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The Demographic Transition and Population Policy in Egypt: An Integrated Methodology at the Household Level

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1.0 Overview[1]

This paper examines household-level fertility research within the broader contexts of the demographic transition and public policy. The framework chosen for this examination is the Easterlin/Crimmins (1982, 1985) model which we modify and apply to a sample of rural Egyptian households. The remainder of this section describes the value of that model in analyzing the demographic transition and in formulating public policy. Section 2 provides a summary of the theory, 3 a critical discussion of the empirical model and its application to rural Egypt, and 4 the results.

1.1 The Demographic Transition

Empirical descriptions of the Demographic Transition highlight several phases of population growth deriving from underlying patterns of fertility and mortality. Most analyses of this transition have been cast in aggregate terms where modernization variables, such as education and urbanization, account for the underlying patterns. However, an adequate explanation of these patterns must ultimately be based on an analysis of household behavior as it responds to the influences of modernization. To sort out such behavioral responses, it is necessary to construct socio-economic-biological, micro-based models that simultaneously consider the manner in which fertility and mortality respond to modernization.

One of the more interesting of these models was originally posed by R. A. Easterlin in his "synthesis framework" as represented in figure 1. In

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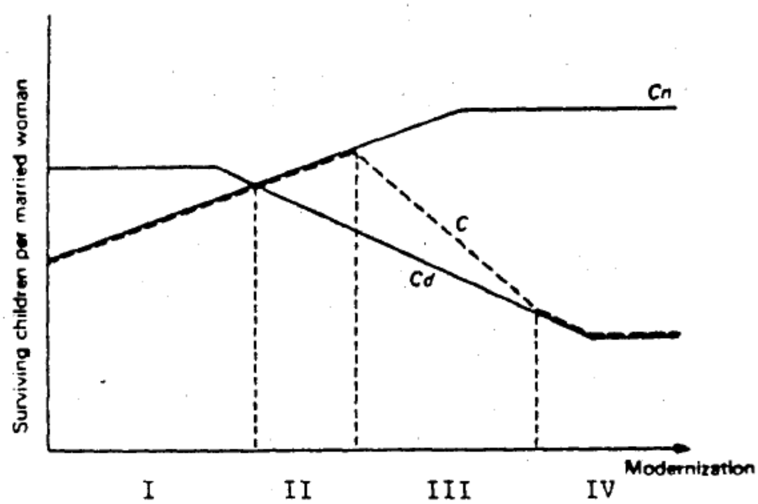
[1]We are grateful for comments on an earlier version of this study by R. K. Bhala, Richard A. Easterlin, M. Nabil El-Khorazaty, Hussein A. Sayed, T. Paul Schultz, and G. E. Tauchen.

Phase I of modernization, the desired number of surviving children (C_d) exceeds the number of surviving children under a natural fertility regime (C_n). Population growth is thereby constrained by natural fertility, and surviving children (C) equals C_n. In Phase II this biological constraint is released (C_n exceeds C_d), but contraception is too costly (unavailable, expensive, perhaps culturally taboo) and C remains at C_n. In Phase III contraception becomes increasingly pervasive as the gap between C_n and C_d widens and contraceptive

Figure 1

Easterlin's Model of Fertility Determination



Reproduced from Easterlin and Crimmins (1985, page 26).

costs decline. Finally, the Demographic Transition is complete in Phase IV where contraceptive costs are negligible relative to the motivation for fertility reduction. C is largely explained by C_d. The model, then, focuses on rising natural fertility, falling costs of contraception, and declining family size desires in accounting for the Demographic Transition. While the framework is quite general, its power depends largely on empirical considerations: the importance of the supply constraint, the role of family planning costs, and the relationship of socioeconomic change and desired family size.

Unfortunately, an empirical representation of this model has been difficult to implement since C_n, C_d, and often many of the important costs of contraception are unobservable. Moreover, factors governing C_d, C_n, and contraceptive use are interrelated, posing difficult econometric problems in sorting out the individual impacts of modernization.[2] For example, increases in the mother's education can (a) increase fecundity and natural fertility, (b) reduce child mortality, (c) decrease desired fertility, and (d) improve the efficiency and efficacy of contraceptive use. Reduced-form specifications which fail to decompose these individual impacts of education conceal some of the important linkages between modernization and the Demographic Transition.

In a 1982 paper, Easterlin and Crimmins attempt to provide an empirical specification which confronts some of these problems, can be implemented using data provided in the World Fertility Surveys, and employs relatively straightforward statistical procedures. In a recent book (E/C, 1985), they refine some of the econometrics. While their framework offers promise in sorting out aspects of the underlying mechanism of the Demographic Transition, we believe their empirical specifications can benefit from some modification and augmentation. Providing these modifications represents a major objective of the present paper. Additionally, since an interesting dimension of their framework is the presence of a phase of development where fertility is constrained by biological factors--a phenomenon most likely to occur in rural

[2] A useful discussion of these econometric difficulties is provided by T. Paul Schultz (1986).

settings in the Third World--our data set from rural Egypt offers an excellent opportunity to explore this aspect of their model.

The E/C framework is also useful for delineating the relative importance of "behavioral" versus "family-planning" factors in explaining changes in the fertility of a population. For many analysts, this policy perspective, which focuses on an examination of the relative role and importance of family planning, constitutes the central area of interest. Thus, the thrust of the exposition of this paper will be cast in these policy-related terms, realizing that the model being examined is really quite general, and applies equally to many of the issues underlying the Demographic Transition.

1.2 Public Policy

Debates about population policy in the Third World have frequently cast policy strategies in an either-or context: population growth can be slowed either through the manipulation of socioeconomic variables, or through the provision and promotion of family planning services. Fortunately, most analysts now agree that family planning and socioeconomic development should supplement rather than supplant one another. Socioeconomic development provides the environment conducive to reducing family size norms; effective family planning enables the populace to attain their smaller targets.[3]

Thus far, social science research has provided limited insights into which combinations of family planning and development strategies are likely to yield the highest returns. In part this is because research on fertility typically focuses on "reduced-form" relationships which show only the net impacts of socioeconomic change, or on the "proximate" determinants of fertility

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[3] For a similar position, see A. R. Omran and M. N. El-Khorazaty (1977).

which generally abstract from linkages with socioeconomic change.[4] Seldom have these two approaches been effectively combined, and for good reason. Such integration poses formidable theoretical, empirical, and statistical problems. However, given the trend toward population policies that combine family planning with socioeconomic development, it is necessary to redirect the focus of research methodologies so as to explicate the separate and the combined effects of family planning and socioeconomic development on population growth.

As an example of the limitations of the net-impact approach, consider the relationships between female education and completed family size. Many studies which employ this approach show that the upgrading of female education is associated with reductions in completed family size. But what is the specific mechanism for this reduction? On the one hand, education can exert a negative influence on fertility through avenues such as delaying marriage, raising the cost of children (the value of the mother's time), increasing the efficiency-of-use and knowledge of contraceptives, shifting tastes toward higher-quality children, and fostering a more positive attitude toward family planning. On the other hand, education can simultaneously exert an offsetting, positive influence on completed family size through avenues such as increasing the demand for children (an income effect), enhancing the capacity to care for children (and thereby reducing child mortality), and increasing nutrition, health, and possibly natural fertility. Therefore it is not surprising that

[4] In his seminal article on proximate determinants, J. Bongaarts (1978) cites the need for relating the proximate determinants to socioeconomic change. One approach for Egypt has been demonstrated by Loza and El-Khorazaty (1979). They find that locational impacts (urban versus rural) on contraception are particularly important to explaining differences in fertility in Egypt.

a comprehensive World Bank report finds the association between fertility and education to be mixed: it can be negative, positive, or non existent; it can be strong or weak; it can vary with the stage of economic development, by locale (e.g., urban/rural), and by population grouping (e.g., by religion); and it can be nonlinear.[5] The apparent inconclusiveness of this research does not necessarily demean its quality. Rather, it might result from the potentially strong, but compensating influences noted above. As a result, the net impacts can vary over time and setting. The analytical complexity and possible ambiguity of the net impact of education on fertility is further emphasized by T. W. Schultz (1974, p. 10):

> The education of parents, notably that of the mother, appears to be an omnibus. It affects the choice of mates in marriage. It may affect the parent's preferences for children. It assuredly affects the earnings of women who enter the labor force. It evidently affects the productivity of mothers in the work they perform in the household, including the rearing of their children. It probably affects the incidence of child mortality, and it undoubtedly affects the ability of parents to control the number of births. The task of specifying and identifying each of these attributes of the parents' education in the family context is beset with analytical difficulties.

The policymaker who hopes to use such research to formulate or evaluate programs faces a dilemma. If the net impacts of policy variables such as education vary from setting-to-setting and time-to-time, how is it possible to identify the likely population consequences of encouraging education?

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[5]S. H. Cochrane (1979). She concludes "...that the relation between education and fertility is not always inverse. The earlier generalization about such a relation probably resulted from scarcity of data in the poorest, least literate societies and in rural areas where the inverse relation is less likely to occur." (p. 42) For additional discussion of the education-fertility relationship, see J. M. Stycos (1968), and S. Timur (1977). In the case of Egypt, there are many studies showing a nonlinear relationship between education and completed family size. See, for example, A. M. Khalifa (1971a, 1971b, 1973), S. M. Gadalla (1978), H. A. Sayed and M. N. El-Khorazaty (1980), and M. S. A. Issa (1981).

After all, development is itself proceeding apace, and the affected population is heterogeneous. One answer to this question is that scholars must address the aforementioned research difficulties and develop approaches which analyze the specific influences of socioeconomic change in an integrated framework. That is, studies are required which simultaneously examine the factors that influence the supply of (e.g., proximate determinants, including family planning), and the demand for (e.g., behavioral influences) children. There have been several recent attempts at such a synthesis,[6] and while the methodologies presented in these papers are still formative, they do indicate the direction in which fertility research might proceed. In the present paper we will not innovate yet another approach, but will instead modify one of these attempts at synthesis--the Easterlin-Crimmins (E/C) framework--and apply it to the 1979 Egyptian Rural Fertility Survey (RFS-I). This should serve to broaden the empirical base of this particular framework since it will provide an opportunity to compare the results of several countries (rural Egypt with Colombia and Sri Lanka), and to offer results useful to the current policymaking in Egypt. Indeed, an integrated family planning and socioeconomic development strategy has been espoused in Egypt by the Supreme Council on Population and Family Planning (1980), taking the form of a formal program, the Population and Development Project (PDP).

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[6]B. L. Boulier and N. G. Mankiw (1980); R. A. Easterlin and E. M. Crimmins (1982 and 1985), and M. R. Rosenzweig and T. P. Schultz (1985a and 1985b).

2.0 The Analytic Framework

An important step in the Demographic Transition as well as a key goal of population policy is the increase in the use and effectiveness of family planning. At the family level the family-planning decision translates into factors that determine the demand for, and the cost of contraception. Symbolically, this might be written as

(1) $V = f(C_n - C_d, \ CR)$ where

- V is some measure of voluntary birth control use;
- C_n is the expected number of surviving children the family would have in the absence of contraception;
- C_d is the desired number of surviving children; and
- CR are the costs of fertility regulation, including monetary, time, psychological and information costs.

