Population and Resources: An Exploration of Reproductive and Environmental Externalities

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POPULATION GROWTH ELICITS widely different responses from various observers. Some believe it to be among the causes of the most urgent problems facing humankind today (e.g., Ehrlich and Ehrlich 1990), while others permute the elements of this causal chain, arguing, for example, that contemporary poverty and illiteracy in poor countries are the causes, rather than the consequences, of rapid population growth.[1] Still others claim that even in the poorest countries population growth can be expected to provide a spur to economic progress.[2] Among the many who remain, there is a wide spectrum of views, both on the determinants of population growth and on the effects of that growth on the natural-resource base and human welfare. It would seem not only that our attitudes toward population size and its growth differ, but that there is no settled view on how the matter should be studied. As with religion and politics, many people have opinions on population that they cling to with tenacity.

In this article I bring together theoretical and empirical findings to argue that such divergence of opinion is unwarranted. In the first two sections I offer the conjecture that differences persist because the interface of population, resources, and welfare at a spatially localized level has been a relatively neglected subject. Neglect by experts is probably also the reason why the nexus has attracted much popular discourse, which, while often illuminating, is frequently descriptive rather than analytical.

It is not uncommon among those who write about population, resources, and welfare to adopt a global, future-oriented view: the emphasis frequently is on the deleterious effects a large and increasingly affluent population would have on Earth in the future.[3] This slant has been instructive, but it has drawn attention away from the economic misery and ecological degradation endemic in large parts of the world today. Disaster is not something for which the poorest have to wait; it is a frequent occurrence. Moreover, among the rural poor in developing countries, decisions on fertility,

on allocations concerning education, food, work, health care, and on the use of the local natural-resource base are in large measure reached and implemented within households that are unencumbered by compulsory schooling and visits from social workers, that do not have access to credit and insurance in formal markets, that cannot invest in well-functioning capital markets, and that do not enjoy the benefits of social security and old-age pension schemes. These features of rural life direct me, in the third section, to study the interface of population growth, poverty, and environmental stress from a myriad of household, and ultimately individual, viewpoints.

Women's education and reproductive health have come to be seen as the most effective channels for influencing fertility. In subsequent sections I provide an outline of the theoretical and empirical reasons why they are so seen. An interesting analytical feature of both education and reproductive health is that they can be studied within a framework where households make decisions in isolation from other households. Thus, the theory of demand for education and reproductive health can be treated as a branch of the "new household economics," which has been much engaged in the study of the isolated household.[4] But theoretical considerations suggest that a number of factors arising from interhousehold linkages could also influence fertility decisions. In this article I am much interested in exploring such linkages. Appropriately, they include those in which women's education and reproductive health play a role. The findings I report are consistent with the contemporary emphasis on women's education and reproductive health. These matters are explored in the final two sections and the Appendix. I conclude that there is substance to what has been called the population problem. I also argue that in the Indian subcontinent and in sub-Saharan Africa, the problem has for a long while been an expression of human suffering, and that the problem could well persist even if all regions of the world were to make the transition to low fertility rates.

Framing links between population, resources, and welfare

It is appropriate first to identify some of the ways social scientists have framed the links between population growth, resources, and human welfare. I review them in this section. This outline will enable us to compare and contrast the way the links have generally been framed with the way I frame them here.

There are three sets of examples to discuss here. They concern the way modern theories of economic growth view fertility and natural resources, the way population growth and economic stress in poor countries are studied by environmental and resource economists, and the way development economists accommodate environmental stress in their analysis of contemporary poverty. The examples are discussed in the next three sections. If I grumble, there is cause. Judging by level of analysis, most of those who

have been investigating economic growth, poverty, environmental stress, and fertility behavior have not read widely beyond their particular fields of interest. One cannot but think that this has impeded progress in our understanding of some of the most complex issues in the social sciences.

Population and resources in modern theories of growth

For the most part, modern theories of economic growth assume population change to be a determining factor of human welfare. A central tenet of the dominant theory is that although population growth does not affect the long-run rate of change in living standards, it adversely affects the long-run standard of living (Solow 1956).

Recent models of economic growth have been more assertive. They lay stress on new ideas as a source of progress, supposing that the growth of ideas is capable of circumventing any constraint the natural-resource base may impose on the ability of economies to grow indefinitely. Such models note too that certain forms of investment (e.g., research and development) enjoy cumulative returns because the benefits are durable and can be shared collectively. The models also assume that growth in population leads to an increase in the demand for goods and services. An expansion in the demand for and supply of ideas implies that, in the long run, equilibrium output per head can be expected to grow at a rate that is itself an increasing function of the rate of growth of population. (It is only when population growth is nil that the long run rate of growth of output per head is nil.) The models regard indefinite growth in population to be beneficial.[5]

Contemporary growth theory does not explicitly model the nature of new products. One can only conjecture that it assumes future innovations to be of such a character that indefinite growth in output would make no more than a finite additional demand on the natural-resource base. The assumption is questionable (Daily 1997; Dasgupta 2001). In any event, we should be skeptical of a theory that places such enormous burden on an economic regime not much more than 200 years old (Fogel 1994; Johnson 2000). Extrapolation into the past is a sobering exercise: over the long haul of history (some 5,000 years), economic growth even in the currently rich countries was for most of the time not much above zero. The study of possible feedback loops between poverty, demographic behavior, and the character and performance of both human institutions and the natural-resource base is not yet on the research agenda of modern growth theorists.

Demography and economic stress in environmental and resource economics

In its turn, the environmental and resource economics that has been developed in the United States has not shown much interest in economic stress

and population growth in poor countries. In their survey of the economics of environmental resources, Kneese and Sweeney (1985, 1993) and Cropper and Oates (1992) bypassed the subject matter of this article. They were right to do so, for the prevailing literature regards the environmental-resource base as an "amenity." Indeed, it is today a commonplace that "[economic] growth is good for the environment because countries need to put poverty behind them in order to care" (*Independent*, 4 December 1998), or that "trade improves the environment, because it raises incomes, and the richer people are, the more willing they are to devote resources to cleaning up their living space" (*The Economist*, 4 December 1999: 17).

I quote these views to suggest that natural resources are widely seen as luxuries. This view is hard to justify when one recalls that our natural environment maintains a genetic library, sustains the processes that preserve and regenerate soil, recycles nutrients, controls floods, filters pollutants, assimilates waste, pollinates crops, operates the hydrological cycle, and maintains the gaseous composition of the atmosphere. Producing as it does a multitude of ecosystem services, the natural-resource base is in large part a necessity.[6] A wide gulf separates the perspective of environmental and resource economists in the North (I use the term in its current geopolitical sense) from what would appear to be the direct experience of the poor in the South.[7]

Population and resource stress in development economics

Nor is the population–poverty–resource nexus a focus of attention among development economists. Even in studies on the semi-arid regions of sub-Saharan Africa and the Indian subcontinent (poverty-ridden land masses, inhabited by some 2 billion people and experiencing the largest additions ever known to their population; see Tables 1 and 2), the nexus is largely absent. For example, the authoritative surveys by Birdsall (1988), Kelley (1988), and Schultz (1988) on population growth in poor countries fail to touch on environmental matters. Mainstream demography also makes light of environmental stress facing poor communities in sub-Saharan Africa and the Indian subcontinent. Nor does the dominant literature on poverty (e.g., Stern 1989; Drèze and Sen 1990; Bardhan 1996) take population growth and ecological constraints to be prime factors in development possibilities.[8]

This situation is puzzling. Much of the rationale for development economics is the notion that poor countries suffer particularly from institutional failures. But institutional failures in great measure manifest themselves as externalities. To ignore population growth and ecological constraints in the study of poor countries would be to suppose that demographic decisions and resource use there give rise to no externalities of significance, and that externalities arising from institutional failure have a negligible effect

TABLE 1 Crude birth and death rates per 1,000 people

	Births		Deaths		Births minus deaths	
	1980	1998	1980	1998	1980	1998
China	18	16	6	8	12	8
Bangladesh	44	28	18	10	26	18
India	34	27	13	9	21	18
Pakistan	47	35	15	8	32	27
Sub-Saharan Africa	47	40	18	15	29	25
(Nigeria)	50	40	18	12	32	28
World	27	22	10	9	17	13

SOURCE: World Bank (2000: Table 2.2).

TABLE 2 Magnitude of poverty in extremely poor and poor regions, 1985

	Extremely poor			Poor		
Region	Number (million)	Headcount index (%)	Poverty gap (%)	Number (million)	Headcount index (%)	Poverty gap (%)
Sub-Saharan Africa	120	30	4	180	47	11
East Asia	120	9	0.4	280	20	1
China	(80)	8	1	(210)	20	3
South Asia	300	29	3	520	51	10
India	(250)	33	4	(420)	55	12
Middle East and North Africa	40	21	1	60	31	2
Latin America and the Caribbean	50	12	1	70	19	1
All developing countries	630	18	1	1,110	33	3

NOTES: The poverty line in 1985 purchasing-power-parity dollars is US$275 per capita per year for the extremely poor and US$370 per capita per year for the poor.
Headcount index is the percent of the population below the poverty line.
Poverty gap is the minimum amount of additional income, expressed as a percent of GNP, which, if it is distributed among the poor, can eliminate poverty.
SOURCE: World Bank (1990: Table 2.1).

on resource use and demographic behavior. I know of no body of empirical work that justifies such presumptions.

