses modern time series methods to estimate structural relations using national averages over time for one country. In this section, we look at the methods used and some key results for Africa in each type of study.

3.1. Micro-Level Studies

3.1.1. Structural Models

Figure 1 naturally suggests estimating a structural model with equations for fertility, investments in children, and labor force participation. Fleisher and Rhodes (1979) is an early example, using data from the National Longitudinal Surveys in the United States.[6] They do not use system methods like three-stage least squares because the samples for each estimating equation differ. In part, this is simply a matter of data availability, but because the behavioral outcomes from a given decision manifest themselves at different points in time for a given woman, it is often necessary in a cross-section to use one sample to estimate fertility relations, another to estimate the determinants of children's schooling, and yet another to estimate labor force

[6] In addition to our three equations, Fleisher and Rhodes also estimate a wage equation, recognizing that wages cannot be taken as exogenous insofar as fertility affects time spent in the labor market which, in turn, affects wages. Other authors simply solve out wages, including them neither as a regressor nor a dependent variable. Another option is to use not one's own wages, but the structure of wages where one lives, which might be taken as exogenous. See Schultz (2001) for a discussion.

participation. They do, however, use instrumental variables to handle the endogeneity of our key dependent variables in each equation.

Identifying and interpreting such systems estimates is challenging, and therefore uncommon in the literature. To our knowledge, no such estimation exists for Africa. A more straightforward approach is to estimate the reduced form for each equation -- fertility, investments in children, and labor force participation. Lam and Anderson (2002) is a good example of this approach for Africa. Using data from three rounds of the October Household Survey in South Africa, they estimate three separate equations to examine the impact of education on fertility, investments in children (as measured by the level of schooling a child has completed divided by her/his age minus six), and labor force participation. As in any reduced form, each dependent variable is regressed only on a uniform set of variables claimed to be exogenous. In this paper, the woman/mother's education level achieved, the spouse/father's education level, the woman/mother's age, a rural/urban dummy, province dummies, and dummies for the survey year.[7] Of these, the one policy variable of interest is education, and that is the focus of this paper: how does women's (and men's) education affect fertility, child schooling, and labor force participation.

In theory, there are efficiency gains to estimating the three equations jointly with seemingly unrelated regression, though Lam and Anderson do not do this. The fertility and years of schooling equations are estimated with OLS, while the employment equation is a probit. While their sample is unusually large (because the OHS is an unusually large survey), their methods should be applicable in other African countries with simple cross-sectional datasets.

Lam and Anderson discuss key results equation-by-equation, but then interpret their conclusions in the context of the structure of the model in Figure 1. The first key result of the paper is that more educated women have lower fertility, but only at relatively high levels of education. Up to at least six years, and perhaps ten years of schooling (depending on the sample), schooling has no significant impact on fertility. This is a common result in Africa, but not Asia or Latin America, where lower levels of schooling do seem to lower fertility. (See Schultz, 1993; Appleton, 1996; and Ainsworth, Beegle, and Nyamete, 1996.)

More importantly, Lam and Anderson claim that women's education has even less impact on their probability of employment.[8] Thus, the participation/fertility trade-off does not seem to be important in South Africa. The authors offer the following interpretation: education increases productivity in the labor market, but it also increases productivity in child rearing activities. If the effects are roughly proportional, then it is possible to see higher educated women having fewer children but not changing their labor force participation. Instead of the work/fertility trade-off, the key is a Becker/Lewis-type argument that the price of child quality falls with

[7] Whether it is acceptable to count each of these as exogenous is debatable. For example, woman with an unobserved preference for a small number of well-educated children may move to urban areas where access to birth control and high quality schools is easier. Discussion of education follows in the text.

[8] This claim does not seem entirely consistent with the results that they present for the participation probit, which do show significant effects at roughly the same six or ten-year levels of education where we see fertility effects.

greater female education, and that decline encourages a substitution from child quantity to quality.

The third estimated equation backs up this argument by showing a large and significant effect of mother's education on their children's advancement through school. In sum, Lam and Anderson argue that the quantity/quality trade-off is more important than the work/fertility trade-off. We do not necessarily concur with this conclusion, for two reasons. First, as noted in footnote 8, the employment *do* show increased employment probabilities with more education, and at very similar years of education (about 10 years for the 35-44-year-old sample and six to eight years for the 45-54-year-old sample). We take this as evidence that the work/fertility trade-off does matter (as does the quality/quantity trade-off). In addition, the peculiarities of the South African labor market, with extremely high unemployment, may cause *employment* probabilities to be quite unresponsive to education, though perhaps not labor force participation probabilities.