This formulation defines $(C_n - C_d)$ as the motivation for fertility regulation, which could be negative, zero, or positive. A negative difference (Phase I of figure 1) implies a demand for surviving children larger than might be expected which, in turn, could result in a demand for "negative" contraception or fertility enhancement. This possibility provides a rationale for fertility rites as well as a possible explanation for prolonged breastfeeding (averaging over 20 months in this sample). While only 38 percent of the women recognize breastfeeding as a potential method of birth control, we would be surprised if most did not see it as a means of reducing child mortality. As a practical matter, this model does not allow for negative contraception since the requisite data are not available. Accordingly, the functional form of this equation should impose a zero lower bound on voluntary contraception. If families could precisely attain their targeted number of surviving children, motivation and contraception would both be zero. Moreover, even with a positive difference between C_n and C_d, families might still forego birth control if the costs were excessive (Phase II of figure 1). The core of the research problem, then, is the identification and quantification of those factors which determine the supply of children in the absence of contraception (proximate determinant analysis), the demand for children (largely behavioral analysis), and the various costs of fertility regulation.

The potential supply of surviving children in the absence of fertility regulation (C_n) is largely determined by factors explaining natural fertility.[7] A biological and taxonomic approach to fertility analysis is employed in this explanation. Indeed, a complete articulation of all the proximate determinants of natural fertility must fully "account for" completed family size, although it would not "explain" the number of children ever born (CEB) in a behavioral sense. However, such an accounting framework can be useful in untangling the more complex behavioral elements in the family size decision. With this perspective in mind, we classify the determinants of the supply of surviving children as follows:

(2) $C_n = N\ (1 - m)$

(3) $N = g(PD)$; where

C_n is the potential number of surviving children adjusted for expected mortality;

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[7]Henry (1961) defines natural fertility as being that level of fertility observed within sexual unions in which fertility behavior remains uninfluenced by the number of children already born to a couple. We characterize natural or potential fertility as the "supply" side of a fertility model, while referring to desired family size as the "demand" side. Important qualifications to this categorization are provided in section 3.0.

N is natural fertility--in this model, the estimated number of children ever born (CEB) in the absence of voluntary contraception;

m is the child mortality ratio; and

PD is a vector of proximate determinants including measures of the exposure of couples to the risk of conception (e.g., cohabitation duration, frequency of intercourse, etc.) and measures of the degree of fecundability (e.g., breastfeeding duration and intensity, first birth interval, etc.), but excluding any measures of voluntary contraception.

Having completed the accounting, we now turn to explanations of each of the various determinants on the basis of environmental and socioeconomic conditions. For the present we will use the vector X as a shorthand notation for all such socioeconomic variables, and entertain the hypothesis that

(4) $PD = h_1(X)$.

That is, factors such as the age at marriage, breastfeeding duration, and sterility may themselves be influenced by environmental conditions such as education, employment, and income. These hypotheses represent an extension of the biologically-oriented proximate determinants analysis as it is typically formulated.[8]

The determinants of the demand for children (C_d in equation 1) have been investigated by scholars from various social science disciplines and a review of their theories will not be undertaken here. Suffice it to say that many of these theories highlight, or at least find a role for, the various

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[8] Bongaarts (1978) suggests this extension, concluding that further insight could be obtained by investigating the socioeconomic foundations explaining the important proximate determinants. The present model extends this framework even further by arguing that voluntary contraception is not simply determined by these socioeconomic characteristics. Rather, the voluntary regulation equation (1) treats contraception as an economic decision that explicitly recognizes both benefits and costs.

socioeconomic factors that also influence the supply of children. These hypotheses can be represented as

(5) $C_d = h_2(X)$.

Finally, the determinants of the costs and knowledge of regulation are varied, ranging from the impact of household-specific influences such as education and wealth, to locality-specific influences such as the availability of contraceptive supplies and transportation. Again, these and other costs may well be associated with socioeconomic change, and written as

(6) $CR = h_3(X)$.

The broad analytic framework represented by equations (1) - (6) provides one way to organize the determinants of family planning. The weakness of a net-impact approach which is commonly used in the literature, is exposed clearly when one combines equations (1) - (6) into their reduced form, equation (7).

(7) $V = h(X)$.

Most of the "structure" of the underlying framework is now collapsed into the net impacts of the socioeconomic variables so that the separate influences of socioeconomic conditions through supply and demand are no longer revealed. In this paper, we will highlight the structure of the model as represented in equations (1) - (6), and not with its reduced form as in equation (7).

3.0 Considerations for Implementing the Model

As is true of most empirical work on fertility, two features of the Easterlin-Crimmins (E/C) model require careful consideration. First, many of the variables in the analysis cannot be observed directly. These unobservables include C_n (the expected number of surviving children a family would have in the absence of contraception), C_d (the number of children demanded), CR (the costs of contraception), and m (the expected mortality rate).

Second, the interrelationships between what the literature has come to regard as "supply" factors versus "demand" factors cannot be ignored. While this demarcation has intuitive appeal, the analogy can be carried too far. Unlike the classic supply-and-demand model, in the case of fertility, the same people who supply children also demand them. Consequently, factors categorized as supply may have important demand effects, and vice versa. The E/C model is one of the few which explicitly reveals such interrelationships with respect to voluntary contraception. Although its effect is to inhibit natural supply, contraceptive choice is affected by both supply (C_n) and demand (C_d, CR) influences. More subtle are the workings of other "proximate determinants" of potential supply. For example, while age at first marriage is an important determinant of natural supply, few would deny that delayed marriage is the surest form of fertility regulation in many societies.

This section considers the unobservables and the simultaneity issues as both E/C and the Kelley/Schmidt (K/S) extension approach them. Section 3.1 discusses the observed counterparts of the unobservable variables. Section 3.2 describes earlier and current E/C estimation strategies. Section 3.3 considers simultaneity issues not addressed by those strategies and proposes a new structural equation. Section 3.4 incorporates education directly into the fertility and voluntary control equations.

3.1 Formulation of the Empirical Model

The first task in formulating the empirical counterpart of the model is to construct estimates of the unobservable variables, C_n, C_d, CR, and m. Consider the estimate of C_n. As is seen in equation (2), C_n represents the product of natural fertility (N, an unobservable) and the family's estimated child survival rate (1 - m). The family's natural fertility might be estimated by accounting for the number of children ever born (CEB) in terms of the proximate determinants of fertility. Expressing this in linear form, we have[9]

(8) $CEB = \alpha + \beta\ PD + \gamma\ V + \epsilon_1$.

If one obtains measures of the proximate determinants of fertility (vectors of exposure, fecundity, and birth control variables) for an appropriate sample of families, it is possible to estimate the various parameters of equation (8). Then, by imposing a value of zero for V, which nets out the influence of voluntary family planning, the equation yields a separate estimate of N for each woman. The important aspects of the empirical work, therefore, involve obtaining useful proxies for PD and V, selecting an appropriate sample for the estimation, and devising an estimation strategy.

Davis and Blake (1956), Bongaarts (1978) and others have provided taxonomies of proximate determinants which account for the number of children ever born. These determinants are not perfectly captured by our data set, but given this constraint, the various measures we have used for PD and V are presented in table 1. While these measures are similar to those used by E/C, a few changes have been made since our survey, the RFS-I, provides infor-

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[9] ϵ_1 represents an error which is assumed normal with zero mean and constant variance. Sections 3.2 and 3.3 discuss the error structure of the model.

mation beyond that of the World Fertility Surveys around which the E/C model is structured. Several other changes of a more fundamental nature are also made. Details on the nature, justification, and anticipated sign of all of the measures are found in table 1 and its footnotes. To summarize, CEB is accounted for by (a) length of marriage (MDUR), (b) length of the first and second birth intervals (INTERVAL1, INTERVAL2), (c) secondary sterility (STERILE), (d) extent of pregnancy loss (PLOSS), (e) length of breastfeeding (BRFEED), (f) periodic spousal separations (APART), and (g) duration of use of contraception (CDUR). In general, we expect CEB to increase with the duration of marriage, and to decrease with each of the other variables.

The second grouping of variables in table 1 pertain to the voluntary regulation equation (1). An important variable in that analysis, the number of children demanded (C_d), is also unobservable, although family statements regarding ideal and desired family size are available in the data set. Researchers have considered the merits and deficiencies of these two measures in detail. With respect to rural Egypt, there is evidence that they provide usable information on family size goals.[10] We have used desired family size (DNC) as our measure of C_d.

To forecast its expected surviving family size, each household must also estimate child survival rates. The demographic literature on how this should be done is not extensive, and as a result, *ad hoc* procedures are

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[10] The usefulness of the "desired" and "ideal" family size measures has been analyzed at length by M. S. A. Issa, who examines the consistency of such responses with observed behavior. With specific reference to Egyptian data, he concludes "...the evaluation of the results are reassuring and they enhance the credibility of the information collected in the NFS (1974-75) on desired family size in Egypt" (p. 24). While we have not improved upon his methodology for appraisal, we have no reason to believe that the 1979 RFS-I provides measures any less useful than for the 1974 NFS.

Table 1

Variables within the Model

Variable	Mean & Std. Dev.[a]	Definition and Comment
CEB	6.91 2.40	Number of children ever born alive.
Proximate Determinants used within the CEB Equation		
MDUR	21.01 4.55	The difference between the wife's current age and her age at marriage provides a measure of exposure to the risk of pregnancy.[b] MDUR is entered in quadratic form in the K/S extension to allow families to grow at a decreasing rate over the marital span.[c]
INTERVAL1	2.99 2.48	The interval in years between the dates of marriage and first birth[d] provides a measure of fecundity at the beginning of marriage. No women in the sample contracepted during this period, corroborating its treatment as a natural fertility state.
INTERVAL2	2.20 1.58	The interval in years between the first and second births supplements INTERVAL1 by providing a rough measure of the influences of postpartum abstinence and lactational subfecundity. The sample average is employed for the 12 percent of the sample who contracepted prior to their second birth.
STERILE	0.16 0.36	A binary variable coded as unity if a woman is not currently contracepting, is not separated frequently from her husband, has not had a child in the last five years, and is not currently pregnant. This procedure likely understates secondary sterility since Henry and Vincent (reported in Pittenger, 1973) have estimated the proportion to be around 0.32 for women aged 40. While a better measure might result from a woman's belief that she could not become pregnant again, such a question was not asked in the survey.
PLOSS	0.07 0.12	Pregnancy loss, stillbirths and miscarriages as a proportion of total pregnancies, is a measure of subfecundity (inability to bring a pregnancy to full term) as well as exposure to risk of pregnancy (effect