Population, food, and resources: Why global statistics can mislead

How is one to account for these neglects? It seems to me there are four reasons, one internal to the development of the "new household economics," the others arising from limitations in global statistics.

The first has to do with the preoccupation of those who developed the new household economics.[9] For reasons of tractability they studied choices made by isolated, optimizing households. Such predictions of the theory as that increases in women's labor productivity reduce the household demand for children are borne out in cross-country evidence (Schultz 1997). Nevertheless, the study of isolated households is not a propitious means by which to explore the possibilities of collective failure among households. For example, there have been few attempts to estimate externalities resulting from reproductive choices. One reason is that the theory of demographic interactions in nonmarket environments is still underdeveloped; and without theory it is hard for the empiricist to know what to look for.[10] I later point to scattered evidence, drawn from anthropology, demography, economics, and sociology, of externalities resulting from pronatalist attitudes among rural households in poor countries. I also try to develop some of the analytical techniques that would be required for identifying such externalities. The directional predictions of the resulting theory are not at odds with those of the new household economics (e.g., that an increase in women's labor productivity lowers the demand for children); but their predictions differ on the magnitude of household responses.

The second reason for the neglect of the population–poverty–resource nexus is the outcome of an inquiry made more than a decade ago into the economic consequences of population growth (National Research Council 1986). Drawing on national time-series and cross-regional data, the investigators observed that population size and its growth can have both positive and negative effects. For the purposes of interpreting the data, population growth was regarded as a causal factor in the study. The investigators concluded that there was no reason for concern over the high rates of growth being experienced in poor countries.[11]

But regression results depend on what is being regressed on what. So, for example, one can set against the National Research Council report more recent cross-country studies by Mauro (1995) and Eastwood and Lipton (1999), who have found a negative correlation between population growth and economic growth and a positive correlation between population growth and the magnitude of absolute poverty. In short, cross-country regressions in which population growth is a determining factor have given us mixed messages. Later in this article I show that even though we may have learned something from cross-country regressions, they have frequently misdirected us into asking wrong questions on demographic matters.

The third reason stems from a different set of empirical findings. With the exception of sub-Saharan Africa over the past 30 years or so, gross income per head has grown in nearly all poor regions since the end of World War II. In addition, growth in world food production since 1960 has exceeded the world's population growth by an annual rate of approximately

0.6 percent. This has been accompanied by improvements in a number of indicators of human welfare, such as the infant survival rate, life expectancy at birth, and literacy. In poor regions each of the latter improvements has occurred in a regime of population growth rates substantially higher than in the past: excepting East Asia and parts of South and Southeast Asia, modern-day declines in mortality rates have not been matched by reductions in fertility.

Table 3 presents total fertility rates (TFR), gross national product (GNP) per head, and growth in GNP per head in several countries and groups of countries.[12] Between 1980 and 1998 the TFR declined everywhere, but very unevenly. Sub-Saharan Africa has displayed the most acute symptoms of poverty: continued high fertility rates allied to declining GNP per head in a very poor continent. Nevertheless, as Table 3 confirms, the oft-expressed fear that rapid population growth will accompany deteriorations in living standards has not been borne out by experience when judged from the vantage of the world as a whole. It is then tempting to infer from this, as does Johnson (2000) most recently, that in recent decades population growth has not been a serious hindrance to improvements in the circumstances of living.

The fourth reason stems from economic theory and cross-country data on the link between household income and fertility. Imagine that parents regard children as an end in themselves; that is, assume children to be a "consumption good." If, in particular, children are a "normal" consumption good, an increase in unearned income would lead to an increase in the demand for children, other things being equal. This is the "income effect."[13] In his well-known work Becker (1981) argued, however, that if the increase

TABLE 3 Total fertility rates and GNP per head in a sample of countries and regions

	TFR		GNP per head[a]	Average annual percent growth of GNP per head[b]
	1980	1998	1998	1965–98
China	2.5	1.9	3,051	6.8
Bangladesh	6.1	3.1	1,407	1.4
India	5.0	3.2	2,060	2.7
Pakistan	7.0	4.9	1,652	2.7
Sub-Saharan Africa	6.6	5.4	1,440	–0.3
(Nigeria)	6.9	5.3	740	0.0
United States	1.8	2.0	29,240	1.6
World	3.7	2.7	6,300	1.4

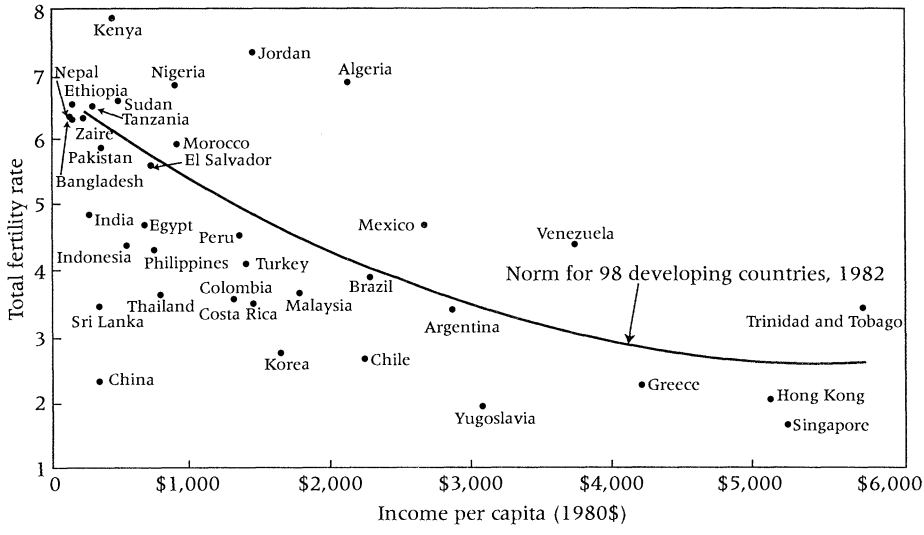
[a]Dollars at purchasing power parity.
[b]GNP growth calculated from constant price GNP in national currency units.
SOURCE: World Bank (2000: Tables 1.1, 1.4, and 2.16).

in household income were the result of an increase in wage rates (i.e., an increase in labor productivity), then the cost of children would increase, because time is involved in producing and rearing them. But other things being equal, this would lead to a decrease in the demand for children (this is the "substitution effect"). It follows that a rise in income owing to an increase in labor productivity would lead to a decline in fertility if the substitution effect were to dominate the income effect, a likely possibility.

Figure 1, taken from Birdsall (1988), shows that, among developing countries that in the early 1980s had incomes above US$1,000 per capita, those that were richer experienced lower fertility rates. A regional breakdown of even the Chinese experience displays the general pattern: fertility is lower in higher-income regions (Birdsall and Jamison 1983). These are only simple correlations and, so, potentially misleading. Moreover, they do not imply causality. But they suggest that growth in income can be relied upon to reduce population growth.

There are three weaknesses with the reasoning just outlined. First, conventional indexes of the standard of living pertain to commodity production, not to the natural-resource base on which production depends. Statistics on past movements of world or regional income and agricultural production say nothing about this base. They do not indicate whether or not increases in GNP per head in a country are being realized by means of a depletion of natural capital (e.g., ecosystem functioning). It could be, for

FIGURE 1 Fertility in relation to income in developing countries, 1982



SOURCE: Birdsall (1988: 482).

example, that increases in agricultural production are in part accomplished by "mining" soil and water. In relying on GNP and other current-welfare measures, such as life expectancy at birth, infant survival, and literacy, we run the danger of ignoring the concerns ecologists have voiced about pathways linking population growth, economic activity, and the state of the natural-resource base.[14]

It can be shown that the correct measure of a community's welfare over the long run is its wealth, where wealth is the social worth of the entire bundle of its assets, including manufactured, human, and natural capital (Dasgupta and Mäler 2000). A community's welfare over the long run would increase only if net investment per head in its capital base were positive. In other words, genuine investment is required if a community's well-being is to be sustainable. Since it is possible for a country's GNP to increase over an extended period even while its wealth is declining, time series of GNP per head could mislead.[15]

Hamilton and Clemens (1999) have provided estimates of genuine saving in a number of countries.[16] Among the resources that make up natural capital, only forests, oil and minerals, and pollution were included (not included were such vital resources as soil quality and water). So there is an undercount. Moreover, the accounting prices used to value natural capital were crudely estimated. Nevertheless, one has to start somewhere.