3.1.2. Single Equation (Semi-)Reduced Form Models

We highlight the Lam and Anderson paper because it uses African data, but mostly because it treats our three key endogenous variables jointly, consistent with the theory discussion. But such papers are quite rare, in African and elsewhere. Even the Lam and Anderson paper addresses the impact of only two of many possible exogenous variables of interest, women's and men's schooling. It is much more common to find papers that estimate reduced forms or semi-reduced forms for only one of the three endogenous variables. Each of these literatures -- the determinants of fertility, of labor supply, and of child education and health outcomes -- is huge in its own right. We cannot possibly review each here. But we do give reference to a few examples, focusing on specification issues and models that use data that are readily available in Africa.

3.1.2.1.Determinants of Women's Labor Supply

There are many papers on women's labor supply, most of which focus on two key issues: the elasticity with respect to wages, and the relationship between fertility and labor supply. The latter is quite obviously related to the theme of this paper, but, as our theoretical model shows, simply including some measure of fertility -- e.g. number of young children that a woman has, or her household's size or composition -- as an explanatory variable for a labor supply model is mis-specified, since these variables are jointly determined. In particular, it is likely that the bias on such fertility variables is negative, i.e. it will exaggerate the impact of fertility on labor supply. Browning (1992) is particularly critical of these sorts of estimates.

Even though our model suggests that fertility is jointly determined with labor supply, there is a way to estimate the effect of fertility. This relies on the fact that fertility is not entirely deterministic. The birth of some children is a "shock," i.e. not planned or anticipated by the parents. If this shock is unrelated to labor supply decisions, then it is possible to estimate consistently the impact of such fertility shocks on labor supply

decisions. The literature contains three approaches to such fertility shocks, each providing a different means of identification.[9]

The first and best-known is due to Rosenzweig and Wolpin (1980b). They argue that having twins at the first birth is an unanticipated fertility shock equal to the impact of having a second child.[10] Using data from rural India, they found that women between the ages of 15 and 24 whose first birth was twins had 0.65 more children than women whose first birth was single, but this difference declines to 0.15 more children twenty years later. In either case, though, the first-born twins do have an impact on fertility, i.e. they are a useful instrumental variable. These women had a 37 percent lower probability of labor force participation than comparable women whose first birth was single when they were 15-24 years-old. However, by the time that they were 35-44 years old, they had a 14 percent *higher* probability of working. In sum, the fertility shock certainly affects labor supply, but an important part of the effect is to alter the timing of labor supply rather than the lifetime supply.

A second approach to fertility shocks is found in Angrist and Evans (1998). Using data from the U.S., they show that parents whose first two children are of the same sex have higher fertility than those that have a boy and a girl. They argue that this reflects preferences for having children of each gender. As a result, a "same-sex" indicator is a useful instrument for fertility. They go on to show that women whose first two children are of the same sex are about 12 percent less likely to participate in the labor force.

Finally, DHS surveys routinely ask women about whether births were "desired" or not, and whether they intend to have more children. While one can easily see that the first answer might be endogenous because women are reluctant to say that they do not want their children, the second question seems likely to elicit more genuine responses. If so, then a follow-up survey of the same women allows the possibility of identifying unwanted births in the interval between the first and second surveys. While they do not analyze the effect of these unwanted births on mother's labor supply, such an analysis would be possible.[11]

None of these approaches is a reduced form per se, i.e. none studies the impact of an exogenous variable on one or more endogenous ones. Rather, they attempt to understand the structural relationship between two of the endogenous variables in our model. While there is obviously great interest in this relationship, the difficulties of estimating it well are significant.[12]

Simpler reduced form estimates of female labor supply decisions in Africa are rare. The particular decision that interests us -- whether or not to work in a formal sector wage job that is incompatible with time spent raising children -- is considered even

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[9] A fourth possible approach uses a dramatic fertility policy change as an instrument. Li and Zhang use the one-child policy in China to identify fertility effects, but there has been no comparably dramatic (and discriminatory, since the policy applied only to Han Chinese) policy in Africa.

[10] They do not use *all* twins because women with high fertility preferences are more likely to have twins by virtue of the fact that they have more births. They do, however, suggest that one could use the ratio of twins births to single births as an exogenous fertility measure.

[11] They do study the effect on older siblings' labor supply, an issue to which we turn below.