Table 1 (continued)

		ively reducing marital duration.) A rise in PLOSS should reduce fertility for both reasons.
BRFEED	20.04 8.44 for E/C 18.29 8.13	The E/C measure for breastfeeding is calculated as the average number of months of breastfeeding over the last two births, or the number for the second-to-last birth if the mother is currently nursing.[e] The K/S measure for breastfeeding nets out those months lost because of child child for K/S deaths while the mother was still nursing.[f] This adjustment to the E/C measure reflects our view that the CEB equation should approximate a biological production function as closely as possible. Breastfeeding introduces a period of subfecundity and the biological role of child mortality is to shorten that period.[g]
APART	0.09 0.29	A binary variable coded as unity if the husband is not usually at home or if either spouse was absent for more than one month during the preceding year. Separation for work or other reasons is a K/S extension[h] included to control for reduced exposure to the risk of pregnancy.
m	0.22 0.20	The child mortality ratio is simply the number of children who have died prior to the time of the survey as a proportion of CEB. While the E/C model includes this variable in the CEB equation, the K/S model does not since we believe that its biological aspects are captured better in our breastfeeding measure. m inappropriately introduces demand-oriented behavior into this equation--hoarding and replacement due to child mortality.[i]
CDUR	4.96 6.62 for E/C 2.93 4.45 for K/S	An approximation of the number of years of fertility regulation of any type. E/C define this as the number of years since initial regulation, less two years for inefficient methods (methods other than the pill, IUD, condom or sterilization). Since our survey queries women about initial and second contraceptive use, our empirical analysis refines this measure as follows: CDUR is the number of years reported for the original contraceptive method plus an estimate of the duration of a second method. For women reporting a second method, this duration is estimated as one-half of the time between the termination of original contraception and the date of the survey.[j]

Table 1 (continued)

Variables Included in the CDUR Equation

s	0.78 0.20	Child survivorship ratio; the complement of the child mortality ratio.
DNC	4.63 2.65	Desired number of children.
NBCKNOWN	2.65 2.06	The E/C measure for the costs of regulation is the number of birth control methods (out of 13 listed) known by the woman.
CR	0.61 0.21	The K/S measure for the costs of regulation is the proportion of women in the village who have never used any contraceptive method.[k] This departure from E/C was made because of likely endogeneity of NBCKNOWN.

Socioeconomic Variables

WE2	0.18 0.38	A binary variable coded as unity if the wife has had at least some primary education.
WE3	0.02 0.14	A binary variable coded as unity if the wife has had some secondary or post-secondary education.
HE2	0.24 0.42	A binary variable coded as unity if the husband has had at least some primary education.
HE3	0.08 0.27	A binary variable coded as unity if the husband has had some secondary or post-secondary education.
MOREWOM	0.90 0.30	A binary variable coded as unity if women other than the wife live in the household.
LOWEGYPT	0.53 0.50	A binary variable coded as unity if the household is in Lower Egypt, which is the Northern part of Egypt and is more urban.
ASSETP	0.91 1.03	The number of personal assets owned by the household out of the following list: stove, refrigerator, television, radio, clock, sewing machine, tape recorder.
ASSETR	1.68 1.14	The number of real assets owned by the household out of the following list: land for building, land for cultivation, buildings, agricultural machines, animals, other.

Table 1 (continued)

s_v	0.777 0.069	Village-level survival rate,[k] acting as a general index of health.

[a]The sample represents 712 women aged 35-44 who have remained married to their original husband and have had at least two children.

[b]The intensity of this exposure, possibly measured by the frequency of intercourse, should also play a role. While no such measure is available in this data set, it was for the E/C study. They report its coefficient to be statistically insignificant for both Colombia and Sri Lanka.

[c]Three influences potentially cause this nonlinearity. A pure duration influence results from varying reproductive behavior (especially coital frequency) over marriage. An age-at-first-marriage influence enters since fecundity varies over the life cycle. This factor would be especially important for marriages taking place before or shortly after menarche, a type of marriage which is common in rural Egypt. Finally, current age could play a role through differential cohort behavior. The cohort effect should be attenuated by the compressed age range of 35-44. Additionally, since all marriages are continuous, the longest marriages (31 years) capture both early and late low-fecundity ages, while short marriages exclude the early period. This provides further justification for a quadratic formulation.

[d]In contrast to E/C's estimates for Sri Lanka and Colombia, the average first birth interval exceeds the second interval in rural Egypt. This could possibly result from a reporting artifact in our data set. Two separate marriages are recognized in Egypt--the date on which the marriage agreement is signed, and the date (possibly several years later) at which the ceremony takes place and cohabitation commences. Were the earlier date consistently reported, the use of first birth interval as an estimate of early marital fecundity would be inappropriate. We do not believe this to be the case since the RFS-I asked for both dates. We used the latter whenever the dates differed. Further, our average age at first marriage, 17.2, actually exceeds other estimates for this cohort in rural Egypt. Loza (1982, p. 38), for example, reports an average age of 14.9 for the current 35-39 cohort and 15.6 for 40-44. Rather than an artifact, we believe that the lengthy first interval results from the very early age at which women marry.

[e]The implicit assumption is that breastfeeding experience over the two most recent births is representative of all births. While this need not be true, the strong cultural aspects of breastfeeding in Egypt tend to reinforce the assumption.

[f]RFS-I includes a mortality history for each live birth, allowing us to identify babies who died while nursing. Our net measure is simply (CEB x BRFEED - total months lost for all early deaths) / CEB.

[g]With regard to functional form, Lesthaeghe and Page (1980) discern a nonlinear relationship between breastfeeding duration and reduced fecundity. Our experimentation with a series of binaries representing various breastfeeding durations failed to detect a nonlinear relationship in this sample. We have, therefore, retained the linear form.

[h]Fridman's (1984) comments on this framework triggered this extension.

[i]From an econometric perspective, the explanatory power of m is likely spurious--CEB is included in the denominator of m. Moreover, causation is bidirectional--child mortality rises with parity; consequently, m rises with CEB. We are also uneasy about interpreting the magnitude of such a coefficient. For example, a coefficient of two would imply that CEB would be increased by one if one-half of the children were to die. This unitary increase in CEB would occur regardless of whether the woman had had two children and one had died, or twelve children of which six had died.

[j]Additionally, rather than make an arbitrary adjustment for the use of "inefficient" contraceptive techniques, we have tested for the difference between coefficients for "modern" (pill, IUD, tablets, cream, jelly, douche, condoms, sterilization) and "traditional" (withdrawal, rhythm, prolonged breastfeeding, abstinence) methods. The difference between the coefficients in an ordinary least squares regression (-0.058 and -0.041 with t-values of -3.62 and -1.58, respectively) is not statistically significant (t-value of -0.62). Our measure, therefore, combines both categories of contraception into a single term.

[k]Both CR and s_v were estimated from our data set for a slightly different cohort (ages 30-49) from our sample (ages 35-44). This broader cohort was chosen since women are influenced by younger and older women as well as by women of their own age.

typically employed. We have used the most commonly employed measure, actual survivorship experienced by each family, although we have considered several alternative measures. An obvious alternative would be the village-level survival rate. Village-level survivorship would be appropriate in a one-period model where a couple estimated their potential and desired fertility levels at the beginning of marriage and then tailored their reproductive behavior accordingly. On the other hand, if fertility is viewed as a series of sequential decisions based upon actual experience to date, then individual-specific survivorship is a relevant, albeit imperfect measure. This treatment introduces the concept of replacement into the model; a couple might reduce contraception because of child mortality.[11]

The final variable in equation (1) is CR, the costs of fertility regulation. There are many relevant costs: monetary costs, time costs, inconvenience costs, psychological costs, knowledge costs, and so forth. Ideally, if one possessed a measure of each of these costs, it might be possible to combine them into a composite measure of CR. The RFS-I data set provides almost no information on the separate costs of contraception and thus we evaluate two alternative measures. The E/C variant, used when we wish to compare rural Egypt with the E/C results for Colombia and Sri Lanka, employs an index of knowledge costs based upon the number of contraceptive techniques known to the female. While this is an interesting variable in its own right, it is flawed for our purposes. It ignores all costs other than those of information, and the direction of causation is unclear. For these reasons, we have selected a

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[11] For a detailed treatment of "hoarding" for expected mortality and "replacement" of excessive child deaths in a sequential decision making framework, see Mauskopf and Wallace (1984).

different measure: the proportion in a woman's village who have never contracepted. Acceptance of contraception as a village norm, availability, distance to family planning centers, knowledge, and other relevant factors are all included in this index. Further, since she is only one person in the village, a woman's decision to contracept does not substantially affect the proportion.

The final set of variables in table 1 are the socioeconomic variables of equations (4) - (6). Certain of these variables will also be used as instruments as discussed in sections 3.3 and 3.4.

The sample used in the estimation consists of intact marriages for women aged thirty-five through forty-four, for whom complete data exist for all relevant variables. Restriction to intact marriages minimizes modeling complexities resulting from marital disruptions. Restriction to women who have largely completed childbearing circumvents the necessity of modeling the timing and spacing of births. No woman above the age of forty-five was included because the use of the 35-44 cohort permits a direct comparison of our results with those of E/C.

3.2 E/C Estimation Strategy: Past and Present

Early applications of the E/C framework[12] combined the analytical model of section 2 with variables similar to those of section 3.1 into equations (9) - (11).[13]

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[12] See, for example, Easterlin and Crimmins (1982).

[13] Normality and homoskedacity of errors is assumed throughout this and succeeding sections. Violations of the other standard assumptions are discussed in the text.

(9) $CEB = a_0 + a_1 \ PD + a_2 \ CDUR + \epsilon_1$

(10) $C_n = (a_0 + a_1 \ PD) \ (1 - m)$

(11) $CDUR = b_0 + b_1 \ (C_n - DNC) + b_2 \ CR + \epsilon_2$

Equation (9) simply accounts for the number of children ever born in terms of a vector of proximate determinants and a measure of family planning. Equation (10) estimates a family's potential supply of children by netting out of its natural fertility forecast the influence of child mortality. Equation (11) explains family planning as a conscious balancing of the motivation for contraception (the family's forecast of its excess supply of children) against the costs of fertility regulation.

In their initial work, Easterlin and Crimmins (1982) estimated this model in three recursive steps, with each employing ordinary least squares (OLS) regression techniques. Step 1 estimates equation (9). Step 2 utilizes these estimated coefficients and equation (10) to calculate the C_n necessary to estimate equation (11). Step 3 regresses each of the exogenous variables from the above system on a vector of socioeconomic variables (e.g., education, income, religion). The regressions of all three steps allow the researcher or policymaker to evaluate the effects of a specific socioeconomic change.