The first column in Table 4 contains estimates of genuine investment as a proportion of GNP in Bangladesh, India, Nepal, Pakistan, China, and sub-Saharan Africa over the period 1970–93. Notice that Bangladesh, Nepal, and sub-Saharan Africa have disinvested: their productive base has shrunk during the period in question. In contrast, genuine investment was positive in China, India, and Pakistan. This could suggest that the latter coun-

TABLE 4 Genuine investment and capital deepening in selected countries and regions: 1970–93

	I/Y[a]	g(L)[b]	g(W/L)[c]	g(Y/L)[d]	g(HDI)[e]
Bangladesh	–0.013	2.3	–2.60	1.0	3.3
India	0.080	2.1	–0.10	2.3	2.2
Nepal	–0.024	2.4	–3.00	1.0	5.3
Pakistan	0.040	2.9	–1.90	2.7	1.8
China	0.100	1.7	0.80	6.7	–0.2
Sub-Saharan Africa	–0.028	2.7	–3.40	–0.2	0.9

[a] I/Y: genuine investment as proportion of GNP. Source: Hamilton and Clemens (1999: Table 3).
[b] g(L): average annual percentage rate of growth of population, 1965–96. Source: World Bank (1998: Table 1.4).
[c] g(W/L): average annual percentage rate of change in per capita wealth. Assumed output–wealth ratio: 0.25.
[d] g(Y/L): average annual percentage rate of change in per capita GNP, 1965–96. Source: World Bank (1998: Table 1.4).
[e] g(HDI): average annual percentage rate of change in UNDP's Human Development Index, 1987–97. Source: UNDP (1990, 1999).

tries were wealthier at the end of the period than at the beginning. But when population growth is taken into account, the picture changes.

The second column in Table 4 contains the annual percentage rates of growth of population over the period 1965–96. All but China have experienced rates of growth in excess of 2 percent per year. Next I estimate the average annual change in wealth per capita during 1970–93. To do this, I multiply genuine investment as a proportion of GNP by the average output–wealth ratio of an economy to arrive at the (genuine) investment–wealth ratio, and then compare changes in the latter ratio to changes in population size. Because a wide variety of natural assets (human capital and various forms of natural capital) are unaccounted for in national accounts, there is an upward bias in published estimates of output–wealth ratios, which traditionally have been taken to be something on the order of 0.30. In Table 4 I have used 0.25 as a check against the upward bias in traditional estimates. This is almost certainly still a conservatively high figure.

The third column in Table 4 contains my estimates of the annual percentage rate of change in per capita wealth. The striking message is that all but China have decumulated their productive base during the past 30 years. Notice how misleading would be an assessment of long-term economic development in the Indian subcontinent if it were based on growth rates in GNP per head (column 4) or time series of UNDP's Human Development Index (HDI, column 5). Pakistan, for example, would be seen as a country where per capita GNP grew at a healthy 2.7 percent per year, implying that the index doubled in value between 1965 and 1996. Pakistan's HDI also improved over the past decade. Unhappily, though, the average Pakistani became poorer (in terms of wealth) by a factor of nearly two during the past quarter-century.

The second weakness with reasonings based on Figure 1 is that among poor countries the relationship between per capita income and fertility is not strong. In Figure 1 countries with GNP per head under $1,000 display nearly the entire range of fertility rates prevailing in the early 1980s: from 2 to 8 births per woman. Notice that countries lying above the fitted curve are in sub-Saharan Africa, those below are in Asia. I will seek an explanation for this. Admittedly, Figure 1 displays a bivariate distribution, which could be misleading for a problem requiring multivariate analysis. The figure nonetheless reflects the possibility that among poor households in rural communities the aforementioned substitution effect is not large and cancels the income effect. This could be because responsibility for childrearing is frequently diffused over the extended family.[17]

The third weakness with global statistics is that they are overly aggregative. They gloss over spatial variations and disguise the fact that even though the world economy as a whole has enjoyed economic growth over the past 50 years or so, large masses of people in particular regions have remained

in poverty (Tables 2–3). Economic growth has not "trickled down" consistently to the poorest, nor have the poorest been inevitably "pulled up" by it.

Population, poverty, and natural resources: Local interactions

In view of the aggregative nature of global statistics, a few investigators have studied the interface of population, poverty, and the natural-resource base at the local level. The ingredients of their work have been around for some time; what is perhaps new is the way they have been assembled. Several models have been constructed to develop the new perspective. We are still far from having an overarching model of the kind economists are used to in the theory of general competitive equilibrium.[18] Some models have as their ingredients large inequalities in land ownership in poor countries and the non-convexities that prevail at the level of the individual person in transforming nutrition intake into nutritional status and, thereby, labor productivity (Dasgupta and Ray 1986, 1987; Dasgupta 1993, 1997b). Other models are based on the fragility of interpersonal relationships in the face of an expanding labor market and underdeveloped credit and insurance markets (Dasgupta 1993, 1998a, 1999). Yet others are built on possible links between fertility behavior and free-riding on local common-property resources (Dasgupta and Mäler 1991, 1995; Nerlove 1991; Cleaver and Schreiber 1994; Brander and Taylor 1998). Although the models differ in their ingredients, they have in common a structure that is becoming increasingly familiar from the theory of locally interacting systems.[19] To put it in contemporary terminology, the new perspective on population, poverty, and natural resources sees the social world as self-organizing into an *in*homogeneous whole, so that, even while parts grow, chunks get left behind; some even shrink. To put it colloquially, these models account for locally confined "vicious circles."[20]

Later in this article I present an outline of this work when seen through a particular lens, namely reproductive and environmental externalities, and I emphasize the arguments that have shaped it and the policy recommendations that have emerged from it. The framework I develop focuses on the vast numbers of small, rural communities in the poorest regions of the world and identifies circumstances in which population growth, poverty, and resource degradation can be expected to interact with one another, cumulatively, over time. What bears stressing is that my account does not regard any of the three to be the prior cause of the other two: over time each of them influences, and is in turn influenced by, the other two. In short, they are all endogenous variables.

The models under discussion assume that people, when subjected to such "forces" of positive feedback, seek mechanisms to cope with the cir-

cumstances they face. The models also identify conditions in which this is not enough to lift communities out of the mire. Turner and Ali (1996), for example, have shown that in the face of population pressure in Bangladesh small landholders have periodically adopted new ways of doing things so as to intensify agricultural production. However, the authors have shown too that this has resulted in an imperceptible improvement in the standard of living and a worsening of the terms of land ownership, the latter probably owing to the prevalence of distress sales of land. Moreover, as Table 4 suggests, Bangladesh has decumulated its assets. These are the kind of findings that the new perspective anticipated and was designed to meet.

Economic demographers have given scant attention to reproductive externalities. An important exception was an attempt by Lee and Miller (1991) at quantifying the magnitude of reproductive externalities in a few developing countries. The magnitude was found to be small. The authors searched for potential sources of externalities in public expenditures on health, education, and pensions, financed by proportional taxation. But such taxes are known to be very limited in scale in poor countries. Moreover, the benefits from public expenditure are frequently captured by a small proportion of the population. So perhaps it should not be surprising that the reproductive externalities consequent upon public finance are small in poor countries. The externalities I study here are of a different sort altogether.

As we would expect from experience with models of complex systems, general results are hard to come by. The models that have been studied analytically are only bits and pieces. But they offer strong intuitions. They suggest also that we are unlikely to avoid having to engage in simulation exercises if we are to study models less specialized than the ones that have been explored so far.[21] This should have been expected. It would seem that for any theoretical inference, no matter how innocuous, there is some set of data from some part of the world over some period that is not consonant with it.[22] More than 40 years of demographic research have uncovered that the factors underlying fertility behavior include not only the techniques that are available to households for controlling their size, but also the household demand for children. The latter in particular is influenced by a number of factors (e.g., child mortality rates, level of education of the parents, rules of inheritance) whose relative strengths would be expected to differ across cultures, and over time within a given culture, responsive as they are to changes in income and wealth and the structure of relative prices. Thus, the factors that would influence the drop in the total fertility rate in a society from, say, 7 to 5 should be expected to differ from those that would influence the drop from 5 to 3 in the same society.

Across societies the matter is still more thorny. The springs of human behavior in an activity at once so personal and social as procreation are complex and interconnected, and empirical testing of ideas is fraught with

difficulty. Data often come without appropriate controls. So, what may appear to be a counter-example to a thesis is not necessarily so. Intuition is often not a good guide. For example, one can reasonably imagine that since religion is a strong driving force in cultural values, it must be a factor in fertility behavior. Certainly, in some multivariate analyses (e.g., Drèze and Murthi 2000, in their work on district-level data from India), religion has been found to matter (Muslims are more pronatalist than Hindus and Christians). But in others (e.g., Iyer 2000, in her work on household-level data from a group of villages in the state of Karnataka, India), it has not been found to matter. Of course, the difference in their findings could result from the fact that the unit of analysis in one case is the district, while in the other it is the household. But such a possibility is itself a reminder that complicated forms of externalities (e.g., externalities arising from conformist behavior) may be at work in fertility decisions.

Education and fertility control

Education and reproductive health programs together are a means for protecting and promoting women's interests. They were the focal points of the 1994 United Nations Conference on Population and Development in Cairo and are today the two pillars upon which public discussion on population is based.[23] Later in this article I show that the "population problem" involves a number of additional features. Here I review what is known about the influence of education and reproductive health programs on fertility.

Women's education and fertility behavior

In two classic publications, Cochrane (1979, 1983) studied possible connections between women's education and fertility behavior. She observed that lower levels of education are generally associated with higher fertility. Table 5, based on the Demographic and Health Surveys undertaken in Africa in the late 1980s, displays this relationship for Botswana, Ghana, Uganda, and Zimbabwe. The finding has proved to be intuitively so reasonable that social scientists have attributed causality—from education to reduced fertility.

What are the likely pathways of the causal chain? Here are some:

Education helps mothers to process information more effectively and so enables them to use the various social and community services that may be on offer more intensively. The acquisition of education delays the age at marriage and so lowers fertility. In populations with generally low levels of education and contraceptive prevalence, literacy and receptiveness to new ideas complement the efforts of reproductive health programs, leading to longer birth spacing.[24] This in turn reduces infant mortality, which in turn leads to a decline in fertility.

