Fertility Decline in the Modern World and in the Original Demographic Transition: Testing Three Theories with Cross-National Data

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This study uses aggregate data on a large number of the world's societies to test three theories of fertility decline in the modern world and in the original demographic transition. One prominent theory relates fertility decline to the changing economic value of children. With industrialization and overall modernization the economic value of children's labor shifts from positive to negative. This interpretation has been challenged by those who claim that the flow of wealth in preindustrial societies is always from parent to child rather than from child to parent. An alternative interpretation is that fertility levels reflect people's efforts to promote their reproductive success, and that this requires the careful tracking of infant and child mortality. Fertility rates are adjusted to the rate of infant and child survival, and will be high when survival rates are low and low when survival rates are high. A third theory emphasizes female empowerment. Fertility will be high when women are highly subordinated to men, but as women gain more autonomy and control over their own lives they reduce their fertility levels because, among other possibilities, higher levels of fertility present them with serious burdens. We tested all three theories through multiple regression analyses performed on two samples of societies, the first a large sample of the world's nation-states during the period between 1960 and 1990, and the second a sample of now-developed societies between 1880 and 1940. Our findings showed that infant mortality was an excellent predictor of fertility, and that female empowerment was a good predictor. However, there was only weak support for the argument that the economic value of children's labor plays an important role in fertility decisions. The findings were discussed in the context of a broader interpretation of fertility behavior in societies with high levels of industrialization and modernization.

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INTRODUCTION

A well-known feature of life in less-developed countries is the presence of a large number of children per family. Compared to couples in the developed world, couples in less-developed countries produce a good many more offspring. Yet in recent decades there has been a substantial and, to us at least, a surprising reduction in fertility rates. Between 1960 and 1990, total fertility throughout the world fell from 5.56 to 4.29 children per ever married woman, a 23 percent reduction. Efforts to explain this reduction, as well as efforts to explain fertility reduction in the countries of the original demographic transition of the nineteenth and twentieth centuries, have varied widely. In this paper we test three different theories of fertility decline and compare their relative explanatory power.

One of the most widely endorsed theories holds that people adjust their fertility levels to the economic value of children's labor. A major proponent of this view is the anthropologist Marvin Harris (1989; Harris & Ross, 1987). He notes that in societies or regions where the economy is still based on agriculture very young children typically perform such tasks as gathering firewood, carrying water for cooking and washing, grinding and pounding grains, taking food to adults in the fields, sweeping floors, and running errands. Older children are involved in cooking meals, working full time in the fields, hunting, herding, fishing, and making pots, containers, mats, and nets. Under these conditions, it is rational for people to keep their fertility high to maximize the economic benefits that their children provide for them. The shift from high fertility to low fertility results, Harris claims, mainly from the changing economic value of children's labor with industrialization. As children cease to be economic assets, it is much more rational for couples to limit their numbers. Harris has relied heavily on the work of Benjamin White (1973, 1976, 1982), who has shown that children from Javanese peasant families perform nearly half of all household work, and on the work of Mahmood Mamdani (1972) and Nag, White, and Peet (1978). For 20 Javanese households, Nag, White, and Peet found a correlation coefficient of .54 (Spearman rank-order) between the total number of hours children worked in a household and that household's balance of income above and beyond food expenditures. On the basis of these and additional data on Nepalese households, they concluded "that at the current rate of reproduction and under present circumstances, children probably have a net positive economic value to their parents in these villages, aside from the old-age security they provide them" (1978; p. 301).

The same type of argument has also been pressed by a number of demographers. John Caldwell (1976), for example, holds that there are essentially two different types of fertility regimes, one in which it is rational for fertility to be high and the other in which it is rational for fertility to be low, and that it is economic rationality that primarily determines which regime a society adopts. The key issue according to Caldwell is the direction of wealth flows between parents and children. High-fertility societies—primitive and traditional societies—are those in which wealth flows are primarily from child to parent, whereas low-fertility societies—industrial societies—are those in which wealth flows go primarily from parent to child. Caldwell stresses that the divide between high-fertility and low-fertility regimes is "not mechanistically determined by economic conditions" (1976; p. 346), but this is the factor he is clearly stressing as the source of reproductive behavior. Ester Boserup (1986) regards occupational change as the crucial factor leading to fertility decline in countries with high-fertility regimes. Boserup presents fertility rates for people in four different occupations in 28 less-developed countries. Those working in agriculture had the highest rate, 8.38. The lowest rate was obtained by workers in professional, managerial, technical, and clerical jobs, 6.74. People working in sales and service and in manual work had fertility rates that were in between, 7.39 and 7.63 respectively. Boserup comments that (1986; p. 253) "the factor which reduces fertility is the structural change in the labour market. . . . The large declines in fertility in recent years have occurred in Asian and Latin American countries, [which are countries] in which the governments have pursued policies leading to changes of the occupational structure." Note, however, that the fertility differences between occupational groups presented by Boserup are relatively small, and that the fertility of the lowest group is still nearly seven children, much higher than is found in the industrialized countries. This suggests that something is amiss with the economic rationality argument.