Kelley and Schmidt (1983) and Easterlin and Crimmins (1985) have recognized two important complications within the model and consequently have revised the estimation strategy for equations (9) - (11). E/C now employ a two-stage Tobit (2S-Tobit) technique for Steps 1 and 2.[14] We alluded in section 2 to

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[14] E/C (1985) also analyze several other econometric problems, including truncation bias introduced by limiting the sample to women with at least two live births. They reestimated their model for all women after imposing values for the missing data points. For example, a childless woman was assigned a first birth interval equal to her marital span plus nine months. Sample means were used for her second birth interval, breastfeeding, pregnancy loss,

the need for the Tobit technique for equation (11). Couples with an excess demand for children are, within the constraints of our data set, precluded from enhancing their fertility via negative CDUR. A lower bound of zero is effectively imposed on family planning. The Tobit variant is represented in equation (11a).

$$\text{(11a) CDUR} = \begin{cases} b_0 + b_1 (C_n - \text{DNC}) + b_2 \text{ CR} + \epsilon_2 & \text{if rhs} > 0 \\ 0 & \text{if rhs} \leq 0 \end{cases}$$

Simultaneity within these three equations is now addressed through two-stage estimation. The remainder of this section reformulates the structural model with an emphasis on its error structure. We begin with an explanation of unobservable natural fertility (N) rather than observable family size (CEB). We argue that N is influenced by a vector of proximate determinants (PD) and a random element (μ_1).

$$\text{(12) } N = \alpha_0 + \alpha_1 \text{PD} + \mu_1$$

CEB, the variable of ultimate policy concern, is determined by the woman's natural fertility (N), her intervention through voluntary regulation (CDUR), and stochastic factors (μ_2).

$$\text{(13) CEB} = N + \beta_1 \text{ CDUR} + \mu_2$$

Finally, the model states that N, child survivorship (s = 1 - m), family size desires (DNC), and contraceptive costs (CR) determine CDUR in a particular manner.

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and survivorship. Because similar results were obtained, E/C concluded that the truncation bias was not severe.

$$(14)\ \text{CDUR} = \begin{cases} \gamma_0 + \gamma_1 (s\ N - DNC) + \gamma_2\ CR + \mu_3 & \text{if rhs} > 0 \\ 0 & \text{if rhs} \leq 0 \end{cases}$$

The μ_i's are assumed to be normally distributed with zero mean and constant variance.

Since N has no empirical counterpart, equation (12) cannot be estimated directly and we substitute it out of the system. The following two equations result.

$$(15)\ \text{CEB} = \alpha_0 + \alpha_1\ PD + \beta_1\ CDUR + (\mu_1 + \mu_2)$$

$$(16)\ \text{CDUR} = \begin{cases} \gamma_0 + \gamma_1 [s\ (\alpha_0 + \alpha_1\ PD) - DNC] + \gamma_2\ CR \\ \quad + (\mu_3 + \gamma_1\ s\ \mu_1) & \text{if rhs} > 0 \\ 0 & \text{if rhs} \leq 0 \end{cases}$$

The model's error structure is now apparent. Specifically, if μ_1 were zero, then equation (16) demonstrates that CDUR would not be correlated with μ_2, the error term in the CEB equation.[15] Consequently, recursive OLS estimation would be appropriate, providing unbiased and efficient estimates for both equations.

On the other hand, μ_1 being zero implies that our proximate determinants predict N without error. Such an assumption is questionable, particularly in view of the imperfect nature of our proxy measures for PD. If μ_1 is not zero, then CDUR is correlated with the residual of equation (15), and OLS estimates are biased and inconsistent. Accordingly, a two-stage Tobit and least-squares approach (2S-Tobit) technique has been adopted. The first stage employs Tobit estimation for the following variant of equation (16).

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[15] Of course, this discussion presumes that the exogenous variables of the model are not correlated with the error terms. This assumption will be examined in more detail in section 3.3.

$$
(17)\ \text{CDUR} = \begin{cases} \gamma_0 + \gamma_3\ s + \gamma_4\ (s\ \text{PD}) - \gamma_1\ \text{DNC} + \gamma_2\ \text{CR} \\ \qquad + (\mu_3 + \gamma_1\ s\ \mu_1) & \text{if rhs} > 0 \\ 0 & \text{if rhs} \leq 0; \end{cases}
$$

where $\gamma_3 = \gamma_1\ \alpha_0$,

$\gamma_4 = \gamma_1\ \alpha_1$, and

γ_4 is the coefficient vector associated with the PD vector multiplied by the survivorship ratio, s.

The second stage uses predicted CDUR and regression analysis to obtain consistent estimates for CEB equation (15). These coefficients can then be combined with equation (12) to predict N. Finally, consistent Tobit estimates for equation (14), the structural form of CDUR, are obtained using predicted N.

Comparisons of the OLS and 2S-Tobit results are presented in section 4.1. We predict that the largest discrepancy will be for the CDUR coefficient in the CEB equation. To obtain an unbiased estimate of contraceptive efficacy, one must adequately control for fecundity differences between contraceptors and non-contraceptors. If our proximate determinants underestimate fecundity for contraceptors, then μ_1 would be positively correlated with CDUR and its OLS coefficient would be biased downwards. That is, contraception would appear to be less effective than it actually is because contraceptors would have higher natural fertility levels than predicted. Indeed, Kelley and Schmidt (1983) have demonstrated such a result using a 2SLS technique for this model, while Rosenzweig and Schultz (1985a) have demonstrated it using a different model for a sample of women from the United States.

To complete our discussion of simultaneity, consider briefly the estimation of this model through a truly simultaneous technique, say three-stage or full-information maximum likelihood. A simultaneous nonlinear technique would allow the direct estimation of the separate coefficients of equations (15) and (16). We have not chosen that tack for several reasons. Most importantly, equation (16) is underidentified.[16] Additionally, equation (17) is less restrictive than is the structure imposed by equation (16). Equation (17) allows any proximate determinant to have an influence on CDUR as well as its impact on natural fertility; it allows child mortality to play a role beyond reducing potential fertility; and it allows an increase in potential fertility to have a different influence on CDUR than would a decline in desired family size (currently constrained to be the same at γ_1). A reader believing any of these conditions to be important could confine himself to the first-stage Tobit results and ignore the second-stage coefficients. Finally, the gain from simultaneous estimation is efficiency. Given the relatively large size of most data sets to which this model would be applied (712 women in our case), the potential efficiency gain seems small relative to the additional estimation complexity and potential bias.

3.3 Additional Endogenity: A Revised Estimation Strategy

Section 3.2 outlines a procedure for obtaining consistent parameter estimates for the E/C model when natural fertility, completed family size, and contraceptive duration are all endogenously determined. Additional complications arise if other regressors are stochastic and correlated with any of the error terms. This section discusses three such situations. In the case of child survivorship, we formulate a new structural equation and present a revised estimation strategy. For breastfeeding, we find that the theoretical

[16] While this is true here, it is not true of the models presented in sections 3.3 and 3.4 which are all overidentified.

problem is not empirically important within our data set. Finally, we treat the remaining regressors as a group and note the necessary assumptions.

Child survivorship plays a dual role in the E/C model. It is used in the CDUR equation (14) to net out child mortality from natural fertility. It is also used (actually its mortality complement) as a proximate determinant of natural fertility, which in turn introduces survivorship into the CEB equation (15). We exclude mortality from the CEB equation because we believe its influences on CEB are already included in the model. Its primary influence, replacement or hoarding for child deaths, is modeled explicitly in the CDUR equation. Its secondary influence, premature termination of breastfeeding, is captured by the adjustment described in table 1. However, even after accounting for these effects, a negative correlation between CEB and child mortality can still be expected due to bidirectional causation. Specifically, infant and child mortality rates rise with mother's age, especially in an area like rural Egypt where prenatal care is poor. Since mother's age rises with parity, survivorship will vary inversely with CEB. Consequently, we formulate a new structural equation which posits that survivorship is affected negatively by CEB and positively by breastfeeding duration, wife's and husband's educational levels, income as represented by ownership of personal and real assets, and the general level of sanitation and health care in the village as represented by the village's average survivorship ratio (s_v). The full structural system can now be represented by equations (12), (13), (14), and (18).

(12) $N = \alpha_0 + \alpha_1 PD + \mu_1$

(13) $CEB = N + \beta_1 \; CDUR + \mu_2$

$$(14)\ \text{CDUR} = \begin{cases} \gamma_0 + \gamma_1 \ (\text{s N - DNC}) + \gamma_2 \ \text{CR} + \mu_3 & \text{if rhs} > 0 \\ 0 & \text{if rhs} \leq 0 \end{cases}$$

$$(18)\ \text{s} = \delta_0 + \delta_1 \ \text{CEB} + \delta_2 \ \text{BRFEED} + \delta_3 \ \text{WE2} + \delta_4 \ \text{WE3} + \delta_5 \ \text{HE2}$$
$$+ \delta_6 \ \text{HE3} + \delta_7 \ \text{ASSETP} + \delta_8 \ \text{ASSETR} + \delta_9 \ s_v + \mu_4$$

The instruments used for the first-stage estimates of the model are the PD vector, DNC, CR, WE2, WE3, HE2, HE3, ASSETP, ASSETR, and s_v. First-stage estimation techniques are least-squares regression for CEB, Tobit regression for CDUR, and weighted probit (with CEB providing the weights) for s. The second stage proceeds recursively as in section 3.2. That is, the equation (15) variant for CEB is estimated with instrumented CDUR. These coefficients are used in equation (12) to predict N. Predicted N and instrumented s are employed to estimate equation (14). And, instrumented CEB is utilized to estimate equation (18).[17]

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[17]This recursive estimation in the second stage allows estimation through essentially linear techniques. This is true in spite of the fact that the CDUR equation is nonlinear in its parameters (all α's are multiplied by γ_1). We linearize it by imposing the coefficient estimates from the CEB equation (15). Were we to use a truly simultaneous technique to account for possible correlation of errors across equations, nonlinear estimation would be required. More important for the present purposes is the choice of instruments. Very few econometric textbooks discuss the selection of instruments in the context of nonlinear estimation. While there is no standard method for choosing them, a common practice is to use all exogenous variables in linear form. Alternatively, a second-degree polynomial has been suggested in an attempt to capture some of the inherent nonlinearity. Such a set of instruments would include all exogenous variables, their squared terms (except for binaries), and all possible pairwise crossproducts. Either set of instruments will produce consistent parameter estimates as long as they satisfy the conditions set out in Amemiya (1977). The choice between the smaller linear set and the larger quadratic set is equivocal. The gain from adding instruments is efficiency. However, in a finite sample, the greater the difference between the number of observations and the number of instruments, the more is bias reduced. The results presented in the body of this paper employ the linear formulation because of the unwieldy nature of the quadratic form. For example, the 17 exogenous variables in this section's model translate into 142 quadratic variables. For comparison's sake, however, we do present second-stage results using quadratic instruments in a footnote in section 4.2.

Average breastfeeding duration (BRFEED) introduces a different complication since its prolongation can be used as a form of contraception. Indeed, it is the second most common form of contraception among our sample of rural Egyptians.[18] The use of BRFEED in estimating natural fertility (fertility resulting from reproductive behavior which is not influenced by parity) introduces a problem. The natural fertility component of BRFEED would be the number of months a woman breastfeeds when she is not breastfeeding for contraception. The contraceptive component would be the increment when she breastfed to prolong subfecundity. Although our data set precludes the separation of these two components for the relevant women, the directions of biases are clear within the model. Since our measure is based on a woman's last two births, BRFEED is biased upward for women contracepting through prolonged breastfeeding at that time. Since BRFEED reduces natural fertility, estimates of natural fertility for these women are biased downward. This downward bias also biases the contraceptive coefficient downward because we have inadequately controlled for the fecundity of these contraceptors. In lieu of complicating the model further, we have performed a simple test to estimate the extent of the problem. We regressed BRFEED on all of the socioeconomic variables described in section 3.1, additionally including a binary for women who have at some time prolonged breastfeeding for contraception. The coefficient on that binary indicates an increment of 0.82 months for contraceptors (compared with an average of 20 months), but it is statistically insignificant

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[18] Forty-one percent of our sample have used one or more methods of contraception. Of these contraceptors, eighty percent have used the pill at some time, twenty-four percent breastfeeding, twelve percent IUD, and three percent condoms. Other contraceptive methods were used by one percent or fewer of the women.