[12] See the review article by Rosenzweig and Wolpin (2000), which shows that even these instrumental variables strategies have important limitations.

less. One particularly useful paper from this vantage point is Lanot and Muller (1997). They estimate women's labor supply with respect to wages taking into account two key features of the African labor market: the existence of formal and informal employment, and the fact that formal sector employment may well be rationed. Using data from Yaoundé, they find that the wage elasticity of labor supply to the formal sector is 0.37, and to the informal sector is 0.49. These are remarkably close to a "consensus" estimate of the female labor supply elasticity in the United States of 0.4. (See Krueger and Meyer, 2002, who also note that there is a very wide range of estimates in the literature.)

Estimates of other exogenous variables' effects on labor supply are less common, especially in Africa. Given the interest in the joint determination of labor supply, fertility, and investments in children, it would be particularly interesting to understand the effects of fertility policies (e.g. availability of modern birth control) on labor supply, and also policies that facilitate investments in child quality. Clearly, in Africa, there is much room for each of the methods outlined here to improve our understanding of women's labor force participation and fertility decisions.

3.1.2.2.Determinants of Fertility

The literature on the determinants of fertility is huge, with contributions from across the social sciences. We cannot pretend to survey it here. Instead, we focus on three questions that have received the most attention from economists: the impact of women's wages on fertility; the impact of child mortality on fertility; and the impact of family planning policies. Much of this literature comes, again, from the U.S., with relatively few papers to be found on Africa.

3.1.2.2.1. Wage Elasticities

Fleisher and Rhodes (1979) provide one of the first estimates of the fertility response to women's wages, using the structural model described above. They find a rather high elasticity of child quantity to the female wage rate of -0.43, and a similarly large elasticity with respect to male wages (taken to be a pure income effect) of 0.29. Thus, the compensated elasticity for women's wages is quite negative.

However, as we noted above, the wage rate is not exogenous to fertility, because wages depend on experience, which is usually less for women who have had more children. Whether Fleisher and Rhodes successfully instrument wages is debatable. In particular, their reliance on education as an instrument for wages, a common practice, is doubtful. As we have noted, in many societies, it is socially difficult for pregnant girls to attend school. Thus, a pregnancy may terminate a girl's schooling, reversing the causation from fertility to schooling. Further, it is doubtful that education can be excluded from the fertility equation, as it may well affect fertility through attitudes and norms, not just through its effect on wages.[13]

[13] It is, nevertheless, clear that education is highly correlated with fertility outcomes. Heckman and Walker (1990) go so far as to say "The only strong empirical relationship concerning completed fertility is a negative association between mother's education and children ever born." p.1411.

Keeley (1980) uses experimental data on wages from several negative income tax experiments in the U.S. These experiments offered a wage subsidy to a randomly selected group of families, with a control group that did not receive the subsidy. Comparing these two groups shows only small and statistically insignificant effects of wages on fertility. However, while the randomization guarantees that the wage variation is exogenous, it may not be measuring what we want. In particular, if participants understood the subsidy to be temporary (which it was), then the its value over a lifetime is significantly less than a permanent wage increase, say, from improved labor market opportunities, so the impact on labor market choices would be lessened.

Schultz (2001) suggest two alternatives to identifying the effects of wages on fertility, though we are unaware of applications in Africa. The first is to use information on the local structure of wage opportunities available to all women with given sets of characteristics (experience and education). While this usually requires data collection at the community level (in labor markets), such data are increasingly common and rich in LSMS-type surveys. A second possibility is to look at the gender gap, i.e., the difference between wages for women and men with similar characteristics. While each of these would be feasible in many cross-section datasets, they do present the problem that, as location-specific characteristics, they may proxy other unobservable location effects and, more importantly, they may be chosen by the women in the sample through migration.[14]

3.1.2.2.2. Family Planning Services and Fertility

Unlike wages or fertility shocks, family planning services are often the result of a public policy decision and, as such, are more readily addressed in the evaluation framework that is increasingly important in economics. (Ravallion, 1999, gives an informal introduction to the evaluation literature for development economists.) This literature identifies several important statistical problems for estimating the effect of family planning services on fertility. The first and most common is the program placement effect (Pitt, Rosenzweig, and Gibbons, 1995). If, for example, the government consciously places family planning services in the highest fertility areas (where, one might argue, the can do the most good), then a regression of fertility on the availability of such services will have a strong bias, and may make it appear that family planning *increases* fertility. A standard method to deal with this bias is to use a panel that observes communities at two different points in time. This permits a fixed effects control for community characteristics, including pre-existing fertility rates. Gertler and Molyneaux (1994) use this method in Indonesia and find that family planning services have only a minor impact on fertility.