Several social scientists have challenged the view that in preindustrial societies the net flow of benefits is from child to parent (Turke, 1989; Low, 1991, 1993; Low & Clarke, 1992; Kaplan, 1994). Low has claimed that "children's labor is never sufficient to result in a net economic gain to parents" (1993; p. 184), and Turke (1989; p. 76) goes so far as to argue that in all societies "the net flow of services and resources will usually be from older to younger generations." Both Turke and Low and Clarke conclude that traditional demographic arguments have had it backwards: People do not use reproductive resources to acquire economic benefits, but rather use economic resources to acquire reproductive benefits. It is the promotion of inclusive fitness rather than the net economic value of children that governs fertility behavior. Hillard Kaplan (1994) has tested the wealth flows argument by using data from three tribal societies in South America, all of which practiced a mixture of hunting and gathering and horticulture. In all three societies fertility was very high—an average of 8.15 for the societies combined—but children in each society were producing far fewer calories than they were consuming. Kaplan's conclusion was that the flow of benefits was overwhelmingly from parent to child rather than the reverse, even taking into consideration other kinds of work that children performed. "The data from all three groups," he says, "show that even though children were very costly to raise, fertility was high" (1994; p. 763).

This leads us to the second theory of fertility decline, which is a classic form of sociobiological explanation. We identify it as such because the theory assumes that fertility is all about maximizing inclusive fitness rather than economic benefits. The authors of this theory, Carey and Lopreato (1995), argue that the main determinant of the level of fertility is the level of mortality. According to them, humans have evolved a "two-surviving-children psychology" in which they gear their total fertility to the frequency with which offspring survive to adulthood. Where infant and child mortality are high, fertility will be high in order to replace offspring expected to die before they themselves become reproductive. Likewise, where infant and child mortality are low, and thus where most infants survive to reproductive age, fertility is adjusted downward. If two children born are both likely to survive, why have more? Carey and Lopreato note that Darwin himself "argued that, despite the tendency of populations to outpace the growth of their resources, a countertendency toward population stability is a characteristic of all species. The theory of natural selection suggests that, given the real or potential Malthusian scarcity and the associated struggle for existence, the fertility of individuals displays a vigorous tendency to track mortality—a tendency toward a replacement-level reproductive strategy" (1995; p. 616). Carey and Lopreato go on to remark that the original demographic transition itself provides highly suggestive evidence for their interpretation. As mortality levels dropped fertility dropped even though people were living longer and had more years in which to reproduce. The authors argue that the maximization of inclusive fitness is not a matter of the sheer production of offspring, but rather the production of offspring that are likely to survive and reproduce in the next generation. As they say, "parents who invest their limited resources in fewer rather than more children may also have the greater genetic success" (1995; p. 625).

We are skeptical of Carey and Lopreato's argument that people have evolved to aim for only two surviving children, but we accept their more general point that fertility should track mortality and that the maximization of inclusive fitness often means having fewer (but higher quality) children. In fact, demographers have long thought that fertility levels should logically be related to levels of infant mortality, and numerous studies have been carried out to test this argument. Against expectations, widely varied results have been obtained. Matthiessen and McCann (1978) summarize the results of six studies of European countries and regions between 1830 and 1960. The average correlations (Pearson r) were, for Germany, .37; for Portugal, .61; for Wallonia, 15; for England and Wales, .15; for Flanders, .10; for Prussia, –.02; for northern Italy, .36; for southern Italy, .19; for Scotland, –.10; and for France, .41. Many of these correlations are surprisingly low, with two actually negative. Matthiessen and McCann also summarize three studies of the relationship between infant mortality and actual fertility change for several of the same European countries and regions during the same time period. These average correlations were, for Germany, .50; for Prussia, .54; for northern Italy, .25; for southern Italy, .14; for Flanders, .12; and for Wallonia, –.35. Only the correlations for Germany and Prussia are even moderately high, and the substantial negative correlation for Wallonia is jarring to expectations. Van de Walle (1986) found weak correlations between infant mortality and marital fertility for 11 European countries: .156 for 1870; .383 for 1900; and .078 for 1930. However, she found much stronger correlations between infant mortality and overall fertility for the same sample of countries: .232 for 1870; .685 for 1900; and .439 for 1930. Relying on Coale (1966), Cantrelle, Ferry, and Mondot (1978) report a correlation of –.38 between infant mortality and total fertility for 12 sub-Saharan African countries, and a correlation of –.37 between second-year mortality and fertility for the same countries. When the authors recalculated the correlations using 47 subregions within these 12 countries as their units of analysis, this produced correlations of –.058 between fertility and infant mortality and –.061 between fertility and second-year mortality. Cantrelle, Ferry, and Mondot (1978; p. 182) concluded that "every possible combination of levels of mortality and fertility is encountered in tropical Africa, and the overall pattern is one of little association between the two rates." Obviously these African results go totally against expectations, and the overall picture is a mixed bag. Nevertheless, despite some disconfirming results infant mortality is significantly related to fertility in some countries at some times. Something interesting is clearly going on, and the matter would seem to warrant further study.

The third major interpretation of fertility decline is the female empowerment argument (Penn, 1999). In an early study along these lines, Dyson and Moore (1983) showed that fertility was notably higher in the northern states of India than in the southern states and related this difference to kinship patterns affecting the autonomy of women. In the northern states women were subjected to strong pronatalist pressures because their main task was to produce male heirs for their husbands' descent groups, but in the southern states the kinship system allowed women greater autonomy. Family planning received greater acceptance in the southern states, Dyson and Moore argued, probably because women in those states were less controlled by senior wives and because women could communicate more easily with their husbands. Southern Indian women were also more active in the labor force. The authors concluded that "female social status is probably the single most important element in comprehending India's demographic situation" (1983; p. 54).