TABLE 5 Women's education and fertility rates: Selected countries where lower education is associated with higher fertility

Country	Education level (years)	TFR
Botswana	none	5.8
	1–4	5.5
	5–7	4.7
	8+	3.4
Ghana	none	6.8
	1–4	6.6
	5–7	6.0
	8+	5.5
Uganda	none	7.9
	1–4	7.3
	5–7	7.0
	8+	5.7
Zimbabwe	none	7.2
	1–4	6.7
	5–7	5.5
	8+	3.7

SOURCE: Jolly and Gribble (1993: Table 3.6).

Turning to a different set of links, higher education increases women's opportunities for paid employment and raises the opportunity cost of their time (the cost of childrearing is higher for educated mothers). Additionally, educated mothers would be expected to value education for their children more highly. They would be more likely to make a conscious tradeoff between the "quality" of their children and their numbers (Becker 1981).

Yet Cochrane herself was reluctant to attribute causality to her findings, as have been investigators studying more recent data (Cohen 1993; Jolly and Gribble 1993), for the reason that it is extremely difficult to establish causality.[25] Women's education may well reduce fertility. On the other hand, the initiation of childbearing may be a factor in the termination of education. Even when education is made available by the state, households frequently choose not to take up the opportunity: the ability (or willingness) of governments in poor countries to enforce school attendance or make available good educational facilities is frequently greatly limited. Economic costs and benefits and the mores of the community to which people belong influence their decisions. It could be that the very characteristics of a community (e.g., an absence of associational activities among women, or a lack of communication with the outside world) that are reflected in low educa-

tional attainment for women are also those giving rise to high fertility. Demographic theories striving for generality would regard both women's education and their fertility to be endogenous variables. The negative relationship between education and fertility in such theories would be an association, not a causal relationship. The two variables would be interpreted as "moving together" in samples, nothing more. In a later section I explore a theoretical framework that offers this interpretation.[26]

However, the links between women's education and fertility are not as monotonic as I have reported so far. Set against the positive forces outlined above is a possible effect that runs the other way: taboos against postpartum female sexual activity, where they exist, can be weakened through the spread of education. In sub-Saharan Africa, where polygyny is widely practiced, postpartum female sexual abstinence can last up to three years after childbirth. It is also not uncommon for women to practice total abstinence once they have become grandmothers. The evidence, such as it exists, conforms to theory: in Latin America and Asia, primary education, when compared to no education, has been found to be associated with lower fertility, but in several parts of sub-Saharan Africa (e.g., Burundi, Kenya, and Nigeria) the relationship has been found to be the opposite. Table 6 displays the latter.[27] The conventional wisdom that women's education is a powerful force against pronatalism needs to be qualified: the level of education can matter.

TABLE 6 Women's education and fertility rates: Selected countries where primary education is associated with higher fertility

Country	Education level (years)	TFR
Burundi	none	6.9
	1–4	7.1
	5–7	7.3
	8+	5.8
Kenya	none	7.2
	1–4	7.7
	5–7	7.2
	8+	5.0
Nigeria	none	6.5
	1–4	7.5
	5–7	6.0
	8+	4.5

SOURCE: Jolly and Gribble (1993: Table 3.6) and Cohen (1993: Table 2.4).

Family planning

Except under conditions of extreme nutritional stress, nutritional status does not appear to affect fecundity (Bongaarts 1980). During the 1974 famine in Bangladesh, deaths in excess of those that would have occurred under previous nutritional conditions numbered around 1.5 million. The stock was replenished within a year (Bongaarts and Cain 1981). Of course, undernourishment can still have an effect on sexual reproduction, through its implications for the frequency of stillbirths, maternal and infant mortality, and a possible reduction in the frequency of sexual intercourse.

An obvious determinant of fertility is the available technology for birth control. Cross-country regressions (e.g., Pritchett 1994) confirm that the fraction of women of reproductive age who use modern contraceptives is strongly and negatively correlated with total fertility rates. So it should not be surprising that family planning programs are often seen as a prerequisite for an effective population policy. But these regression results mean only that contraception is a proximate determinant of fertility, not a causal determinant. The results could mean, for example, that differences in fertility rates across countries reflect differences in fertility goals, and thus differences in contraceptive use. Of course, the causal route could go the other way. The very existence of family planning programs might influence the demand for children, as women come to realize that it is reasonable to want a small family (Bongaarts 1997).

People in all societies practice some form of birth control: fertility everywhere is below the maximum possible. Extended breastfeeding and postpartum female sexual abstinence have been common practices in Africa. Even in poor countries, fertility is not unresponsive to the relative costs of goods and services. In a study on !Kung San foragers in the Kalahari region, Lee (1972) observed that the nomadic, bush-dwelling women had an average birth spacing of nearly four years, while those settled at cattle posts gave birth to children at much shorter intervals. From the viewpoint of the individual nomadic !Kung San woman, the social custom is for mothers to nurse their children on demand and to carry them during their day-long trips in search of wild food through the children's fourth year of life. Anything less than a four-year birth interval would increase mothers' carrying loads enormously, threaten their own capacity to survive, and reduce their children's prospects of survival. In contrast to bush dwellers, cattle-post women are sedentary and are able to wean their children earlier.

Traditional methods of birth control include abortion, abstinence or rhythm, coitus interruptus, and prolonged breastfeeding.[28] These options are often inhumane and unreliable; modern contraceptives are in many respects superior. Nevertheless, successful family planning programs have proved more difficult to institute than could have been thought possible at first (Cochrane and Farid 1989). Excepting a few countries, fertility rates in

sub-Saharan Africa have not shown significant decline, despite reductions in infant mortality rates over the past few decades.

In a notable article, Pritchett (1994) analyzed data from household surveys conducted by the World Fertility Survey and the Demographic and Health Survey programs, which included women's responses to questions regarding both their preferences and their behavior related to fertility. Demographers had earlier derived indicators of the demand for children from these data. One such indicator, the "wanted total fertility rate" (Bongaarts 1990), can be compared to the actual total fertility rate for the purpose of classifying births or current pregnancies in a country or region as "wanted" or "unwanted." Regressing actual fertility on fertility desires in a sample of 43 countries in Asia, Africa, and Latin America, Pritchett found that about 90 percent of cross-country differences in fertility rates are associated with differences in desired fertility. Moreover, excess fertility was found not to be systematically related to the actual fertility rate, nor to be an important determinant of the rate. The figure of 90 percent may prove to be an overestimate, but it is unlikely to prove to be greatly so.[29] Even in poor households the use of modern contraceptives would involve only a small fraction (1 percent or thereabouts) of income.

Pritchett's finding is significant, if only because it directs us to ask why the household demand for children differs so widely across communities. We turn to this matter next.

The household and gender relations

The concept of the household is not without its difficulties. It is often taken to mean a unit of housekeeping or consumption. The household in this sense is the eating of meals together by members, or the sharing of meals derived from a common stock of food (Hajnal 1982). This definition has the merit of being in accordance with most modern censuses, but one problem with it is that in rural communities it does not yield exclusive units (Goody 1996). A household shares a "table" and may, for example, include live-in servants who do not cook for themselves. In many cases some meals are had in common, while others are not; and often raw and cooked food is passed to parents in adjacent cottages, apartments, or rooms. The boundaries vary with context, especially where food is not consumed together round a table (as in Europe) but in bowls in distinct groups (as in sub-Saharan Africa). In none of these cases is the housekeeping unit the same as the consumption unit, nor is the consumption unit necessarily clearly defined.

Economists have taken the household to be a well-defined concept, but have debated whether it is best to continue to model it as a unitary entity, in the sense that its choices reflect a unitary view among its members of what constitutes their welfare (the utility maximizing model) or

whether instead the household ought to be modeled as a collective entity, where differences in power (e.g., between men and women) manifest themselves in the allocation of food, work, education, and health care.

Of course, one cannot conclude that households are not unitary from the mere observation that intrahousehold allocations are unequal. Poor households would choose to practice some patterns of inequality even if they were unitary. For example, since children differ in their potential, parents in poor households would help develop the most promising of their children even if that meant the remaining ones are neglected. This is confirmed by both theory and evidence (Becker and Tomes 1976; Bledsoe 1994). Daughters are a net drain on parental resources in patrilineal and patrilocal communities, such as those in northern India (dowries can be bankrupting). This fact goes some way toward explaining the preference parents show for sons there (Sopher 1980a, 1980b; Dyson and Moore 1983; Cain 1984) and why girls of higher birth order are treated worse than girls of lower birth order (Das Gupta 1987). In northern parts of India the sex ratio is biased in favor of men.[30]

Nevertheless, the magnitude of the inequalities frequently observed is at odds with what would be expected in unitary households. The indirect evidence also suggests that the household is a collective entity, not a unitary one (Alderman et al. 1995). For example, if a household were unitary, its choices would be independent of which member actually does the choosing. But recent findings have revealed, for example, that income in the hands of the mother has a bigger effect on her family's health (e.g., nutritional status of children) than income under the control of the father (Kennedy and Oniang'o 1990).