While fixed effects methods may eliminate the program placement bias, they do not help with another source of bias, migration. For example, if people with low fertility preferences move to areas where family planning services are available, that will make it appear that the services have more of an impact on fertility than they actually

[14] This latter problem might be avoided by using the wage structure in the place where the woman was born.

do. Perhaps the only convincing way to solve this problem is to make use of a randomized experiment. Given the interest in this theme, randomized evaluations of family planning services are relatively rare. Sinha (2005) reports only one such evaluation in rural Bangladesh.[15] She finds that the availability of randomly placed family planning services reduced fertility by 0.39 children per woman. Compared to an average fertility of 4.29, this is a rather small reduction, about nine percent. This compares to reductions of 7-8 percent *per year* of schooling in the same sample. Thomas and Maluccio (1996) find similarly small effects for non-experimental data in Zimbabwe.

Why might the effect of family planning be so small? Those that believe that family planning services should have a large impact on fertility argue, implicitly or explicitly, that many births are unwanted and occur only because parents do not have access to contraception. However, evidence of two different types suggests that this is not the case. First, DHS surveys regularly show that women in poor countries express a preference for large families. In Africa, total desired fertility of six or more children is typical, and "unwanted" pregnancies are rare (Westhoff and Bankole, 2002). Given this high demand for fertility, it is not surprising that access to family planning does not have a large impact. Second, historians have long noted that fertility declined in the developed countries long before modern contraceptive methods were available. (See Schultz, 2001, for a review.) They use this as evidence that the key to fertility decline is reduced demand for children, not a technological fix.

3.1.2.2.3. Child Mortality and Fertility

The original description of the demographic transition suggested that child mortality is an important determinant of fertility. If parents have a desired number of children, high mortality probabilities will encourage them to have more than that number. This effect is likely to be especially strong if children are seen as old-age insurance. The risk of growing old without enough children to provide adequate support is "catastrophic," so that risk-averse parents have a strong incentive to have more children than even the expected value of surviving children suggests are needed.

Despite this theoretical importance, there are relatively few papers that examine child mortality as a cause of fertility in Africa. An important exception is Benefo and Schultz (1996). Using standard Hausman tests, they find that child mortality is exogenous in a fertility regression, despite the common notion that children of higher fertility women are at greater risk.[16] Using OLS, they find strong fertility responses to child mortality. In Cote d'Ivoire, the "replacement" is complete -- with each child death leading to another birth, on average -- while in Ghana, it is about one half. Using 2SLS, however, with community characteristics as instruments, they find no effect of mortality on fertility, an implausible result which may be due to poor instruments.[17]

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[15] This paper also includes a good literature review of the effect of family planning on fertility.
[16] The do note several studies that find that child mortality *does* depend on fertility.
[17] Again, they note several other studies that come to the opposite conclusion.

3.1.2.3.Determinants of Child Quality

As with women's labor supply, there is a large literature on the determinants of children's schooling and their health status, the two measures of "child quality" that dominate the literature. Glewwe (2002) provides a review of the former, while Strauss and Thomas (1995) review the latter. Here, too, fertility considerations all too often enter the analysis as an afterthought, usually with the inclusion of household size and composition variables are regressors. But of course, if our model is correct, these should be seen as jointly determined with child quality, so their inclusion in the model leads to biased estimates.

Most of the literature on children's health and education outcomes pays little attention to the interactions between women's labor supply, fertility, and child quality. Instead, the concern has been primarily to understand the effects of public policy on outcomes in education and health. As with the fertility literature, there is considerable debate about many effects, but there is a clear and consistent correlation between parents' education levels and the health and education of their children, even after controlling for income and other determinants.

There is a smaller literature that looks at how determinants of labor supply, fertility, and child quality interact. Schultz (2005) uses the same "twins shock" strategy cited above to study the impact of unexpected fertility on a variety of measures of well-being. Even though he finds no significant effect on household incomes, he does find that older children in a twins household have weight-for-height[18] 0.1-0.2 standard deviations below comparable siblings in single-birth households, suggesting that unexpected fertility causes lower child quality. Sinha (2005) uses experimental data on family planning in rural Bangladesh and finds that access to family planning services has no effect on the probability that boys or girls in the household are enrolled in school. Lokshin, et.al. (2004) find that availability and cost of early childhood development centers in Kenya increases the probability that older siblings will attend school. Finally, Pitt (1997) studies the determinants of children's weight and height using DHS data from 14 African countries. While essentially estimating a reduced form, he does correct for possible selection bias in these estimates coming from birth fertility decisions and child mortality (to be in the sample, a child has to be born, and has to survive to the survey date). In addition to the substantive results of the paper, which are standard, an important finding is that neither the fertility nor the mortality selection bias appears to be very important, thus opening the way for simpler OLS approaches to estimating such equations.