Malhotra, Vanneman, and Kishor (1995) extended Dyson and Moore's analysis of the role of gender in fertility differentials between north and south India in a quantitative direction. They looked at the effects on fertility of several dimensions of what they called patriarchy: active gender discrimination, gender bias in the marriage system, and the economic value of women. Discrimination against females was measured by way of the female share of the literate population and the degree of neglect of, or direct infanticide practiced against, female rather than male infants; gender bias in the marriage system involved the proportion of girls aged 15–19 who were married and the extent to which girls had to leave their home villages to marry (village exogamy). The economic value of women was assessed by way of the female share of the labor force and the amount of land under rice cultivation, the latter being an important determinant of women's roles. The authors found that gender discrimination and gender bias in the marriage system exerted strong positive effects on fertility and that the economic role of women exerted some (but a much less powerful) effect. Where gender discrimination and gender bias in the marriage system were at lower levels, fertility was also lower. Furthermore, the effect of these gender variables remained substantial even when controls for economic development, social stratification, and region were introduced.

Murthi, Guio, and Dreze (1995), in another study of Indian fertility differentials, focused in particular on the role of female education. They argued that it should have an impact on fertility reduction for several reasons: educated women are more likely to object to the burdens of repeated pregnancies; educated women are less likely to be dependent on sons as a source of old-age security and social status; educated women frequently have higher aspirations for each of their children and thus a desire to have fewer children while investing more in each; and, since educated women tend to know more about child hygiene and nutrition, they experience lower child mortality and thus need fewer births in order to achieve a desired family size. They found that female literacy and female labor force participation both exerted negative and statistically significant effects on total fertility. Because the authors presented some of their raw data, I was able to reanalyze them and found that the effect of female literacy was much more important than the effect of female labor force participation. The former correlated at $r = -.864$ with total fertility, whereas the latter correlated much more weakly, at $r = -.166$.

Handwerker (1991; 1993) has presented data which he claims support the view that the reduction of fertility on the island of Antigua in the West Indies since the mid-1960s was primarily determined by increasing female empowerment. Handwerker measured female empowerment in terms of both expanding educational opportunities and expanding opportunities for women in the job market. However, he claims that education exerted no direct effect on female empowerment, enhancing it only by way of opening up job opportunities.

Jejeebhoy (1995) has examined 59 studies that explore the relationship between female education and fertility. These studies cover a large number of countries. Of the 59 studies, 26 found an inverse relationship between women's education and fertility. Of the remaining 33 studies, 13 found a reversed-U or reversed-J relationship, another 13 found a 7-shaped relationship, and 7 found either no relationship or a positive relationship. However, if the studies of sub-Saharan African societies, which are unusual with respect to fertility, are ignored, 25 studies show an inverse relationship, 5 show a reversed-U or reversed-J relationship, 7 show a 7-shaped relationship, and only 1 shows a positive relationship or no relationship. It should be noted that reversed-J or 7-shaped relationships resemble straight inverse relationships except that there is a short delay in the beginning of fertility decline. What appears to be happening is that in societies at very low levels of development small amounts of education do not produce a decline in fertility, or in some cases actually lead to an increase in fertility, but when greater amounts of education are obtained fertility then starts a continual decline. At the higher levels of economic development, even small increments in educational attainment lead to fertility decline. The same sort of pattern is found with respect to rural-urban differences and differences in the level of gender inequality. More female education is needed in rural than in urban areas in order to precipitate a fertility decline, and where gender inequality is greater more female education is needed for fertility to start to decline. Jejeebhoy notes that most studies show that the generally strong negative effect of women's education on fertility continues to hold even when household socioeconomic characteristics are controlled. Jejeebhoy stresses, as have others, that education exerts its effect on fertility by way of giving women greater autonomy and empowerment with respect to such things as knowledge, decision-making, physical mobility, feelings and loyalties, and economic behavior.

We are left, then, with three different theories of fertility decline. Each theory assumes that fertility behavior is rational, the first that it is guided by an economic rationality, the second that it is guided by a reproductive rationality, and the third that it is guided by the extent to which women have enough control over their own lives to make rational choices about family size. The aim of this paper is to submit all three theories to further empirical test in order to examine their comparative explanatory power. Most previous studies have been very limited in scope. We know of none that have tested the theories against each other simultaneously. Moreover, most studies have focused on only one country or even one region of a country. This research carries out multiple regression analyses using aggregate data on a large number of the world's countries. It thus explores fertility decline in worldwide perspective.

METHODS

Two separate studies were conducted. In the first, 121 contemporary nation-states were selected for analysis. All of the variables were meaured at two points in time, 1960 and 1990. The dependent variable was total fertility. The three independent variables, conceptually speaking, were the economic value of children's labor, infant mortality, and female empowerment. We measured the economic value of children's labor by using both the percentage of the labor force in agriculture and the percentage of the population living in urban areas. For good measure, we added the gross national product per capita and the adult literacy rate since these are known to be strong correlates of fertility and we wanted to see how they related to fertility when other variables were factored out. Infant mortality was measured as the infant mortality rate, which is the number of children who die in their first year of life for every 1,000 children born. We also included child mortality, since it has been suggested (Matthiessen & McCann, 1978; van de Walle, 1986) that it might be a better measure of offspring survivorship than infant mortality. For 1960 child mortality was measured as the number of children who died between the ages of one and four for every 1,000 children of that age. For 1990, child mortality was measured as the number of children between birth and five years of age who died for every 1,000 children of that age. Child mortality for 1990 thus included infant mortality. We also added the number of physicians in the population because this measure has been used in a study similar to ours by Lopreato and Yu (1988), who found it to be the best predictor of fertility. Female empowerment was measured as a combination of female secondary educational enrollments and percentage of women in the labor force.