(t-value of 0.78).[19] As a result, we have made no adjustments to the model. Rather, we qualify our results by noting that contraceptive efficacy is biased downward slightly.

The treatment of the regressors within the E/C framework implies an apparent contradiction. Although the standard assumption regarding regressors is that they are fixed, the socioeconomic regressions of step 3 openly acknowledge the stochastic nature of each exogenous variable. An appealing approach might be to treat every regressor as endogenous, and use the socioeconomic variables as instruments. Structural equations for these newly-endogenous variables need not be specified; they would likely be underidentified in any event. Rather, predicted values from the socioeconomic regressions could be used to estimate the structural equations for CEB and CDUR. We have estimated the model in this manner and will present the results in section 4.1. Prerequisite to the successful application of this approach is a good set of socioeconomic instruments. As will be seen in section 4.1, the socioeconomic variables available in our data set are poor predictors of most of our regressors. More will be said on this subject in that section.

Lacking a viable set of instruments, we must assume that these regressors are either uncorrelated with the error terms or have large variances relative

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[19] The regression, with t-values in parentheses, is:

$$\begin{aligned} \text{BRFEED} = {} & \underset{(15.57)}{17.71} - \underset{(0.40)}{0.36}\ \text{WE2} - \underset{(0.71)}{1.62}\ \text{WE3} - \underset{(0.40)}{0.32}\ \text{HE2} - \underset{(0.42)}{0.51}\ \text{HE3} \\ & + \underset{(1.27)}{1.28}\ \text{MOREWOM} + \underset{(0.81)}{0.51}\ \text{LOWEGYPT} - \underset{(0.68)}{0.22}\ \text{ASSETP} - \underset{(1.11)}{0.30}\ \text{ASSETR} \\ & - \underset{(0.78)}{0.82}\ \text{Ever-used-as-contraceptive}; \qquad R^2 = 0.01. \end{aligned}$$

to the equation errors in order to obtain unbiased estimates.[20] As a slight variation on this theme and to illustrate how such correlation could arise, consider family size preferences, C_d. The desired number of children (DNC) as stated at the end of childbearing is employed as a proxy for the unobservable C_d. More explicitly,

(19) $DNC = C_d + \mu_5$.

If one believed that women rationalize too many or too few births by retro-fitting their preferences, then μ_5 would be correlated with μ_1 and possibly also with μ_3. To interpret our empirical results, we must assume that such measurement error is not the result of rationalization, or if it is, that the impact is small.

3.4 An Extension of the Model: The Role of Education

The E/C model relegates education, indeed all socioeconomic influences, to an indirect role in fertility analysis. Completed family size and contraceptive choice are affected directly by the proximate determinants of fertility as well as by family size preferences. Education influences the latter. This section extends that framework by introducing education directly into the children-ever-born (CEB) and contraceptive-duration (CDUR) equations. We attempt to maintain the integrity of the E/C framework in the process. That is, we continue to model CEB as biological production and CDUR as the balancing of motivational benefits against contraceptive costs.

Rosenzweig and Schultz (1985b) envision three potential influences of schooling on fertility. It may (a) enhance the efficiency of contraception, (b) enable couples to recognize systematic versus random components of high

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[20] Maddala (1977, p. 153).

fertility, and (c) alter tastes. The E/C model incorporates the third influence in its socioeconomic phase. Additionally, the E/C socioeconomic phase provides for a direct impact of education on fecundity.[21] The first two influences are ignored in an effort to isolate tastes and preferences to the socioeconomic phase. We believe this is unnecessary; the model can be formulated to include these two influences without introducing tastes and preferences.

Rosenzweig and Schultz (R/S) argue that schooling could influence the productivity of contraception if information concerning its effective use were not completely disseminated across all families. Presuming that education enhances information acquisition, then the educated would have an advantage in voluntary fertility reduction. We model this simply by interacting education with contraceptive duration in the CEB equation (13). We employ wife's education since she is the active contraceptor for our most prevalent contraceptive types--the pill, IUD, and breastfeeding. Education is measured by two binaries representing at least some primary education but no secondary education (WE2), and education beyond the primary level (WE3). Equation (13a) results.

$$\text{(13a)}\quad CEB = N + \beta_1\ CDUR + \beta_2\ (CDUR)(WE2) + \beta_3\ (CDUR)(WE3) + \mu_2$$

Predicted signs for the interactions are negative, although we anticipate that they will be weak for our sample. The dominant contraceptive types either are provided by family planning clinics (the pill, IUD), presumably with the requisite training, or are simple in application (prolonged breast-

[21] Rosenzweig and Schultz (1985a, p. 992) argue that fecundity is not affected by socioeconomic conditions, at least not in the United States. While the E/C socioeconomic phase allows for such fecundity influences, those coefficients need not reflect biological factors only. For example, the impact of education on delaying marriage might be demand-originated.

feeding). The educational advantage is plausibly greater the more complicated the contraceptive technique and the less information available concerning its use. Thus, R/S find no statistically significant impact in the United States for the widely-available, doctor-prescribed modern methods, but they do for "ineffective" methods (jelly, foam, douche, withdrawal, and rhythm).

The second educational influence appears more relevant to rural Egypt. R/S model fertility as a dynamic optimization process within the larger context of household production and female labor force participation. They model a period's decision to contracept as being responsive not only to past fertility but also to the attribution of that fertility to random events vis-a-vis fecundity. That is, fertility which is already too high provides an incentive to contracept in a period. If this high fertility is recognized to be the result of unusually high fecundity, then an additional incentive is provided. In contrast, if the high fertility is perceived to result solely from chance, no extra incentive is provided. To the extent that education equips a couple to recognize a higher natural fertility level earlier, the more educated will contracept longer for a given motivational level. We test this hypothesis by including educational interaction terms with the motivational factor of CDUR equation (14). We use husband's education for this purpose since he dominates the contraceptive decision in rural Egypt. The same levels (HE2, HE3) are employed in equation (14a) as in (13a).

$$\text{(14a)}\quad CDUR = \begin{cases} \gamma_0 + \gamma_1\,(s\,N - DNC) + \gamma_2\,(s\,N - DNC)\,(HE2) \\ \quad + \gamma_3\,(s\,N - DNC)\,(HE3) + \gamma_4\,CR + \mu_3 & \text{if rhs} > 0 \\ 0 & \text{if rhs} \le 0 \end{cases}$$

Both interaction coefficients are predicted to be positive. The estimation strategy remains the same as described in section 3.3.

4.0 The Results

Section 3 presented a critical analysis of the Easterlin/Crimmins (E/C) model, developed several variants of that model, and broached a number of econometric issues. This section estimates the separate models under alternative estimation strategies. Section 4.1 employs the "basic" Kelley/Schmidt (K/S) model while focusing on estimation techniques. Section 4.2 provides international comparisons by contrasting E/C's results from Sri Lanka and Colombia with ours from rural Egypt using both the E/C and K/S models. Section 4.2 emphasizes modeling by utilizing a two-stage technique for the basic K/S model and two extensions.

4.1 Estimation Strategies

This section examines alternative estimation strategies for the same model, the basic K/S model. This model combines the variables of section 3.1 with the structure of equations (14) and (15) to produce a framework similar to the E/C model. Both models treat CEB and CDUR as endogenous, and both utilize similar proximate determinants. Our model differs in several important dimensions: (a) we have refined the breastfeeding measure, which permits the elimination of a questionable variable, the child mortality rate, from the CEB equation; (b) we allow for a possible nonlinear impact of marital duration on CEB; (c) we introduce a binary for periodic spousal absence; and (d) we employ a cost-of-regulation measure, the proportion of the village who have never contracepted, which is unequivocally exogenous.

Table 2 presents estimates of the CEB equation (15) under four alternative estimation strategies: ordinary least squares (OLS); two-stage with CDUR instrumented via a least-squares regression (2SLS); two-stage with CDUR instrumented via a Tobit regression (2S-Tobit); and two-stage with every proximate determinant, survivorship, and family-size desires instrumented (2S-All). Strategies thus run the gamut from treating all variables exogenously to treating all variables endogenously. Equation (17) denotes the instruments used for the 2SLS and 2S-Tobit estimates in the first-stage CDUR equation. First-stage estimates were obtained for 2S-All by using the full complement of table 1's socioeconomic variables as instruments.[22]

The most dramatic disparities among the first three columns of table 2 are for the CDUR coefficients. The fourfold increase from OLS (-0.059) to 2SLS (-0.268) corroborates our earlier argument with respect to CDUR. More fecund women likely contracept earlier and longer than less fecund women, *ceteris paribus*. If our set of proximate determinants do not capture these disrepancies between contraceptors and noncontraceptors fully, then OLS estimates of the efficacy of contraception are biased toward zero. This appears to be the case in rural Egypt as well as in Sri Lanka and Colombia (Easterlin-Crimmins, 1985, pp. 102-103). The slight decrease in the CDUR coefficient between 2SLS (-0.268) and 2S-Tobit (-0.205) also parallels E/C's findings. Our coefficients imply that averting a single birth would require, *ceteris paribus*, 17 years of contraception under the OLS estimate, 4 years under 2SLS, and 5 years under 2S-Tobit. We prefer the two-stage technique over OLS because of the apparent endogeneity of CDUR. We prefer the 2S-Tobit

[22] Least-squares regressions were employed in the first stage for continuous variables (INTERVAL1, INTERVAL2, BRFEED, DNC, and MDUR via age at marriage), probit estimation for binaries (STERILE, APART), weighted probit for survivorship rate (weighted by CEB) and PLOSS (weighted by total number of pregnancies), and Tobit regression for CDUR.