Because gender inequities prevail in work, education, and allocation of food and health care, it should not surprise us that they prevail in fertility choices as well. Here also, women bear the greater cost. To grasp how great the burden can be, consider that in sub-Saharan Africa the total fertility rate has for long been between 6 and 8 (Figure 1). Successful procreation involves at least a year and a half of pregnancy and breastfeeding. So in societies where female life expectancy at birth is 50 years and the total fertility rate is 7, women at birth can expect to spend about half their adult lives in pregnancy or nursing. And we have not allowed for unsuccessful pregnancies.

In view of this difference in the costs of bearing children, we would expect men to desire more children than women do. Birth rates are expected to be lower in societies where women are more "empowered." Data from the 1980s on the status of women from 79 so-called Southern countries (see Table 7) confirm this and display an unmistakable pattern: high fertility, high rates of female illiteracy, low women's share of paid employment, and a high percentage of women working at home for no pay all go hand in hand. From the data alone it is difficult to discern which measures

TABLE 7 Fertility rates and indicators of women's status in 79 developing countries

TFR	No. of countries	Women's share of paid employment (%)	Women in unpaid family work (%)	Women's illiteracy rate (%)
>7.0	(9)	10.6	46.9	65.7
6.1–7.0	(35)	16.5	31.7	76.9
5.1–6.0	(10)	24.5	27.1	46.0
<5.0	(25)	30.3	18.1	22.6

SOURCE: IIED/WRI (1987: Table 2.3).

are causing high fertility and which are merely correlated with it. But the findings are consistent with the possibility that a lack of paid employment and education limits women's ability to make decisions—a condition that promotes high fertility.

Household decisions would assume strong normative significance if the household were unitary, less so if it were not. The evidence is that the unitary household is especially uncommon when the family is impoverished and the stresses and strains of hunger and illness make themselves felt. Despite these caveats, I adopt a unitary view of the household in what follows. Because I am concerned here with reproductive and environmental externalities, doing so helps to simplify the exposition without losing anything essential.

Motives for procreation

One motive for procreation, common to humankind, relates to children as ends in themselves. We are genetically endowed to want and to value them. It has also been said that children are the clearest avenue open to "self-transcendence" (Heyd 1992). Viewing children as ends ranges from the desire to have offspring because they are playful and enjoyable, to a desire to obey the dictates of tradition and religion. One such injunction emanates from the cult of the ancestor, which, taking religion to be the act of reproducing the lineage, requires women to bear many children.[31] The latter motivation has been emphasized by Caldwell and Caldwell (1990) to explain why sub-Saharan African societies have proved so resistent to fertility reduction.

The problem with this explanation is that, although it does well to account for high fertility rates in sub-Saharan Africa, it does not adequately explain why the rates have not responded to declines in infant mortality. The cult of the ancestor may prescribe reproduction of the lineage, but it does not stipulate an invariant fertility rate. Since even in sub-Saharan Africa fertility rates have been below the maximum possible, they should be

expected to respond to declines in infant mortality. This is a matter I return to below, where I offer one possible explanation for the resistance that the semi-arid regions of sub-Saharan Africa have shown to fertility reduction.[32]

But for parents, children are not only an end; they can also be a means to economic betterment. In the extreme, they can be a means to survival. Children offer two such means. First, in the absence of capital markets and social security, children can be a source of private security in old age. There is evidence that in poor countries children do offer such security (Cain 1981, 1983; Cox and Jimenez 1992). This fact leads to a preference for male offspring if males inherit the bulk of their parents' property and are expected to look after them in their old age.

Second, in agriculture-based rural economies children are valuable in household production. Evidence of this is extensive, although such evidence is, of course, no proof that parents have children in order to obtain additional labor. For example, people could have large numbers of offspring by mistake and put them to work only because they cannot afford to do otherwise. Or large families might be desired as an end in itself, and putting children to work at an early age may be the only avenue open for financing that end. However, these conjectures are hard to substantiate directly. The former is in any case difficult to believe, since it suggests an inability to learn on the part of parents in a world where they are known to learn in other spheres of activity, such as cultivation. But because the latter is not at variance with any evidence I know, I explore it in a later section.

Caldwell (1981, 1982) put forward the interesting hypothesis that the intergenerational transfer of resources flows from children to their parents in societies experiencing high fertility and high mortality rates, but that it flows from parents to their children when fertility and mortality rates are low. Assuming this to be true, the relationship should be interpreted merely as an association. The direction of intergenerational resource transfers would be endogenous in any general theory of demographic behavior; thus it would not be a causal factor in fertility transitions.

The historical change in the North in parents' attitudes toward their children (from regarding children as a "means" to economic ends, to regarding them simply as an "end") can seem to pose a puzzle, as can differences between the attitudes of parents in the North and South today. Some demographers have remarked that a fundamental shift in adults' "world view" must have been involved in such changes in attitudes, a shift that Cleland and Wilson (1987) have called an "ideational change."

These observers may be right. On the other hand, not only is the explanation something of a deus ex machina, it is also difficult to test. A different sort of explanation, one that is testable, is that children cease being *regarded* as productive assets when they cease *being* productive assets. When schooling is enforced, children are not as readily available for household and farm chores.

If the growth of urban centers makes rural children less reliable as old-age security (because children are now able to leave home and not send remittances), children cease being a sound investment for parents' old age.[33] In short, if children were to become relatively unproductive in each of their roles as an economic asset, their only remaining value would be as an end. No change in world view would necessarily be involved in this transformation.

The above argument does not rely on economic growth. It involves a comparison between the productivity of different forms of capital assets. Children could cease being a sound economic investment even if the economy remained poor.

Reproductive and environmental externalities

What causes the private and the social costs and benefits of reproduction to differ? One likely source of the distinction has to do with the finiteness of space (World Bank 1984; Harford 1998). Increased population size implies greater crowding, and households acting on their own would not be expected to "internalize" crowding externalities. The human epidemiological environment becomes more and more precarious as population densities rise. Crowded centers of population provide a fertile ground for the spread of pathogens, and there are always new strains in the making. Conversely, the spread of infections, such as HIV, would be expected to affect demographic behavior, although in ways that are not yet obvious (Ezzell 2000).

Large-scale migrations of populations occasioned by crop failure, war, or other disturbances are an obvious form of externality. But by their very nature they are not of the persistent variety. Of those that are persistent, at least four types come to mind. In the remainder of this section I look into them.

Cost-sharing

Fertility behavior is influenced by the structure of property rights, for instance rules of inheritance. In his influential analysis of fertility differences between preindustrial seventeenth- and eighteenth-century Northwest Europe, on the one hand, and Asiatic preindustrial societies, on the other, Hajnal (1982) distinguished between "nuclear" and "joint" household systems. He observed that in Northwest Europe marriage normally meant establishing a new household, which implied that the couple had to have, by saving or transfer, sufficient resources to establish and equip the new residence. This requirement in turn led to late ages at marriage. It also meant that parents bore the cost of rearing their children. Indeed, fertility rates in England were a low 4 in 1650–1710, long before modern family planning methods became available and long before women became widely literate (Coale 1969; Wrigley and Schofield 1981). Hajnal contrasted this situation

with the Asiatic pattern of household formation, which he saw as joint units consisting of more than one couple and their children.

Parental costs of procreation are also lower when the cost of rearing the child is shared within the kinship. In sub-Saharan Africa fosterage within the kinship is a commonplace: children are not reared solely by their parents; the responsibility is more diffuse within the kinship group (Goody 1976; Bledsoe 1990; Caldwell and Caldwell 1990). Fosterage in the African context is not adoption. It is not intended to, nor does it in fact, break ties between parents and children. The institution affords a form of mutual insurance protection in semi-arid regions. It is possible that, because opportunities for saving are few in the low-productivity agricultural regions of sub-Saharan Africa, fosterage also enables households to smooth their pattern of consumption across time (Serra 1996).[34] In parts of West Africa up to half the children have been found to be living with kin other than their parents at any given time. Nephews and nieces have the same rights of accommodation and support as do biological offspring. There is a sense in which children are seen as a common responsibility. However, the arrangement creates a free-rider problem if the parents' share of the benefits from having children exceeds their share of the costs. From the point of view of parents, taken as a collective, too many children would be produced in these circumstances.[35]

In sub-Saharan Africa, communal land tenure within the lineage social structure has in the past offered further inducement for men to procreate. Moreover, conjugal bonds are frequently weak, so fathers often do not bear the costs of siring children. Anthropologists have observed that the unit of African society is a woman and her children, rather than parents and their children. Frequently there is no common household budget for the man and woman. Descent in sub-Saharan Africa is for the most part patrilineal and residence is patrilocal. Patrilineality, weak conjugal bonds, communal land tenure, and a strong kinship support system of children, taken together, have been a broad characteristic of the region (Caldwell and Caldwell 1990; Caldwell 1991; Bledsoe and Pison 1994). They are a source of reproductive externalities that stimulate fertility. Admittedly, patrilineality and patrilocality are features of the northern parts of the Indian subcontinent also,[36] but conjugal bonds are substantially greater there. Moreover, because agricultural land is not communally held in India, large family size leads to fragmentation of landholdings. In contrast, large families in sub-Saharan Africa are (or at least were, until recently) rewarded by a greater share of land belonging to the lineage or clan.