Total fertility rates for 1960 were obtained from *World Tables*, volume II, 3rd ed. (World Bank, 1983). The rates for 1990 were obtained from the *Human Development Report 1992* (United Nations, 1992). Gross national product per capita for 1960 was obtained from the *Statistical Abstract of the United States 1972* (U.S. Bureau of the Census, 1972), and the figure for 1990 was taken from the *Human Development Report 1992*. Adult literacy for 1960 was obtained from *World Tables*, volume II, 3rd ed., and for 1990 was selected from the *World Development Report 1992*. Percentage of the labor force in agriculture for 1960, infant mortality for 1960, number of physicians in the population for 1960, and female secondary enrollments for 1960 were obtained from the *World Development Report 1984* (World Bank, 1984). Percentage of the labor force in agriculture for 1990 was taken from the *World Development Report 1997* (World Bank, 1997). Infant mortality for 1990 was taken from *World Development Report 1992*. Child mortality for 1960 was obtained from the *World Development Report 1984*, and for 1990 was taken from the *World Development Report 1993* (World Bank, 1993). Number of physicians in the population for 1990 was obtained from *Human Development Report 1995* (United Nations, 1995). Female secondary enrollments for 1990 was taken from *World Development Report 1993* (World Bank, 1993). Percentage of the population living in urban areas in 1960 and 1990 was obtained from *Human Development Report 1992*. Percentage of women in the labor force in 1960 was taken from *World Tables*, volume II, 3rd ed., whereas the same variable for 1990 was obtained from *Human Development Report 1992*. Because of missing data on several variables, the number of cases on which analyses could be conducted was reduced to between 39 and 63.

In the second study, data were collected for 24 countries in Europe and North America, as well as for Japan, Australia, and New Zealand. All of these data pertained to three time periods—1880, 1910, and 1940—in order to capture the early and late points of the demographic transition. The data were obtained from B.R. Mitchell, *International Historical Statistics 1750–1993* (Mitchell, 1998). Three independent variables were selected for the analysis: infant mortality rate, percentage of the labor force in agriculture, and percentage of the labor force in manufacturing. Because of the small number of cases, no additional independent variables could be employed. Although information was collected for 27 societies, missing data reduced the number of cases in two analyses to 16 and 17, respectively.

The basic form of statistical analysis was multiple regression. All variables whose skewness was 1.000 or greater were logarithmically transformed.

Many demographers object to the use of the kinds of highly aggregated data that are used in this study, preferring instead to concentrate on close case studies of individual societies. This latter technique certainly has its merits, but a tremendous advantage of aggregate data is their comprehensiveness, and comprehensive data are certainly necessary if we are to build a true science of human behavior. In 1950, W.S. Robinson identified a fallacy that he called the *ecological fallacy.* This amounted, he said, to drawing conclusions about the behavior of individuals from data on populations. However, over time many sociologists (the background of the authors) have come to suspect that this so-called fallacy is not really a fallacy at all, and that Robinson was unnecessarily alarmist. It may occasionally come into play, but in most instances no harm is done by using aggregate data to make inferences about individual behavior. In the cases of such variables as fertility and crime, aggregate data are nothing more than the behavior of individuals added together, and thus *are* data about individual behavior. Another good reason for using aggregate data is that they allow us to use multiple regression analyses, which enable us to determine the relative explanatory power of several independent variables. This represents, we believe, a significant advantage over previous studies.

RESULTS

Study 1

Gross national product per capita, percentage of the labor force in agriculture, adult literacy, percentage urban, female empowerment, and infant and child mortality were in nearly all cases moderately to strongly correlated with fertility in both 1960 and 1990. The number of physicians in the population was highly correlated with fertility, but it washed out when the infant mortality rate was controlled, so it was dropped. To understand fertility change in the modern world, six sets of multiple regression analyses were carried out. In the first (Table 1), the six independent variables were regressed on 1960 fertility levels. These show that infant mortality, female empowerment, and percentage urban are the best predictors of

TABLE 1

Effects of 1960 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Adult Literacy, Percentage Urban, Female Empowerment, and Infant Mortality on Fertility in 1960

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*	*VIF*
LogGross nat. product	–.564	.286	.436	1.763	.087	6.160
% labor force agriculture	.539	.024	.041	.142	.888	8.198
Adult literacy rate	–.671	.057	.076	.335	.740	5.135
% urban	–.503	–.233	–.440	–1.415	.166	9.725
Female empowerment	–.640	–.529	–.495	–3.688	.001	1.808
Infant mortality rate	.703	.362	.553	2.295	.028	5.840

$R = .807$
$R^2 = .650$
Adj. $R^2 = .612$
$N = 42$

fertility. As infant mortality falls, fertility falls as well; and as females become more empowered and more of the population lives in urban areas fertility falls as well. Both percentage of the labor force in agriculture and adult literacy largely wash out when the other independent variables are controlled, and so are extremely weak predictors. Gross national product is inversely correlated with fertility, as expected, but it undergoes a sharp sign reversal when the other variables are factored out. It therefore cannot be regarded as an important predictive variable one way or the other.

Table 2 repeats this analysis but substitutes child mortality (ages 1–4) for infant mortality. Matthiessen and McCann (1978) have suggested that if parents are decreasing their fertility in response to lower mortality, then what is really important is the rate of child rather than infant surivorship (cf. van de Walle, 1986; p. 210). However, our results show that child mortality is a much poorer predictor of fertility than infant mortality. In this analysis female empowerment is the best predictor, and child mortality ranks even below percent urban, which is a relatively good predictor. As in the the first analysis, gross national product undergoes a sign reversal

TABLE 2

Effects of 1960 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Adult Literacy, Percentage Urban, Female Empowerment, and 1-4 Mortality on Fertility in 1960

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*	*VIF*
LogGross nat. product	−.564	.176	.252	1.057	.298	5.172
% labor force agriculture	.539	.050	.088	.294	.771	8.177
Adult literacy rate	−.671	−.058	−.079	−.346	.732	4.827
% urban	−.503	−.174	−.399	−1.047	.302	9.559
Female empowerment	−.640	−.527	−.526	−3.670	.001	1.881
1–4 mortality rate	.602	.211	.251	1.279	.209	3.524

R = .784
R^2 = .615
Adj. R^2 = .573
N = 42

when the other variables are controlled, and thus it is very difficult to know how to interpret it except to say that it strongly deviates from expectations.