Table 2

CEB Equation: Alternative Estimation Strategies for the Basic K/S Model[a]

	OLS	2SLS	2S-Tobit	2S-All
Intercept	2.132*	1.971*	1.888*	16.607*
	(2.51)	(2.07)	(2.10)	(2.27)
MDUR	0.498**	0.556**	0.558**	-0.482
	(5.88)	(5.81)	(6.17)	(0.77)
$MDUR^2$ / 100	-0.457*	-0.464*	-0.532**	1.508
	(2.17)	(1.96)	(2.38)	(1.04)
INTERVAL1	-0.325**	-0.401**	-0.373**	-0.428
	(11.93)	(11.54)	(12.15)	(0.63)
INTERVAL2	-0.458**	-0.517**	-0.496**	-0.056
	(11.08)	(10.78)	(11.16)	(0.07)
STERILE	-2.468**	-3.177**	-2.941**	-0.611
	(12.78)	(11.96)	(12.85)	(0.11)
PLOSS	-0.840	-0.621	-0.478	6.058
	(1.51)	(0.99)	(0.81)	(0.84)
BRFEED	-0.050**	-0.047**	-0.049**	-0.277
	(6.20)	(5.22)	(5.75)	(1.59)
APART	-0.571**	-0.747**	-0.680**	-2.570
	(2.52)	(2.92)	(2.83)	(0.81)
CDUR	-0.059**	-0.268**	-0.205**	-0.110
	(3.92)	(5.54)	(5.79)	(0.71)
Standard Error	1.712	1.917	1.810	3.091
R^2	0.50			
	Observed	Estimated	Estimated	Estimated
CDUR Minimum	0	-4.30	0.00	0.42
Maximum	20	9.65	14.23	14.11

a. Numbers in parentheses are t-values for OLS, asymptotic t-values for other techniques.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

procedure over 2SLS because of heteroskedasticity around zero in the 2SLS estimate. Fifty-nine percent of our sample have never contracepted. The relative inability of 2SLS to impose this zero lower limit is demonstrated in the last two rows of table 2 which present the minimum and maximum values of CDUR used in estimation. 2S-Tobit will be employed for the remainder of this paper.

The opposite extreme to assuming all variables in the CEB equation to be exogenous is to assume them all to be endogenous. Column 4 of table 2 presents second-stage estimates using this treatment. Glaring among the results is the lack of any significant coefficient other than the intercept.[23] The problem is that our socioeconomic instruments have very little explanatory power in the majority of the first-stage equations. There are two possible explanations for this. The first is that the variables truly are exogenous, and concerns about their endogeneity are exaggerated, at least for rural Egypt. The second is that the set of socioeconomic variables available in our data set represents a poor set of instruments. As is the case with the World Fertility Surveys used by E/C, the 1979 Egyptian Rural Fertility Survey has a paucity of socioeconomic variables, and the ones included are crudely measured.[24] Regardless of the reason for the weak first-stage estimates, we

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[23] The first-stage equations specified the socioeconomic variables in linear form. We also estimated these equations in a quadratic form which included each variable, its square (except for binaries), and all pairwise crossproducts. Three variables were statistically significant in that estimation (INTERVAL2, STERILE, and BRFEED).

[24] The RFS provides no income data for either the family or the household. While we have attempted to fill that gap by constructing two indexes of wealth (number of personal assets ranging from 1 to 7, and number of real assets ranging from 1 to 6), these are only rough measures. We have also contructed two village-level aggregates, the child survivorship rate and the proportion who have never contracepted, but these lack household specificity. The remain-

are uneasy about assuming all variables to be endogenous, at least in this data set. Rather, we attempt to resolve what we perceive to be the most serious of these problems by focusing on contraceptive duration and child survivorship.

Table 3 presents the results for the structural form of the CDUR equation. Both motivation and regulation costs are statistically significant under all

Table 3

CDUR Equation: Alternative Estimation Strategies for the Basic K/S Model[a]

			2S-Tobit		2S-All	
	OLS	2SLS	Index	Partial	Index	Partial
Intercept	5.876**	5.566**	5.100**		7.186**	
	(11.60)	(10.84)	(4.13)		(5.53)	
Motivation ($C_n \div C_d$)	0.404**	0.414**	1.170**	0.464	0.706**	0.285
	(7.40)	(8.01)	(8.83)		(3.31)	
CR	-5.378**	-5.204**	-13.931**	-5.533	-16.115**	-6.508
	(7.01)	(6.80)	(6.64)		(7.25)	
Std. Error[b]	4.159	4.134	7.834		8.307	
R^2	0.17					

a. Numbers in parentheses are t-values. Given the nonlinear nature of this model, coefficient estimates are not asymptotically efficient. The t-values are biased downwards.

b. The standard errors of the least-squares and Tobit estimates are not directly comparable.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

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ing variables are binaries, with education encompassing only three categories. Moreover, there is little variance in religion in rural Egypt: ninety-six percent of our sample is Moslem.

four estimation techniques. Coefficients change only slightly between OLS and 2SLS. Since the Tobit index coefficients are not comparable to least-squares coefficients, a column entitled "Partial" is included. This column represents the partial derivative of the expected contraceptive duration with respect to each variable as evaluated at the sample means. Interestingly, these partial derivatives are very similar at the sample means to the 2SLS estimates, although they will differ increasingly as one moves further from the sample means.

4.2 International Comparisons

This section compares the results of the E/C model when applied to three different countries of widely varying cultures on three different continents. The estimates for Sri Lanka and Colombia have been taken from Easterlin and Crimmins (1985, ch. 4) and represent both rural and urban areas. We have followed the E/C model as faithfully as possible for our sample of rural Egyptian women. As a point of contrast, we also present estimates of the basic K/S model for rural Egypt. Three sets of results are discussed: the CEB proximate determinants equation; the CDUR contraceptive use equation; and summary comparisons of non-contraceptors and contraceptors.

Table 4 presents a comparative accounting for the proximate determinants of CEB. We are encouraged by the model since all coefficients in each country are of the anticipated sign and most are significant at the one-percent level. Concentrating on the E/C model, coefficients are broadly the same across countries both in magnitude and statistical significance. (Note, however, the substantive implications in the next paragraph for MDUR.) The major exception is the impact of contraception, which is much smaller in rural

Egypt. While the difference was expected--after all, prevalence rates are low in rural Egypt, and the Colombia and Sri Lanka samples include urban areas--its magnitude was not. If these results can be accepted at face value, 3.0 years of contraception in Sri Lanka, 3.4 in Colombia, and 13.2 in rural Egypt would reduce completed family size by one. Recall from table 1 and section 3.3 when interpreting these figures, however, that these CDUR measures likely overestimate actual contraceptive duration and thereby overstate these numbers. Despite these qualifications, the statistically significant negative impact of contraception on completed family size is a result which to our knowledge has not been convincingly demonstrated previously on Egyptian rural data.

Turning to the estimates for the basic K/S model, we note that the exclusion of child mortality does not seriously hamper the model. The APART binary indicates that periodic separation, even in the latter years of child-bearing, reduces family size by about 0.7 children, *ceteris paribus*. The quadratic term for marital duration is statistically significant and provides the biologically-appealing implication that fecundity declines nonlinearly with age.[25] For example, the E/C results imply that the *ceteris paribus* impact of an additional ten years of marriage is to raise completed family size by 3.7 children in Sri Lanka, 4.8 in Colombia, and 3.2 in rural Egypt, regardless of when in the marriage this decade was added. Our nonlinear

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[25] Contrast this result with Easterlin and Crimmins' (1985, page 42) statement, "... one would expect, other things constant, that an additional year of exposure (marriage) would, other things constant [*sic*], be expected to have the same impact in raising fertility whatever the initial duration of exposure (marriage)."

Table 4

CEB Equation: International Comparisons; Second-Stage Least-Squares Results[a]

	Easterlin/Crimmins Model			Basic K/S Model	
	Sri Lanka	Colombia	Rural Egypt	Rural Egypt	Std. Coeff.[b]
Intercept[c]			2.834** (8.12)	1.888* (2.10)	
MDUR	0.335** (31.27)	0.481** (20.73)	0.317** (18.12)	0.558** (6.17)	1.059
$MDUR^2$ / 100				-0.532** (2.38)	-0.406
INTERVAL1	-0.389** (11.17)	-0.496** (6.34)	-0.328** (10.97)	-0.373** (12.15)	-0.386
INTERVAL2	-0.578** (14.24)	-0.593** (7.06)	-0.447** (10.14)	-0.496** (11.16)	-0.328
STERILE	-2.621** (17.37)	-3.164** (10.98)	-2.716** (12.81)	-2.941** (12.85)	-0.448
PLOSS	-1.597** (3.31)	-1.060 (1.26)	-0.436 (0.76)	-0.478 (0.81)	-0.024
BRFEED[d]	-0.024** (5.48)	-0.060** (3.90)	-0.017** (2.42)	-0.049** (5.75)	-0.166
APART				-0.680** (2.83)	-0.082
CDUR[d]	-0.338** (13.16)	-0.299** (8.28)	-0.076** (3.42)	-0.205** (5.79)	-0.211
m	0.284 (0.74)	2.338** (3.78)	2.317** (6.63)		
Std. Error[e]			1.728	1.810	
Observations	1608	507	712	712	

a. Results from Sri Lanka and Colombia are from Easterlin and Crimmins (1985, p. 63). Numbers in parentheses are asymptotic t-values.

b. Calculated by rescaling coefficients as if all variables had zero mean and unit variance.

c. We have redefined E/C's not-secondarily-sterile binary to conform with our STERILE binary. Consequently, E/C's reported intercepts are inappropriate and are not reported here.

d. BRFEED and CDUR differ in the K/S model from the E/C model. See table 1. Additionally, we have rescaled E/C's INTERVAL1 and INTERVAL2 coefficients to change their units from months to years.

e. Standard errors are not reported in E/C.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

results imply the following increments for the first three decades, respectively: 5.0, 4.0 and 2.9 children. With regard to our refined variables, the breastfeeding measure which allows for early cessation due to child death performs better than its counterpart under E/C. Most interesting, however, is the improvement in the relationship between CDUR and completed family size. Contraception is now more effective (coefficients of -0.076 versus -0.205) implying a decline from 13.2 to 4.9 years of contraception necessary to avert a single birth. While this is more in line with Sri Lanka and Colombia, the estimates are not directly comparable. The improvement in contraceptive efficacy resulted from more accurately estimated measures and a slightly different model. We do not have the data necessary to replicate these estimates for Sri Lanka and Colombia.

The last column of table 4 presents standardized coefficients for the basic K/S model. They provide one way of abstracting from the units of measurement. Their interpretation is that a one standard-deviation change in the regressor will result in the coefficient number of standard deviations in CEB. These results provide some insight into the relative importance of the various proximate determinants of CEB.[26] The most powerful influence is the duration of marriage, followed by several of the fecundity measures.[27] This dominant role for marital duration presents a challenge to reducing fertility in rural Egypt given of the very young age at which women marry. In our sample, the average age is 17.2 with 52 percent having married by age 16, but

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[26]One must still be cautious in interpreting the relative sizes of these variables as connoting "importance" since the variables themselves change over time at different paces.

[27]This result is consistent with that found by Loza and El-Khorazaty (1979).

Loza (1982, p. 38) reports the average to be about 15.3 for the 35-44 cohort. While Egyptian law sets the legal minimum age for marriage at 16, strong cultural and/or economic incentives for early marriage remain. Loza notes that overreporting of the marital age rather than postponed marriage may be the result of the law. Notable also is the strong inhibiting impact of breastfeeding whose standardized coefficient, -0.166, rivals that of contraception, -0.211. This factor will have to be reckoned with as modernization moves families toward reduced use of breastfeeding as a form of child nourishment.