Conformity and "contagion"

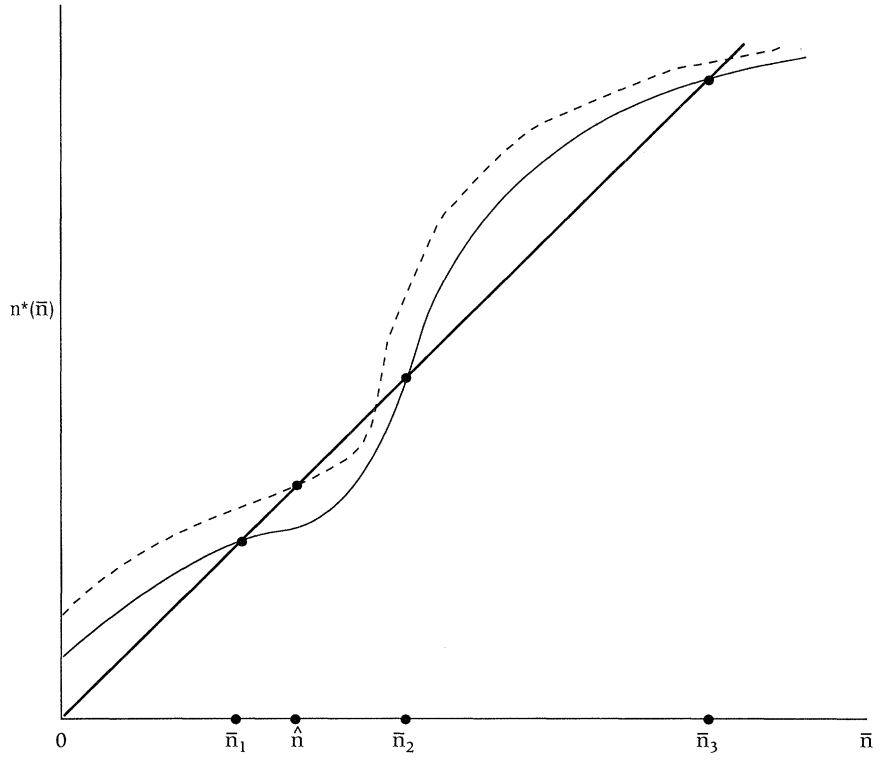
That children are seen as an end in themselves provides another mechanism by which reasoned fertility decisions at the level of every household

can lead to an unsatisfactory outcome from the perspectives of all households. The mechanism arises from the possibility that traditional practice is perpetuated by conformity. Procreation in closely knit communities is not only a private matter, it is also a social activity, influenced by both family experiences and the cultural milieu. Formally speaking, behavior is conformist if, other things being equal, every household's most desired family size is the greater, the larger is the average family size in the community (Dasgupta 1993: ch. 12). This is a "reduced form" of the concept, and the source of a desire to conform could lie in reasons other than an intrinsic desire to be like others. For example, similar choices made by households might generate mutual positive externalities, say, because people care about their status; and a household's choice of actions signals its predispositions (e.g., their willingness to belong) and so affects its status (Bernheim 1994; Bongaarts and Watkins 1996). In a world where people conform, the desire for children is endogenous.

Whatever the basis of conformism, there would be practices encouraging high fertility rates that no household would unilaterally desire to break. Such practice could well have had a rationale in the past, when mortality rates were high, rural population densities were low, the threat of extermination from outside attack was large, and mobility was restricted. But practices can survive even when their original purposes have disappeared. Thus, as long as all others follow the practice and aim at large family size, no household on its own may wish to deviate from the practice; however, if all other households were to restrict their fertility rates, each would desire to restrict its fertility rate as well. In short, conformism can be a reason for the existence of multiple reproductive equilibria (Dasgupta 1993: ch. 12). These multiple equilibria might even be Pareto rankable, in which case a community could get stuck at an equilibrium mode of behavior even though another equilibrium mode of behavior would be better for all.

Figure 2 depicts fertility choices in a stylized community where households are identical and are conformists and where the government has no population policy in place. The horizontal axis denotes $\bar{n}$, which is the average number of children born per household. It represents the TFR in the community. The vertical axis denotes n^*, which is the number of children desired by the representative household.[37] Since households are identical, every household is representative. Because n^* is a function of $\bar{n}$, we write it as $n^*(\bar{n})$. It is drawn as an increasing function, the distinctive feature of conformism. In Figure 2 it is drawn so that it intersects the 45° line at three points, $\bar{n}_1$, $\bar{n}_2$, and $\bar{n}_3$. Each is an equilibrium. To confirm this, imagine for example that each household expects all other households to have $\bar{n}_3$ children. Then $\bar{n}_3$ will be each household's choice, thus confirming the expectations. And so on for $\bar{n}_1$ and $\bar{n}_2$. Notice as well that $\bar{n}_1$, $\bar{n}_2$, and $\bar{n}_3$ are the only equilibria. Let us assume now that out-of-equilibrium households expect the TFR in each period to be the previous period's TFR (this is a special

FIGURE 2 Desired number of children in a representative household, $n^*(\bar{n})$, as a function of average number of children born per household, $(\bar{n})$



form of so-called adaptive expectations). It is then easy to check that $\bar{n}_1$ and $\bar{n}_3$ are (locally) stable, while $\bar{n}_2$ is unstable. So our interest here lies in $\bar{n}_1$ and $\bar{n}_3$.

I have not offered a micro-foundation for $n^*(\bar{n})$. The model is of a reduced form. But all households may be better off at $\bar{n}_1$ than at $\bar{n}_3$. However, in view of the externality, neither equilibrium is a socially optimal state of affairs.[38] The optimal TFR may lie somewhere between $\bar{n}_1$ and $\bar{n}_3$ (say, at $\hat{n}$). If this were so, then from the social point of view TFR would be too low at $\bar{n}_1$ and too high at $\bar{n}_3$. In either situation there would be a need for government policy (e.g., a tax subsidy) of a kind that would sustain equilibrium TFR at $\hat{n}$. In Figure 2 the broken curve is the representative household's desired number of children as a function of the community's TFR when the optimum policy is in place. It intersects the 45° line at $\hat{n}$.

These are theoretical possibilities. Analytical reasoning tells us that a society could in principle get stuck at a self-sustaining mode of behavior characterized by high fertility (and low educational attainment), even when there is another, potentially self-sustaining mode of behavior characterized by low fertility (and high educational attainment).

This does not mean that the hypothetical society would be stuck with high fertility rates forever. External events could lead households to "coordinate" at $\bar{n}_1$ even though they had earlier "coordinated" at $\bar{n}_3$.[39] The external events could, for example, take the form of public exhortations aimed at altering household expectations about one another's behavior (e.g., family planning campaigns run by women). This is a case where the community "tips" from one mode of behavior to another, even though there has been no underlying change in household attitudes ($n^*(\bar{n})$ has not changed) to trigger the change in behavior.

In their aforementioned article Cleland and Wilson (1987: 9) argued that the only plausible way to explain the recent onset of fertility transitions among countries at widely different levels of economic development was an ideational change, "a psychological shift from, *inter alia*, fatalism to a sense of control of destiny, from passivity to the pursuit of achievement, from a religious, tradition-bound, and parochial view of the world to a more secular, rational, and cosmopolitan one." The authors may be right that societies have undergone ideational changes, but they are wrong in thinking that ideational change must be invoked to explain recent fertility transitions. The tipping behavior I have just discussed is not a response to ideational changes. This said, I know of no evidence that is able to discriminate between the two types of explanation.

In addition to being a response to external events, the tipping phenomenon can occur because of changes in the peer group on whose behavior households base their own behavior. This amounts to the function $n^*(\bar{n})$ shifting slowly. Such shifts also may fall short of an ideational change. As I indicate below, however, the process can precipitate a demographic transition.

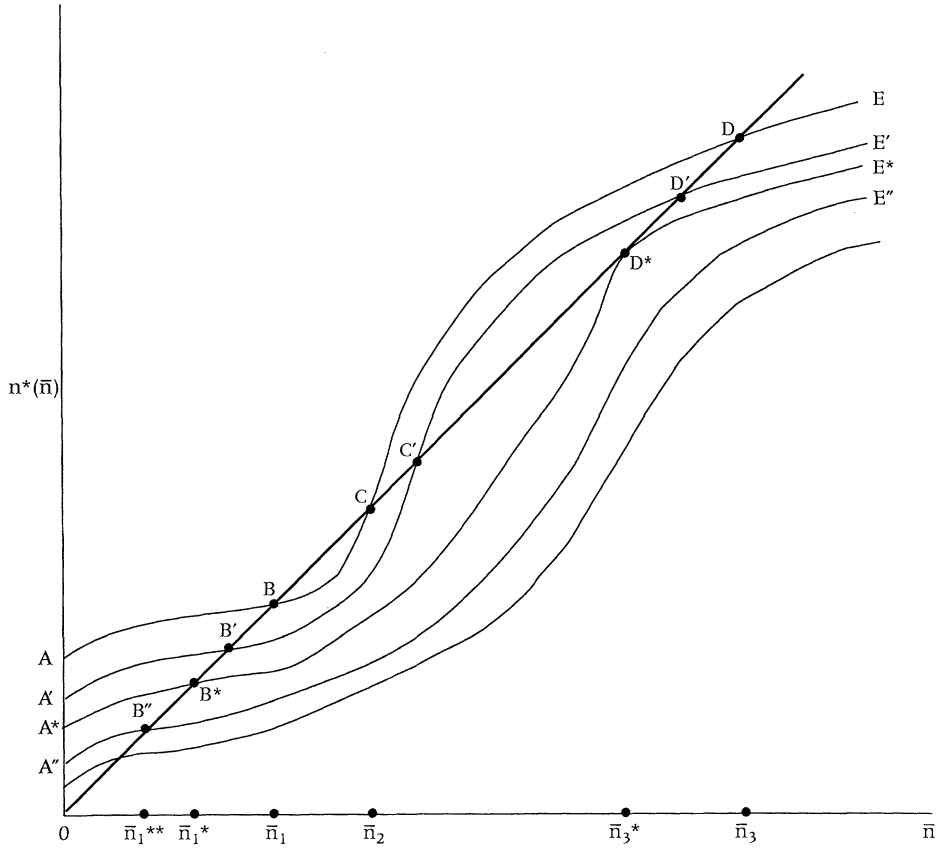
One pathway by which $n^*(\bar{n})$ can shift arises from the fact that people differ in their absorption of traditional practice. Inevitably there are those who experiment, take risks, and refrain from joining the crowd. They subsequently influence others. They are the tradition-breakers, often leading the way. It has been observed that educated women are among the first to make the move toward smaller families (see Farooq, Ekanem, and Ojelade 1987, for a commentary on West Africa). Members of the middle classes can also be the trigger, becoming role models for others.