The third analysis (Table 3) repeats the first analysis but uses 1990 levels of the variables. Here again infant mortality is the best predictor, with female empowerment next in line. Gross national product, literacy, and percentage urban are very weak predictors, and percentage of the labor force in agriculture is only marginally better. Overall, the six independent variables explain at least 81 percent of the variance in fertility, with infant mortality and female empowerment explaining the vast majority of this. The next analysis (Table 4) repeats the third analysis but substitutes child mortality for infant mortality. Actually, this analysis uses the mortality rate for children aged 0–5, and thus is a combination of infant and child mortality. These results therefore are not strictly comparable to those in Table 2. In any event, we see that 0–5 mortality is clearly the best predictor of 1990 fertility, with female empowerment again the next best. Percentage urban and literacy essentially wash out, and the predictive ability of gross national product and percentage of the labor force in agriculture is quite modest.

The total variance explained is 81 percent, the majority of which is being explained by 0–5 mortality and female empowerment.

It could be argued that, if declining infant mortality leads to lower fertility it can only do so if people are given time to assess its effects over the medium to long run (this is similar to the argument that child mortality should be a stronger determinant of fertility than infant mortality). To test this possibility we repeated the analysis of Table 3 but substituted the 1982 infant mortalty rate for the 1990 rate (Table 5). Here we see that the predictive ability of infant mortality drops substantially and that female empowerment becomes the best predictor. The predictive ability of infant mortality is not only less than that of female empowerment, but infant mortality is only a slightly better predictor than the percentage of the labor force in agriculture. It thus appears that, whatever effect infant mortality has on fertility, this effect is felt quickly rather than after a lag in time.

In our final analysis of this data set we looked at how changes in fertility between 1960 and 1990 related to changes during the same period of

TABLE 3

Effects of 1990 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Adult Literacy, Percentage Urban, Female Empowerment, and Infant Mortality on Fertility in 1990

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*	*VIF*
LogGross nat. product	–.745	.040	.040	.297	.768	5.789
% Labor force agriculture	.767	.143	.167	1.084	.283	7.407
LogAdult literacy rate	–.319	.087	.044	.650	.518	1.429
% Urban	–.616	.063	.052	.469	.641	3.887
Female empowerment	–.838	–.440	–.388	–3.667	.001	3.491
Infant mortality rate	.878	.456	.506	3.834	.000	5.441

$R = .903$
$R^2 = .816$
Adj. $R^2 = .810$
$N = 63$

TABLE 4

Effects of 1990 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Adult Literacy, Percentage Urban, Female Empowerment, and 0-5 Mortality on Fertility in 1990

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*	*VIF*
LogGross nat. product	−.745	.179	.206	1.364	.178	7.233
% Labor force agriculture	.767	.214	.241	1.643	.106	6.788
LogAdult literacy rate	−.319	.138	.070	1.045	.300	1.429
% Urban	−.616	.081	.067	.608	.545	3.841
Female empowerment	−.838	−.412	−.364	−3.384	.001	3.657
Log0–5 Mortality rate	.880	.468	.626	3.963	.000	7.010

R = .905
R^2 = .819
Adj. R^2 = .806
N = 63

levels of the six independent variables. The results are shown in Table 6. Here infant mortality change was clearly the best predictor of fertility change, and female empowerment change was the only other variable with much predictive ability.

Study 2

Can these results be replicated for the original demographic transition between 1880 and 1940? Of the two most important predictive variables in Study 1, infant mortality and female empowerment, it was only possible to examine the effects of infant mortality. As far as we know, no data exist that would measure female empowerment for these rather distant time periods. However, it is unlikely that there was much female empowerment occurring at these times (especially in 1880 and 1910). Married women were a minuscule proportion of the labor force in all of the now-industrialized societies, and they were much less involved in the educational world than is true today. Therefore it is probably safe to assume that female empowerment could not have been an important determinant of fertility decline during the original demographic transition, at least on the level that female empowerment reaches today.

The results for 1880 are shown in Table 7, and are given in terms of the full explanatory model and the best explanatory model. These data show that infant mortality is the best predictor of fertility in 1880, but they are weak in their support. The best model is infant mortality by itself, but even this explains only 14.7 percent of the variance at most. The reason for such weak results is probably the data themselves. Older data are often more unreliable than more recent data, and in this case several values had to be estimated for some cases. This interpretation is reinforced by the fact that the data for 1910 and 1940 show much stronger results (Tables 8 and 9). Infant mortality is far and away the most important predictor of fertility rates in 1910. For 1910, infant mortality and percentage of the labor force in manufacturing together explain at least 72.3 percent of the variance, and infant mortality is explaining most of this. The results are not quite as strong

TABLE 5

Effects of 1990 Levels of Gross National Product, Percentage of the Labor Force in Agriculture, Adult Literacy, Percentage Urban, and Female Empowerment, and 1982 Infant Mortality on Fertility in 1990

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*	*VIF*
LogGross nat. product	–.740	–.050	–.054	–.370	.713	5.442
% Labor force agriculture	.758	.178	.221	1.332	.188	7.051
LogAdult literacy rate	–.277	.172	.095	1.280	.206	1.412
% Urban	–.621	.065	.059	.476	.636	3.949
Female empowerment	–.842	–.466	–.484	–3.872	.000	4.021
Infant mort. rate 1982	.835	.273	.285	2.082	.042	4.813