The results of equation (14), which explains the number of years of contraceptive use (CDUR) in terms of the "motivation" for use (C_n - C_d) and the cost of fertility regulation (CR), are presented in table 5. We observe that the t-values are high throughout the table. The Tobit coefficients are not directly comparable across countries. Roughly comparable coefficients can be obtained by multiplying each Tobit coefficient by the proportion of the sample that has contracepted. These values approximate partial derivatives of expected CDUR when evaluated at the respective sample means. Since these partial derivatives are nonlinear, more interesting comparisons could be made at the same motivational level and CR for each country. Unfortunately, E/C do not provide the equation standard errors necessary for those calculations. The following discussion is made subject to this qualification. The responsiveness, evaluated at sample means, of families under the E/C model to both motivation and contraceptive costs is highest in Sri Lanka (an additional 0.97[28] years for every child of excess supply, and 1.09 years for

[28]This value was calculated by multiplying the proportion of contraceptors in the Sri Lanka data set by the Tobit coefficient: (0.55) (1.753) = 0.97. All other values were computed similarly.

every additional birth control device known), second highest for rural Egypt (0.78 and 0.82 years, respectively), and lowest in Colombia (0.66 and 0.65 years, respectively). The relative responsiveness of rural Egyptians is encouraging in light of the facts that both the Sri Lankan and Colombian

Table 5

CDUR Equation: Intercountry Comparisons; Second-stage Tobit Estimates[a]

	Easterlin/Crimmins Model			Basic K/S
	Sri Lanka	Colombia	Rural Egypt	Rural Egypt
Intercept[b]	-6.821	-1.256	-8.891** (6.99)	5.100** (7.86)
Motivation ($C_n - C_d$)	1.753** (10.48)	0.950** (6.66)	1.893** (7.78)	1.170** (8.83)
CR[c]	1.976** (8.67)	0.931** (4.26)	2.004** (6.40)	-13.931** (6.64)
Standard Error[d]			11.638	7.834
Observations	1608	507	712	712
Proportion of Contraceptors	0.55	0.69	0.41	0.41

a. Results for Sri Lanka and Colombia are from Easterlin and Crimmins (1985, p. 75). Numbers in parentheses are t-values. Given the nonlinear nature of this model, coefficient estimates are not asymptotically efficient. The t-values are biased downward.

b. E/C do not report t-values for intercepts.

c. The E/C model employs the number of birth control methods known by the wife as the costs-of-regulation (CR) measure. The K/S model employs the village proportion of women who have never contracepted as the CR measure.

d. Standard errors are not reported in E/C.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

data sets encompass urban as well as rural areas, and that family planning programs have been much more successful in these two countries. These findings bode well for the potential of family planning in rural Egypt. In particular, while it has been observed that rural Egypt approximates a natural fertility regime, we find that families do and will respond to a situation in which their fertility potential exceeds their family size target. Moreover, factors which lower the costs of family planning can have a quantitatively significant impact on its use. This statement holds whether we employ the E/C cost measure (number of birth control methods known by the wife) or the more inclusive K/S cost measure (proportion of the village's families who have never contracepted).

Finally, consider the summary implications of the proximate determinants estimates for the three countries. Table 6 compares the estimated supply of children (C_n) with demand (C_d), and the estimated natural fertility level (N) with the number of children ever born (CEB), first for women who have never contracepted and then for contraceptors. Some interesting contrasts emerge. While we focus on the E/C results for rural Egypt, we do note the K/S parallels in parentheses. In both Sri Lanka and Colombia, women who have never contracepted exhibit an excess supply of about one child, on the average! Either regulation costs are substantial or estimates of C_n and/or C_d are poor. In rural Egypt, however, neither excess supply nor excess demand exists at the mean for noncontraceptors. Since noncontraceptors are in the natural fertility state by definition, N would be identical to CEB if no error existed in the proximate determinants equation. Apparently error exists since estimated N exceeds CEB by 0.80 children in Sri Lanka, 1.00 in Colombia, and 0.25 (0.38 for K/S) in rural Egypt. The CEB equation overestimates natural fertility

Table 6

Means and (Standard Deviations) for Estimated C_n, C_d, Estimated N, CEB; Noncontraceptors versus Contraceptors

	Noncontraceptors				Contraceptors			
	Est. C_n	C_d	Est. N	CEB	Est. C_n	C_d	Est. N	CEB
Sri Lanka[a]	5.95	4.95	6.68	5.88	6.73	4.38	7.33	5.52
E/C Model	(2.10)	(2.11)	(2.54)	(2.11)	2.01	(1.94)	(2.11)	(2.53)
Colombia[a]	6.78	5.62	8.18	7.16	7.98	4.47	8.90	6.43
E/C Model	(2.48)	(2.56)	(3.18)	(3.66)	(2.53)	(2.79)	(2.71)	(3.14)
Rural Egypt	5.06	5.08	6.94	6.69	6.15	3.98	7.72	7.23
E/C Model	(1.74)	(2.00)	(2.55)	(2.70)	(1.44)	(1.87)	(1.50)	(2.12)
Rural Egypt	5.23	5.08	7.07	6.69	6.51	3.98	8.10	7.23
K/S Model	(1.99)	(2.09)	(2.55)	(2.70)	(1.70)	(1.87)	(1.54)	(2.12)

a. Values for Sri Lanka and Colombia are from Easterlin and Crimmins (1985, pp. 65, 67-68).

for noncontraceptors, implying that C_n and motivation are overestimated as well. This result is in spite of the two-stage estimation procedure.

Several points can be noted for contraceptors. If N, C_n, and motivation are overestimated for noncontraceptors, then they are likely underestimated for contraceptors. Consequently, the motivation coefficient in the CDUR equation is biased downward. We note that C_n ("supply") is higher for contraceptors than for noncontraceptors--by 0.8 children in Sri Lanka, 1.2 in Colombia, and 1.1 in rural Egypt (1.3 for K/S). On the other hand, C_d ("demand") is lower for contraceptors--by 0.6 children in Sri Lanka, 1.2 in Colombia, and 1.1 in rural Egypt. In sum, contraceptive motivation is about two children higher for contraceptors than for noncontraceptors in each country. About one-half of this arises from supply differences, the other half from demand differentials. The number of births averted through contraception (N - CEB) is estimated to be 1.8 in Sri Lanka, 2.5 in Colombia, and 0.5 (0.9 for K/S) in rural Egypt. These estimates represent lower bounds because of the downward bias in the estimate of N.

4.3 Extensions to the Basic K/S Model

Section 3.3 examines the variables of the basic K/S model and concludes that exogenous treatment of the child survivorship rate, s, could pose serious problems for the analysis of rural Egyptian fertility. Consequently, equation (18) specifies a structural equation for s. Section 3.4 further expands the model by introducing a direct role for education into the CEB and CDUR equations. Specifically, equation (13a) indicates that a wife's education could enhance contraceptive efficiency. And, equation (14a) depicts an environment wherein a husband's education could intensify the motivation for contraception, possibly by earlier recognition that excess fertility is the result of higher fecundity levels rather than random factors. This section compares the results from the basic K/S model with each of those variants.

Table 7 presents the second-stage estimates of the CEB equation for the three models. The results are encouraging for each model. All proximate determinants have the predicted signs, and with the exception of PLOSS, each is statistically significant at the one-percent level. Furthermore, coefficient magnitudes are remarkably similar across models for all variables other than CDUR. These similarities lead to the following observations. The rate of fertility declines over marriage as indicated by MDUR's quadratic term which is negative and significant. *Ceteris paribus*, the first decade of marriage is estimated to add five live births, the second decade four, and the third

Table 7

CEB Equation: The Basic K/S Model and Extensions[a]

	Basic K/S	s Endog.	s Endog. & Educ.
Intercept	1.888*	1.987*	2.009*
	(2.10)	(2.29)	(2.31)
MDUR	0.558**	0.537*	0.536*
	(6.17)	(6.16)	(6.13)
$MDUR^2$ / 100	-0.532*	-0.508*	-0.509*
	(2.38)	(2.36)	(2.35)
INTERVAL1	-0.373**	-0.359**	-0.360**
	(12.15)	(12.10)	(11.96)
INTERVAL2	-0.496**	-0.479**	-0.479**
	(11.16)	(11.22)	(11.19)
STERILE	-2.941**	-2.778**	-2.779**
	(12.85)	(12.72)	(12.47)
PLOSS	-0.478	-0.591	-0.641
	(0.81)	(1.03)	(1.12)
BRFEED	-0.049**	-0.049**	-0.049**
	(5.75)	(6.00)	(5.93)
APART	-0.680**	-0.638**	-0.637**
	(2.83)	(2.75)	(2.74)
CDUR	-0.205**	-0.154**	-0.164**
	(5.79)	(4.77)	(4.12)
CDUR x WE2			0.034
			(0.88)
CDUR x WE3			-0.052
			(0.71)
Standard Error	1.810	1.748	1.754

a. Numbers in parentheses are asymptotic t-values.
* Significant at the 0.05 level.
** Significant at the 0.01 level.

decade three. Each year between marriage and the first birth (INTERVAL1) reduces completed fertility by 0.4 births, while an additional year between the first and second births (INTERVAL2) implies 0.5 fewer births. Each six months of breastfeeding per infant (BRFEED) extends subfecundity enough to avert 0.3 births over the marriage, while periodic separations (APART) prevent 0.6 births on average.

Although coefficients remain nearly constant across equations for the PD vector, substantial changes are evident in the CDUR coefficient. In the basic K/S model of column 1 the coefficient of -0.202 implies that 4.9 years of contraception[29] would be required to avert a single birth. The analogous figures when treating survivorship endogenously in column 2 are -0.154 and 6.5 years.[30] Neither of the interaction terms between CDUR and wife's education is significant in column 3. Nevertheless, using these coefficients as our

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[29]Recall that this is an average for all forms of contraception. This coefficient would likely differ among methods. Recall also from table 1 and section 3.3 that our CDUR measurement likely overestimates true contraceptive duration, thus biasing our coefficients downward.

[30]The only difference between these two equations is the form of the first-stage Tobit regression for CDUR. Basic K/S uses equation (17) which includes observed s, interactions between s and the PD vector, DNC, and CR. With endogenous s, the instruments are WE2, WE3, HE2, HE3, village-average s, PD vector, DNC, and CR. No interaction terms are employed. Clearly, the CDUR coefficient in the CEB equation is sensitive to the manner in which CDUR is instrumented. Accordingly, we have also estimated this equation with the quadratic form for the first-stage CDUR equation described in footnote 17. The results of that estimation are

$$\begin{aligned} CEB = {} & \underset{(2.50)}{2.111} + \underset{(5.98)}{0.505}\,MDUR - \underset{(2.24)}{0.467}\,MDUR^2 - \underset{(11.98)}{0.332}\,INTERVAL1 - \underset{(11.18)}{0.461}\,INTERVAL2 \\ & - \underset{(12.72)}{2.531}\,STERILE - \underset{(1.33)}{0.738}\,PLOSS - \underset{(6.22)}{0.050}\,BRFEED - \underset{(2.54)}{0.572}\,APART \\ & - \underset{(3.64)}{0.080}\,CDUR, \end{aligned}$$

with an equation standard error of 1.702.

best point estimates, the impact on CEB of an additional year of contraception would be -0.164 for an illiterate woman (6.1 years to avert a birth), -0.130 with some primary education (7.7 years), and -0.217 with some secondary education (4.6 years). The insignificance of the education interactions is consistent with Rosenzweig and Schultz's (1985b) finding of no statistically significant educational impact for doctor-prescribed modern methods in a United States sample. The pill and IUD are the dominant forms of contraception in our sample.