Possibly an even clearer pathway is the influence that newspapers, radio, television, and now the Internet exert in transmitting information about other lifestyles (Freedman 1995; Bongaarts and Watkins 1996; Iyer 2000). The analytical point here is that the media may be a vehicle through which a new form of conformism increasingly becomes based on the behavior of a population wider than the local community: the peer group widens.

Such pathways can give rise to demographic transitions, in that fertility rates display little or no trend over extended periods, only to cascade downward over a relatively short interval, giving rise to the classic logistic curve of

diffusion processes. To illustrate this, consider Figure 3, which is based on Figure 2. Begin with an isolated community. The curve ABCDE is the representative household's demand for children as a function of the community's total fertility rate, $n^*(\bar{n})$. As with Figure 2, there are three equilibria, $\bar{n}_1$, $\bar{n}_2$, and $\bar{n}_3$, of which $\bar{n}_1$ and $\bar{n}_3$ are locally stable, and $\bar{n}_2$ is unstable. We are to imagine that households have equilibrated at D, where the total fertility rate is $\bar{n}_3$. Imagine now that the community begins to have exposure to the outside world. To grasp the point in the simplest possible way, assume that the rate at which the community is exposed to outside influence (as measured, say, by the rate of increase in the number of television sets in the community) is small and steady. It is natural to assume next that, as outside influence increases, $n^*(\bar{n})$ shifts downward slowly. This means that the equilibrium TFR declines slowly. In Figure 3 the curve A'B'C'D'E' represents one such transitional demand schedule. The corresponding equilibrium TFR is associated with D'. Since D' is locally stable,

FIGURE 3 A model of demographic transition



the assumption that the community equilibrates to D′ is correct. The underlying hypothesis is that outside influence is a slow-moving variable and that the community equilibrates quickly to changes in the extent of outside influence.

What would statistical demographers make of the process thus far? They would record that the community's TFR had declined in response to increasing exposure to the outside world. But they would record that the decline was slow. As time passes, the demand schedule in Figure 3 continues to shift downward slowly and the TFR declines slowly, until eventually the schedule attains the position where there are only two equilibria: $\bar{n}_1$* and $\bar{n}_3$*. (The intermediate equilibrium point has vanished at this critical juncture.) This stage is represented by the curve A*B*D*E*. Since the community will have equilibrated at D*, statistical demographers would observe that there had so far been no dramatic decline in fertility.

But what happens when the curve shifts down slightly further, say to become the curve A″B″E″ in Figure 3? Now the schedule intersects the 45° line only once, at the stable equilibrium B″ (at a TFR of $\bar{n}_1$**). But because TFR had only recently been substantially above $\bar{n}_1$**, households will display disequilibrium behavior for a while, as they "seek" $\bar{n}_1$**. Demographers would record a substantial decline in TFR to $\bar{n}_1$**. Subsequent declines in TFR (one such decline is depicted in the lowest curve in Figure 3) again would be observed to be slow. Statisticians would record the period in which TFR declined sharply as a "demographic transition." In our model the transition would be an extended period of disequilibrium behavior. It is worth noting that, in showing how fertility cascades can occur, I have assumed household responses to changes in outside exposure to be nonlinear: the shape of $n^*(\bar{n})$ has the nonlinearity built into it.[40]

In a pioneering article Adelman and Morris (1965) found "openness" of a society to outside ideas to be a powerful stimulus to economic growth. It is possible that the recent fertility reductions experienced in India and Bangladesh (Table 3) were the result of the wider influence people have been subjected to via the media or of attitudinal differences arising from improvements in family planning programs. To be sure, fertility reductions have differed widely across the Indian subcontinent (not much reduction in Pakistan so far), but we should not seek a single explanation for so complex a phenomenon as fertility transition.[41]

Demographers have made few attempts to discover evidence of behavior that is guided in part by an attention to others. Two exceptions are Easterlin, Pollak, and Wachter (1980) and Watkins (1990). The former studied intergenerational influence in a sample of families in the United States. They reported a positive link between the number of children with whom someone had been raised and the number of children they themselves had.

In her study of demographic change in Western Europe over the period 1870–1960, Watkins (1990) showed that regional differences in fertil-

ity and nuptiality within each country declined. In 1870, before the large-scale declines in marital fertility had begun in most areas of Western Europe, demographic behavior differed greatly within countries: provinces (e.g., counties and cantons) differed considerably, even while differences within provinces were low. There were thus spatial clumps within each country, suggesting the importance of the influence of local communities on behavior. By 1960 differences within each country were less than they had been in 1870. Watkins explained this convergence in behavior in terms of increases in the geographical reach national governments enjoyed over the 90 years in question. The growth of national languages could have been the medium through which reproductive behavior spread.

One recent finding could also point to contagious behavior. Starting in 1977 (when the TFR in Bangladesh exceeded 6), 70 "treatment" villages were served by a massive program of birth control in Matlab Thana, Bangladesh, while 79 "control" villages were offered no such special service. The prevalence of contraceptive use in the treatment villages increased from 7 percent to 33 percent within 18 months, and then rose more gradually to a level of 45 percent by 1985. The prevalence also increased in the control villages, but only to 16 percent in 1985. Fertility rates in both sets of villages declined, but at different speeds, with the difference in fertility rates reaching 1.5 births per woman, even though there had been no difference to begin with (Hill 1992). If we assume that, although influence travels, geographical proximity matters, we could explain why the control villages followed the example of villages "under treatment," but did not follow them all the way. Contagion did not spread completely.[42]

Interactions among institutions

Externalities are prevalent when market and nonmarket institutions coexist. How and why might such externalities affect fertility behavior? A number of pathways suggest themselves (see also Dasgupta 1993, 1999).

Long-term relationships in rural communities of poor countries are frequently sustained by social norms—for example, norms of reciprocity. Social norms can be reliably observed only among people who expect to encounter one another in recurring situations.[43] Consider a community of "far-sighted" people who know one another and expect to interact with one another for a long time. By far-sighted, I mean someone who applies a low rate to discount future costs and benefits of alternative courses of action. Assume that the parties in question are not individually mobile (although they could be collectively mobile, as in the case of nomadic societies); otherwise the chance of future encounters with one another would be low, and people would discount heavily the future benefits of the current costs they incur for the purposes of cooperation.

Simply stated, if people are far-sighted and are not individually mobile, a credible threat by all that they would impose stiff sanctions on anyone who broke the agreement would deter everyone from breaking it. But the threat of sanctions would cease to have bite if opportunistic behavior became personally more profitable. The latter would happen if formal markets develop nearby. As opportunities outside the village improve, people with lesser ties (e.g., young men) are more likely to take advantage of them and make a break with those customary obligations that are enshrined in prevailing social norms. People with greater attachments would perceive this and infer that the expected benefits from complying with agreements are now lower. Norms of reciprocity would break down, making certain groups of people (e.g., women, the old, and the very young) worse off. This is a case where improved institutional performance elsewhere (e.g., growth of markets in the economy at large) has an adverse effect on the functioning of a local, nonmarket institution: it is a reflection of an externality.

When established long-term relationships break down, people build new ones to further their economic opportunities. Those who face particularly stressful circumstances resort to draconian measures to build new economic channels. Guyer (1994) has observed that in the face of deteriorating economic circumstances, some women in a Yoruba area of Nigeria have borne children by several men so as to create immediate lateral links with them. Polyandrous motherhood enables women to have access to more than one resource network.

In his well-known work Cain (1981, 1983) showed that where capital markets are nonexistent and public or community support for the elderly is weak, children provide security in old age. The converse is that if community-based support systems decline, children become more valuable. But we have just noted that community-based support systems in rural areas may degrade with the growth of markets in cities and towns. So there is a curious causal chain here: growth of markets in towns and cities can lead to an increase in fertility in poor villages, other things being the same. Earlier we deduced an influence running in the opposite direction. There we noted that growth of markets in towns and cities, by making children less reliable as an investment for old age, can lead to a reduction in fertility. Only formal modeling of the process would enable us to determine which influence dominates under what conditions.