$R = .888$
$R^2 = .789$
Adj. $R^2 = .774$
$N = 61$

TABLE 6

Effects of 1960–1990 Changes in Gross National Product, Percentage of the Labor Force in Agriculture, Percentage Urban, Female Empowerment, and Infant Mortality on 1960–1990 Changes in Fertility

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*	*VIF*
LogGNP change	–.283	–.028	–.021	–.164	.871	1.379
% Lab. force agri. change	.594	.017	–.019	–.099	.922	2.984
Log% Urban change	.345	.158	.126	.918	.365	1.539
LogFemale empowerment change	–.562	–.353	–.278	–2.167	.038	1.333
Infant mortality rate change	.724	.453	.551	2.920	.006	2.896

R = .770
R^2 = .593
Adj. R^2 = .558
N = 39

for 1940, but they are still good. The full model explains only 22.3 percent of the variance, but infant mortality is clearly the dominant predictive variable, and by itself it is able to explain 29.4 percent of the variance.

It was not possible to explore the effects of change in the independent variables on changes in fertility rates because an insufficient number of cases made the analyses unstable and unpredictable. More cases, probably at least twice as many, would be needed for this type of analysis to be reliable.

DISCUSSION

One of the most striking findings of our study is that both infant and child mortality are much more strongly related (zero order) to fertility than has been the case in most previous studies. The average correlation between infant mortality and fertility for 1960 and 1990 was a whopping

.808, and the correlation between 1960–1990 infant mortality change and 1960–1990 fertility change was .724. For the 1880–1940 data the average correlation was .588. The average correlation between child mortality and fertility for 1960 and 1990 was .732. No previous study has achieved average correlations anywhere near these numbers. We are not sure how to explain why our results are so much better; one possibility is the higher level of aggregation of our data compared to the data used in previous studies.

In the regression analyses for the 1960–1990 period, our results show that infant mortality and female empowerment were by far the best predictors of fertility. We designate infant mortality as the best overall predictor because it was the best predictor in four of the six analyses, and also because it was clearly best in predicting actual fertility *change*. Moreover, infant mortality was a much better predictor than child mortality, and the presumed effects of infant mortality occur very quickly rather than after a lag of time.

Our results are broadly consistent in one way with those from an ear-

TABLE 7

Effects of 1880 Infant Mortality Rate, Percentage of the Labor Force in Agriculture, and Percentage of the Labor Force in Manufacturing on 1880 Birth Rate

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*
(a) Full Model					
Infant mortality rate	.384	.299	.323	1.130	.279
% L.F. in agriculture	.201	.149	.243	.542	.597
% L.F. in manufacturing	–.016	.079	.128	.286	.780
$R = .414$					
$R^2 = .171$					
Adj. $R^2 = -.020$					
$N = 17$					
(b) Best Model					
Infant mortality rate	.384	.384	.384	1.610	.128
$R = .384$					
$R^2 = .147$					
Adj. $R^2 = .090$					
$N = 17$					

lier study by Lopreato and Yu (1988). They carried out a multiple regression analysis on data from 63 contemporary nation-states. Their principal finding was that the number of physicians in the population was the best predictor of fertility, and they regarded their physicians variable as a proxy for the rate of infant and/or child survivorship. They included infant mortality in their regression analysis, but it was not a strong predictor. This is surprising in view of the fact that the infant mortality rate is a direct rather than an indirect indicator of infant survivorship. We found that both the number of physicians and infant mortality were highly correlated (zero order) with fertility, but, as expected, the number of physicians washed out when infant mortality was controlled. In this respect our results are different from Lopreato and Yu's. Nevertheless, Lopreato and Yu interpret their findings in the same way that we do: the survival rate of infants, which is determined in large part by the level of health care in a society, is a major correlate of fertility level. Also in a similar way to our study, Lopreato and Yu found that two female empowerment variables, percentage of women in the labor

TABLE 8

Effects of 1910 Infant Mortality Rate, Percentage of the Labor Force in Agriculture, and Percentage of the Labor Force in Manufacturing on 1910 Birth Rate

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*
(a) Full model					
Infant mortality rate	.814	.827	.736	5.090	.000
% L.F. in agriculture	.499	.149	.136	.521	.612
% L.F. in manufacturing	–.473	–.227	–.208	–.807	.435
R = .875					
R^2 = .765					
Adj. R^2 = .707					
N = 16					
(b) Best Model					
Infant mortality rate	.814	.831	.748	5.390	.000
% L.F. in manufacturing	–.473	–.538	–.319	–2.300	.039
R = .872					
R^2 = .760					
Adj. R^2 = .723					
N = 16					

TABLE 9

Effects of 1940 Infant Mortality Rate, Percentage of the Labor Force in Agriculture, and Percentage of the Labor Force in Manufacturing on 1940 Birth Rate

Variable	*Zero-order*	*Partial*	*Standard Beta*	*t*	*Sig.*
(a) Full Model					
LogInfant mortality rate	.567	.430	.469	1.780	.097
% L.F. in agriculture	.431	.029	.034	.108	.916
% L.F. in manufacturing	−.405	−.186	−.196	−.709	.490
R = .600					
R^2 = .360					
Adj. R^2 = .223					
N = 18					
(b) Best Model					
LogInfant mortality rate	.567	.567	.567	3.441	.002
R = .567					
R^2 = .321					
Adj. R^2 = .294					
N = 27					

force and percentage of women who are literate, were good predictors of fertility.