3.1.3. Panel Data Studies

Most of the studies cited above use simple cross-section data, perhaps merging the data from two different datasets (e.g. one on demography and health, another on public service provision). But panel data can be useful to understand some aspects of fertility and labor supply behavior, particularly timing of births. Among other things,

[18] Weight-for-height is a measure of "wasting," a standard metric for children's health status.

these models allow estimation of an n^{th} birth in a given time period conditional on the lag to the $(n-1)^{th}$ birth. In a well-known study, Heckman and Walker (1990) use a very long panel of Swedish women to find strong evidence for "economic" determinants of fertility, particularly women's wages and other household income. In Africa, Aassve, et.al. (2005) use a panel of Ethiopian households to study the dynamic relationship between fertility and poverty. They find that households that are poor in period t have period t+1 fertility that is similar to households that are not poor. That is, poverty does not appear to "cause" fertility, in the temporal sense. However, households that experience in birth in period t are more likely to become poor in period t+1 than other households, so fertility "causes" poverty.

3.2. Cross-Country, Cross-Regional, and Time Series Studies

The early literature on labor supply and fertility often used cross-country or time series regressions. These regressions are plagued with all of the endogeneity problems discussed above, but with little hope for finding identification in experiments, natural or otherwise. As such, we discuss only a couple Africa-specific studies here. Wasao (1998) uses district level data in Kenya to find a simple negative correlation between female wage employment and fertility. In a more careful study, Feng and Bishai (2006) use 19 DHS surveys in Africa to generate district-level "price of child survival" data in 97 sub-regions of those countries. This is done by observing how child survival varies with wealth. They then regress sub-region level fertility rates on this (and other) variables, finding a very large elasticity of 1.71 for the response of fertility with respect to this "price". They also find a rather small income elasticity of -0.19. Feng and Bishai interpret this as the cross-price effect of child quality on fertility, though it might well be considered an own-price effect since the dependent variable in the first stage is simply survival. Finally, Schultz (n.d.) uses cross-country regression to find that Africa is the only continent where urbanization is strongly correlated with lower fertility.

3.2.1. Time Series Studies

The development of cointegration and error-correction methods of estimation has been a major achievement in econometrics, one which with AERC researchers are familiar. A particularly useful feature of these estimators is that they provide strongly consistent estimates of the relationship between two or more jointly determined variables. This greatly eases the identification problems that we have noted throughout this section.

Researchers have begun to use these methods for fertility research. For example McNown and Rajbhandary (2003) estimate an error-correction model for fertility, female labor supply, female/male relative income, and female wages for data from the U.S. They find that there are two cointegrating relationships in these data, which they interpret as a labor supply equation and a fertility equation. While shocks to fertility do reduce labor supply, the opposite is not the case. They also find a very elastic response of fertility to female wages. Narayan and Smith (2006) study the cointegration of fertility, infant mortality, and female labor force participation in Australia. They find both fertility and infant mortality Granger cause female labor force participation, but the opposite is not true. Similarly, in Africa, Ukpolo (2002)

finds that population growth and growth in GDP per capita are cointegrated in Nigeria, but not Cote d'Ivoire. He also finds the population growth Granger causes economic growth, but the reverse is not true.

While relatively novel, this literature is promising for African countries, assuming that sufficiently long time series on key variables are available.

3.3. Discussion

We have reviewed a variety of empirical studies that look at the determinants of female wage labor supply, fertility, and investments in children, either individually or jointly. While this literature is quite large, there are still relatively few papers on Africa, particularly papers that address in a statistically satisfactory way the interaction between these three endogenous variables. At the same time, there are many high quality datasets available in Africa for research using established methods. In our view, this leaves the field wide open for AERC researchers to pursue some of these important topics in their own work, with readily available datasets and methods. Research that looks at how policies intended to affect one of the endogenous variables (e.g. labor policies, family planning policies, education and child health policies) affect the other endogenous variables in the model is particularly promising and interesting.

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