Equation (18) provides the structural form of the survivorship equation. The second stage of this equation was estimated by weighted probit, with CEB providing the weights. This weighting scheme implicitly assumes that the larger the number of births, the more reliable is the use of child survivorship rates as survivorship probabilities. The second-stage results are presented below with asymptotic t-values in parentheses.

$$\text{(18)}\quad s = \underset{(5.74)}{-1.572} - \underset{(3.78)}{0.052}\ \text{CEB} + \underset{(9.62)}{0.025}\ \text{BRFEED} - \underset{(0.87)}{0.050}\ \text{WE2} + \underset{(0.94)}{0.151}\ \text{WE3}$$

$$+ \underset{(1.78)}{0.094}\ \text{HE2} + \underset{(2.56)}{0.212}\ \text{HE3} - \underset{(3.17)}{0.067}\ \text{ASSETP} + \underset{(0.40)}{0.007}\ \text{ASSETR} + \underset{(9.49)}{2.924}\ s_v$$

The endogenous nature of survivorship is verified by the statistical significance of CEB; survival probabilities do decline with parity. The other significant coefficients indicate that breastfeeding, husband's education, and village-level health conditions all raise survivorship probabilities. Surprisingly, ASSETP, intended to act as a proxy for income, appears to affect survival negatively. Perhaps personal assets are acquired at the expense of expenditures which raise health standards, rather than out of additional income.

Table 8 presents the second-stage Tobit estimates for contraceptive duration. Motivation and the costs of regulation are highly significant in all three models, and the magnitude of their coefficients do not change much across models. On the one hand, this is not surprising given the similarity of the coefficients from table 7 which are used in estimating motivation. On the other hand, the first model uses observed survivorship while the latter two employ a predicted value. Apparently, ignoring the endogeneity of survivorship introduces an insubstantial amount of bias into this equation for this data set.

Consider more closely our most comprehensive model represented in column 3 of table 8. Both the motivational effect of excess fertility and the inhibiting effect of regulation costs are of the anticiptated signs and are highly significant. While some primary education on the part of the husband does not statistically alter the motivational impact, education beyond the primary level does. The incremental impact of some secondary education (1.072) is nearly as large as the Tobit index coefficient for the pure motivation variable (1.232). Since the Tobit coefficients lend little insight into the quantitative influence of motivation and regulation costs, we have provided an additional column entitled "Partials." This column presents the partial derivatives of the expected value of CDUR with respect to each variable. This nonlinear function has been evaluated at, in order of presentation, (a) one standard deviation below the sample means of all variables, (b) the means, and (c) one standard deviation above the means. As can be seen, at the sample means (about one child of excess supply in a village where 39 percent have contracepted), the motivational impact of an additional child of excess supply would raise CDUR by only about 0.5 years when the husband is illiterate, and 0.9 years when he has had some secondry education. Had an additional 10 percent of the village had contraceptive experience, CDUR would rise by another

Table 8

CDUR Equation: The Basic K/S Model and Extensions[a]

	Basic K/S			s Endogenous			s Endogenous & Education Interactions		
	Index	Partials[b]	Stat's[c]	Index	Partials[b]	Stat's[c]	Index	Partials[b]	Stat's[c]
Intercept	5.100**			4.930**			4.777**		
	(4.13)			(7.06)			(3.89)		
Motivation	1.170**	0.158	1.129	1.291**	0.180	0.950	1.232**	0.155	0.956
$(C_n - C_d)$	(8.83)	0.464	3.093	(9.94)	0.513	2.778	(6.34)	0.491	2.779
		0.841	-15.760		0.920	-14.570		0.907	-14.570
			7.760			6.125			6.132
Motivation							-0.114	-0.014	0.356
x HE2							(0.52)	-0.045	1.457
								-0.084	-14.400
									5.961
Motivation							1.072*	0.135	0.161
x HE3							(2.14)	0.427	0.785
								0.790	-3.500
									5.257
CR	-13.931**	-1.882	0.392	-13.483**	-1.883	0.392	-13.295**	-1.671	0.392
	(6.64)	-5.526	0.213	(6.48)	-5.358	0.213	(6.47)	-5.299	0.213
		-10.011	0.000		-9.611	0.000		-9.794	0.000
			0.895			0.895			12.446
Std. Error	7.833			7.859			7.783		

a. Numbers in parentheses are t-values. Given the nonlinear nature of this model, coefficient estimates are not asymptotically efficient. The t-values are biased downwards.

b. Partial derivatives of the expected value of CDUR with respect to the variable. This nonlinear function is evaluated at, in order, (a) one standard deviation below the means of all variables, (b) the means of all variables, and (c) one standard deviation above the means of all variables.

c. Descriptive statistics in the following order: mean, standard deviation, minimum value, and maximum value.

* Significant at the 0.05 level.

** Significant at the 0.01 level.

0.5 years. About 70 percent of these increases could be attributed to an increase in the probability of contracepting, the remaining 30 percent to marginal increases in duration conditional upon contracepting.[31] In contrast, at one standard deviation above the means (excess supply of 3.7 children in a village where 60 percent have contracepted) the motivational impacts are 0.9 years for an illiterate husband and 1.7 years with secondary education. Increasing village experience by 10 percent implies an additional year of contraception. Only 48 percent of these increases result from an increased probability of contracepting; 52 percent derive from marginal increases in duration.

An interesting sidelight of the table is a comparison of motivation by educational level. At the means, estimated excess supply is 0.6 children for couples with illiterate husbands, 1.5 where husbands have some primary education, and 2.0 when husbands have education beyond the primary level.[32] Slight differences in excess supply exist among the most motivated in the three educational levels (motivational maxima of 6.1, 6.0, and 5.2, respectively). More glaring discrepancies exist with respect to couples with excess demand. For couples with at least some secondary education, none had an excess demand for children greater than 3.5 compared with about 14.5 for less-educated couples (motivational minima of -14.6, -14.4, and -3.5).

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[31] We have followed the decomposition suggested by McDonald and Moffitt (1980). Specifically, the first component of the partial derivative is calculated by weighting the partial derivative of the probability of contracepting by the expected contraceptive duration if contracepting. The second component is computed by weighting the partial of the expected value if contracepting by the probability of contracepting.

[32] These have been calculated from the means provided in the table and the sample proportions, 0.684, 0.237 and 0.786 for illiterate, some primary, and at least some secondary, respectively.

4.4 Summary of the Empirical Results

While the detailed empirical results following from our modification and application of the E/C framework to rural Egypt have been presented above and will not be summarized here, in keeping with the broad orientation of this paper, it would be useful to conclude with a synopsis of the findings as they relate to the Demographic Transition and to policymaking in Egypt. Three sets of results are particularly notable.

First, the ability of the model to estimate natural fertility levels at the household level allows us to categorize subportions of the population within the stages of the Demographic Transition illustrated in figure 1. Table 6 of section 4.2 provides the necessary information, estimated C_n (surviving natural fertility) and C_d (desired surviving family size), for women who have never contracepted versus those who have in rural Egypt, Sri Lanka, and Colombia. We find,

a. On average, C_n approximately equals C_d for the noncontracepting subpopulation of rural Egypt. These families have little or no motivation for contraception and remain in the the premodernization Phase I of figure 1's schema. Their family sizes could well continue to rise for a period of time before the benefits from contraception exceed its costs.

b. In contrast, the noncontracepting subset of families drawn from both the rural and urban areas of Sri Lanka and Colombia have already embarked on Phase II. In each country C_n exceeds C_d by approximately one child, on average. An increasing number of women in these countries can be expected to begin contracepting.

c. By applying child survivorship rates (s) to actual fertility for the contracepting subsets of women, we find that, on average, actual surviving fertility exceeds C_d by 1.0 children in rural Egypt (s = 0.81), 2.0 in Sri Lanka (s = 0.94), and 2.9 in Colombia (s = 0.94). All three of these subpopulations are in Phase III. Paradoxically, the sample with the lowest contraceptive prevalence, rural Egypt, appears to have the smallest gap between family size desires and outcomes. Part of the explanation might be that child mortality remains three to four times higher in rural Egypt. The women in these samples are all 35-44 years old. Mortality has fallen precipitously during the lives of the Sri Lankan and Colombian women, but much less dramatically for the Egyptians. The large gaps in the case of Sri Lanka and Colombia might partially result from unexpectedly large survivorship.

Second, we find that the methodology represented in our study offers promise in identifying the separate influences of family planning and socio-economic change, and in so doing, the results provide insights into the basic determinants underlying the Demographic Transition. In particular,

a. Duration of marriage is by far the single most powerful determinant of completed family size in rural Egypt. As long as women continue to marry very early in rural Egypt (on average, 17 years of age in our sample), family planning will play a secondary role in reducing fertility.

b. Prolonged breastfeeding (20 months on average) is only slightly less powerful in reducing fertility in rural Egypt than is contraception. Reductions in fertility through increased contraception could be largely offset by reductions in breastfeeding if rural Egyptian women follow the example of women in more developed countries.

c. The rise in child survivorship inherent in socioeconomic development raises the natural supply of children. For a family in an excess-supply situation, the motivation for contraception will be enhanced and additional fertility regulation can be expected, on average. In contrast, for families where the costs of regulation still outweigh the increased motivation, and for those in an excess-demand situation, the result will be larger surviving families. On net, the impact of development on population growth in the intermediate future in rural Egypt is uncertain, depending largely on the relative sizes of the excess-supply, excess-demand groups, and their individual responses to modernization.

Finally, our conceptual and econometric extensions to the E/C framework are useful. This revised specification provides a model whose specific empirical results yield a cautiously optimistic assessment of the potential for reduction in family size in rural Egypt through family planning and socio-economic change. Notably,

a. We have sharpened the model in its treatment of the child survivorship rate, eliminated the child mortality ratio from the family size equation thereby removing the problem of bidirectional causality while retaining infant mortality's proximate-determinants' role, refined the measures of breastfeeding and contraceptive duration, and incorporated education into the structural model.

b. We have found that families <u>do</u> respond when family size expectations exceed desires, with the most educated being the most responsive.

c. Contraceptors are more fecund than are non-contraceptors in rural

Egypt, and their child survivorship rates are higher. Frameworks which do not take careful account of these fecundity differences will underestimate contraceptive efficacy. Failure to take the fecundity/contraception relation into account results in an estimate of 17 years of contraception to avert one birth. Properly estimated, this figure drops to 5 years.

d. While short-run changes in rural Egyptian fertility will likely be downward, expectations of <u>dramatic</u> short-run declines might be somewhat unrealistic. More importantly, the downward trend will plausibly gain momentum in the long run as more effective family planning programs are implemented, as socioeconomic change is advanced beyond the presently low threshold levels, and as integrated family planning and development programs become more pervasive and effective.

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