Our results for the 1960–1990 period thus support both the sociobiological argument that emphasizes infant mortality and the female empowerment argument. However, our results show weak support for the argument that fertility is being adjusted primarily to the economic value of children's labor. Three of the standardized beta coefficients for percentage of the labor force in agriculture were not much above zero, and the other coefficients were weak. In terms of percentage of the population living in urban areas, this was a good predictor for 1960 but not for 1990 or for changes during the 1960–1990 period. In fact, the beta coefficient with respect to 1960–1990 change carries the wrong sign. Finally, it cannot be a simple increase in material wealth or the standard of living that is determining fertility change. Three of the beta coefficients for gross national product were barely above zero and the other three, though substantially larger, were in the wrong direction.

Our analyses of the original demographic transition, the 1880–1940 period, show even more support for infant mortality. Here infant mortality was easily the best predictor of fertility, and in 1910 it explained well over half of the variance. However, there is slightly more support here for the role of the changing economic value of children's labor, and so this may have been somewhat more important for the original demographic transition than for the 1960–1990 period.

Although we have found that fertility does not decline simply because societies develop economically and become wealthier, the transformation of society from a rural and agricultural base to an urban and industrial base is no doubt an important part of the story (even if not in a way that is measured by any of our independent variables). Hillard Kaplan (1996) suggests that modernization has produced a situation in which people reduce the number of offspring they have but invest much more in each offspring: they trade quantity (an r strategy) for quality (a K strategy) (cf. van den Berghe & Whitmeyer, 1990). He proposes that it is the development of skills-based competitive labor markets that is the crucial factor. Such markets have the effect of increasing the importance of parental investment in offspring well-being. In having fewer children but investing more in each parents are not necessarily maximizing their fitness in the classic sense, even in the long run. However, at the very least they are maximizing the "cultural fitness" of their offspring (and grandoffspring, etc.). Kaplan's argument is highly consistent with the common observation that in modern societies better-educated and wealthier parents tend to have fewer offspring than couples with less education and lower income. Alan Rogers (1995) has argued that the concept of fitness should be expanded to include not only the total number of offspring produced, but also the economic well-being of each offspring. As he puts it, "In a world with heritable wealth, wealth has value over and above its effect on the number of one's offspring. By continuing to earn, a rich person can increase the wealth of descendants several generations removed. Thus, the marginal effect of wealth on fitness may remain positive even among the very wealthy" (1995; p. 94) (cf. Borgerhoff Mulder, 1998).

What is missing in these arguments is any reference to reduced infant mortality. In order for parents to have only two or three children and invest heavily in each child the rate of infant and child survivorship must be very high, as it is in modern industrial societies. As Wiley and Carlin (1999) have shown, mother-child attachment is likely to be high only in those societies that have both low fertility and low infant mortality, i.e., in post-demographic transition societies. "Exclusive attachment," they say, "may . . . be an outcome of low mortality, as parents are relatively assured that their investment will pay off" (1999; p. 153). Strong mother-child attachment (and perhaps even father-child attachment) would seem to be a prerequisite for intensive parental investment.

The importance of female empowerment in the process of fertility decline fits well into the picture we have been sketching. One likely reason female empowerment helps reduce fertility is that women often regard having a large number of children as a serious burden since it is they who take on most of the duties of child care in all societies. As women are empowered they will be in a position to act on their desire to have fewer children (Penn, 1999; but cf. Mason & Taj, 1987). Also, more empowered women are not as likely to be dependent on sons for security and status. Moreover, female empowerment, especially as the result of greater education, leads women to have higher aspirations for each child and to desire to trade child quality for child quantity (Murthi, Guio, & Dreze, 1995). Better educated women are more likely to be open to innovation, emotionally independent, self-reliant, and able to develop close bonds with their husbands (Jejeebhoy, 1995). Education also decreases infant and child mortality because it increases maternal knowledge of hygiene and nutrition, and as a result fewer births are needed to achieve a desired family size (Murthi et al., 1995). Female empowerment and infant and child mortality are thus closely related to each other just as each is to fertility. In a sense we have come full circle.

Unfortunately, the argument sketched above only works if we can show, with at least moderate conviction, that the causal arrows are actually pointing from lower infant mortality to lower fertility. A number of demographers have suggested that the causal arrows could be running in the opposite direction (Chowdhury, Khan, & Chen, 1978; Knodel & van de Walle, 1986). In this argument, high fertility leads to high mortality because more children stress family resources and place greater burdens on mothers, both of which produce a poorer level of infant and child care. When fertility declines (for whatever reason) it generates circumstances favorable for a decline in infant mortality. As women have fewer children they are able to provide a higher standard of care to each and thus increase the rate of infant survivorship. Indeed, research does support the argument that high fertility does have unfavorable consequences for mortality (Wray, 1971; Nortman, 1974; cf. Chowdhury, Khan, & Chen, 1978). The whole question of which way the causal arrows are pointing can be examined by attempting to identify the temporal order between mortality change and fertility change. Several demographers have tried to do this. Matthiessen and McCann (1978), summarizing data from Knodel and van de Walle (1967), found that in 8 European countries infant mortality began to fall before fertility, whereas in 7 others fertility began to fall first. A separate analysis by van de Walle (1986) of 18 European countries showed that in 13 countries marital fertility fell before infant mortality, in 4 countries infant mortality fell first, and in 1 country the rates began to decline at virtually the same time. On the other hand, in 12 European countries total infant and child mortality (ages 0–15) began to fall before fertility, in 2 countries the declines began in the same year, and in only 2 other cases did fertility begin to fall before mortality (Matthiessen & McCann, 1978). Chowdhury, Khan, and Chen (1978) summarize the research of several studies (Hassan, 1966; Adlakha, 1970; Wyon & Gordon, 1972; Harrington, 1971) showing that women in Egypt, Turkey, India, and Taiwan who had had one or more of their children die had higher fertility than women who had not experienced any child mortality. Ben-Porath (1978) has shown that Israeli couples that had experienced child mortality had more births than couples without such experience. In a study of nineteenth-century German villages, Knodel (1986) found no consistent relationship at the aggregate level between an earlier decline in child mortality and a subsequent decline in marital fertility. However, when Knodel examined data for individual couples, declining child mortality did tend to be followed by fertility declines. He concluded that (1986; p. 385) "favorable child mortality experience apparently facilitated a couple's adoption of family limitation, leading to lower fertility, while unfavorable experience with child mortality seems to have impeded, if not totally prevented, such efforts."

The results of all of these studies are thus highly inconclusive. In an attempt to shed more light on this difficult question, we carried out an additional analysis in which we assessed the degree to which fertility could predict infant mortality. We found that infant mortality was a moderately better predictor of fertility than fertility was of infant mortality. We draw two conclusions: (1) there is just as much evidence to support the argument that infant mortality determines fertility as there is for the reverse argument; (2) on grounds of plausibility alone, we prefer the argument that makes mortality causally prior to fertility. However, more research is clearly needed for a definitive answer to be possible.

If infant mortality decline is a major cause of fertility decline, what is the mechanism or mechanisms whereby this occurs? We are assuming that, to a large extent, people are limiting family size as a response to greater infant survivorship—that humans have an evolved brain module that causes them to track infant mortality closely and to adjust their fertility accordingly (the degree to which this is occurring consciously is a somewhat open question). However, something else may be occurring as well. As Chowdhury, Khan, and Chen (1978) suggest, when infants die in the first year of life women stop lactating and begin ovulating again, which makes them likely to get pregnant rather quickly. As a result fertility remains high. But with greater infant survivorship women continue to lactate and generally fail to ovulate, thus increasing birth spacing and reducing their total lifetime fertility. This process might play an important role in the early stages of demographic transition, and it may help explain why infant mortality rather than child mortality is more closely related to fertility. But how important this mechanism of fertility decline is relative to what was suggested above—a postulated human tendency to track infant mortality and adjust fertility accordingly—is a question that cannot be answered by this study, but it remains an important one for future research.

CONCLUSION

In conclusion, we have provided evidence to suggest that declining infant mortality and increasing female empowerment are the two most important determinants of fertility decline. However, these variables hardly explain all of the variation in fertility and fertility change. Much is still left unaccounted for. We know this has to be the case, because fertility levels in most countries in the world today are still above replacement level (in many cases far above replacement level). Much more remains to be learned about the causes of fertility behavior.

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APPENDIX A: FULL LIST OF COUNTRIES FOR STUDY 1

1. Canada
2. Japan
3. Norway
4. Switzerland
5. Sweden
6. United States
7. Australia
8. France
9. Netherlands
10. United Kingdom
11. Germany
12. Denmark
13. Finland
14. Austria
15. Belgium
16. New Zealand
17. Israel
18. Italy
19. Ireland
20. Spain
21. Hong Kong
22. Greece
23. Czechoslovakia
24. Hungary
25. Uruguay
26. Trinidad and Tobago
27. Poland
28. Soviet Union
29. Korea, Republic of
30. Bulgaria
31. Chile
32. Yugoslavia
33. Portugal
34. Singapore
35. Costa Rica
36. Argentina
37. Venezuela
38. Kuwait
39. Mexico
40. Iraq
41. Jordan
42. Tunisia
43. Lebanon
44. Iran, Islamic Republic of
45. Gabon
46. Algeria
47. El Salvador
48. Nicaragua
49. Indonesia
50. Guatemala
51. Honduras
52. Viet Nam
53. Morocco
54. Lesotho
55. Zimbabwe
56. Bolivia
57. Egypt
58. Myanmar
59. Congo
60. Kenya
61. Madagascar
62. Papua New Guinea
63. Zambia
64. Cameroon
65. Ghana
66. Pakistan
67. India
68. Namibia
69. Cote d'Ivoire
70. Haiti
71. Tanzania, United Republic of
72. Zaire
73. Nigeria
74. Lao People's Democratic Republic
75. Liberia
76. Togo
77. Uganda
78. Rwanda

79. Mauritius
80. Albania
81. Malaysia
82. Colombia
83. United Arab Emirates
84. Brazil
85. Romania
86. Panama
87. Jamaica
88. Saudi Arabia
89. Thailand
90. South Africa
91. Turkey
92. Syrian Arab Republic
93. Sri Lanka
94. Ecuador
95. Paraguay
96. China
97. Philippines
98. Peru
99. Oman
100. Dominican Republic
101. Bangladesh
102. Cambodia
103. Senegal
104. Ethiopia
105. Angola
106. Nepal
107. Malawi
108. Burundi
109. Central African Republic
110. Sudan
111. Mozambique
112. Bhutan
113. Mauritania
114. Benin
115. Chad
116. Somalia
117. Mali
118. Burkina Faso
119. Afghanistan
120. Sierra Leone
121. Guinea

APPENDIX B: FULL LIST OF COUNTRIES FOR STUDY 2

1. Canada
2. United States
3. Australia
4. New Zealand
5. Japan
6. Austria
7. Belgium
8. Bulgaria
9. Czechoslovakia
10. Denmark
11. Finland
12. France
13. Germany
14. Hungary
15. Ireland
16. Italy
17. Netherlands
18. Norway
19. Poland
20. Portugal
21. Romania
22. Russia
23. Scotland
24. Spain
25. Sweden
26. Switzerland
27. United Kingdom