Household labor needs and the local commons

The poorest countries are in great part agriculture-based subsistence economies.[44] Much labor is needed even for simple tasks. Moreover, many households lack access to the sources of domestic energy available to households in advanced industrial countries. Nor do they have water on tap. In semi-

arid and arid regions water supply is often not even close at hand, nor is fuelwood nearby when the forests recede. This means that the relative prices of alternative sources of energy and water faced by poor rural households are quite different from those faced by households elsewhere. In addition to cultivating crops, caring for livestock, cooking food, and producing simple marketable products, household members may have to spend several hours a day fetching water and collecting fodder and wood. These complementary activities have to be undertaken on a daily basis if households are to survive. Labor productivity is low because both capital and environmental resources are scarce. From an early age, children in poor households in the poorest countries mind their siblings and domestic animals, fetch water, and collect fuelwood, dung (in the Indian subcontinent), and fodder. Mostly, they do not go to school. Not only are educational facilities in the typical rural school woefully inadequate, but parents need their children's labor. Children between ages 10 and 15 years have been routinely observed to work at least as many hours as adult males (see, for example, Bledsoe 1994; Cleaver and Schreiber 1994; Filmer and Pritchett 1996).

The need for many hands can lead to a destructive situation when parents do not have to pay the full price of rearing their children, but instead share such costs with their community. In recent years, social norms that once regulated local resources have changed. Since time immemorial, rural assets such as village ponds and water holes, threshing grounds, grazing fields, swidden fallows, and local forests and woodlands have been owned communally. As a proportion of total assets, the presence of such assets ranges widely across ecological zones. In India the local commons are most prominent in arid regions, mountain regions, and unirrigated areas; they are least prominent in humid regions and river valleys (Agarwal and Narain 1989). There is a rationale for this, based on the human desire to reduce risks. Community ownership and control enabled households in semi-arid regions to pool their risks.[45] An almost immediate empirical corollary is that income inequalities are less where common-property resources are more prominent. Aggregate income is a different matter, though, and the arid and mountain regions and unirrigated areas are the poorest. As would be expected, dependence on common-property resources even within dry regions declines with increasing wealth across households.

Jodha (1986, 1995), studying evidence from more than 80 villages in 21 dry districts in India, concluded that, among poor families, the proportion of income based directly on their local commons is for the most part in the range of 15–25 percent. A number of resources (such as fuelwood and water, berries and nuts, medicinal herbs, resin and gum) are the responsibility of women and children. In a study of 29 villages in southeastern Zimbabwe, Cavendish (1998, 1999) arrived at even larger estimates: the proportion of income based directly on the local commons is 35 percent, with

the figure for the poorest quintile reaching 40 percent. Such evidence does not of course prove that the local commons are well managed, but it suggests that rural households have strong incentives to devise arrangements whereby they would be well managed.

A number of investigators—among them Howe (1986); Wade (1988); Chopra, Kadekodi, and Murty (1990); Ostrom (1990, 1992); and Baland and Platteau (1995)—have shown that many communities have traditionally protected their local commons from overexploitation by relying on social norms, by imposing fines for deviant behavior, and by other means. I argued earlier that the very process of economic development, as exemplified by urbanization and mobility, can erode traditional methods of control. Social norms are endangered also by civil strife and by the usurpation of resources by landowners or the state. For example, resource-allocation rules practiced at the local level have frequently been overturned by central fiat. A number of states in the Sahel imposed rules that in effect destroyed community management practices in the forests. Villages ceased to have authority to enforce sanctions against those who violated locally instituted rules of use. State authority turned the local commons into free-access resources.[46] As social norms degrade, whatever the cause, parents pass some of the costs of their children onto the community by overexploiting the commons. This is another instance of a demographic free-rider problem.

The perception of an increase in the net benefits of having children induces households to have too many. This is predicted by the standard theory of the imperfectly managed commons (see the Appendix). It is also true that when households are further impoverished owing to the erosion of the commons, the net cost of children increases (of course, household size continues to remain above the optimum from the collective point of view). Loughran and Pritchett (1998), for example, have found in Nepal that increasing environmental scarcity lowered the demand for children, implying that the households in question perceived resource scarcity as raising the cost of children. Apparently, increasing firewood and water scarcity in the villages in the sample did not have a strong enough effect on the relative productivity of child labor to induce higher demand for children. Environmental scarcity there acted as a check on population growth.

On the other hand, theoretical considerations suggest that, in certain circumstances, increased resource scarcity induces further population growth: as the community's natural resources are depleted, households find themselves needing more "hands." No doubt additional hands could be obtained if the adults worked even harder, but in many cultures it would not do for the men to gather fuelwood and fetch water for household use.[47] No doubt, too, additional hands could be obtained if children at school were withdrawn and put to work. But, as we have seen, mostly the children do not go to school anyway. In short, when all other sources of additional labor

become too costly, more children are produced, thus further damaging the local resource base and, in turn, providing the household with an incentive to enlarge yet more. This does not necessarily mean that the fertility rate will increase. If the infant mortality rate were to decline, there would be no need for more births in order for a household to acquire more hands. However, along this pathway poverty, household size, and environmental degradation would reinforce one another in an escalating spiral. By the time some countervailing set of factors diminished the benefits of having further children and, thereby, stopped the spiral, many lives could have suffered by a worsening of poverty. In the Appendix I provide a simple model to illustrate such possibilities.

Cleaver and Schreiber (1994) have provided rough, aggregative evidence of a positive link between population increase and environmental degradation in the context of rural sub-Saharan Africa; Batliwala and Reddy (1994) for villages in Karnataka, India; and Heyser (1996) for Malaysia. In a statistical analysis of data from villages in the Sindh region in Pakistan, Filmer and Pritchett (1996) tentatively reported a positive link between fertility and deterioration of the local natural-resource base. The macroeconomic statistics in Table 4 are not at variance with this possibility either.

None of these investigations quite captures what the theory I am sketching here tells us to study, namely, the link between desired household size and the state of the local natural-resource base. But they come close enough; limitations in existing data prevent investigators from getting closer to the theory.[48] In any event, these studies cannot reveal causal connections, but, excepting the study by Loughran and Pritchett (1998), they are consistent with the idea of a positive-feedback mechanism such as I have described. Over time, the spiral would be expected to have political effects, as manifested by battles for scarce resources, for example among competing ethnic groups (Durham 1979; Homer-Dixon, Boutwell, and Rathjens 1993; Homer-Dixon 1994). This last connection deserves greater investigation than it has elicited so far.[49]

To be sure, families with greater access to resources would be in a position to limit their size and propel themselves into still higher income levels. Admittedly, too, people from the poorest backgrounds have been known to improve their circumstances. Nevertheless, there are forces at work that pull households away from one another in terms of their living standards. Such forces enable extreme poverty to persist despite the growth in wellbeing for the rest of society.

Institutional reforms and policies

If in earlier days social scientists looked for policies to shape social outcomes for the better, their focus today is more on the character of institutions within

which people make decisions. But if policies that read well often come to naught in dysfunctional institutions, the study of institutions on their own is not sufficient: good policies cannot be plucked from air. There is mutual influence here, and the task of the social scientist is to study it.

Demographers, like economists, seek good news. There is a danger that the recent onset of demographic transitions in parts of the Indian subcontinent and signs of an onset in some of the urban regions of sub-Saharan Africa will make demographers complacent. A distinguished student of demography remarked to me recently that, in view of the many signs of demographic transitions everywhere, the "population problem" is now over.

But it is not over. The ultimate size of the world's population once the transitions have occurred will matter greatly. There is likely to be a world of difference between a global population of 11 billion and one of 5 billion, even if we ignored differences in their spatial distributions that would inevitably be implied (Cohen 1995). In this connection, it is worth stressing that some of the externalities I have identified in this article operate mainly *in* time, while others operate mainly *through* time (economists refer to them, respectively, as "static" and "dynamic" externalities). So even if world population were to stabilize, there would remain externalities whose presence calls for public policies.

In this article I have identified a number of institutional failures that are allied to pronatalist reproductive externalities. I have done this by trying to connect demographic and environmental perspectives. The perspective that emerges tells us that the most potent avenue for reducing the population problem in various parts of the world involves the simultaneous deployment of a number of policies, not a single panacea, and that the relative importance of the several prongs depends on the community in question. Thus, while family planning services (especially when allied to public health services) and measures that empower women (through both education and improved employment opportunities) are certainly desirable, other policies also commend themselves, such as the provision of infrastructural goods (e.g., cheap sources of household fuel and potable water), changes to property rights (e.g., the rules of inheritance), means of communication with the outside world (e.g., roads, telephones, radios, television, newspapers, and the Internet), and measures that directly increase the economic security of the poor. A number of these policies might well not have come to mind had we studied demographic problems in isolation.

In any event, the aim should not be to force people to change their reproductive behavior. Rather, it should be to identify policies and encourage such institutional changes as would "internalize" the externalities I have uncovered here. Recent declines in fertility rates in the Indian subcontinent and in parts of sub-Saharan Africa suggest that outside influence, via the media, may have been powerful. Observing lifestyles elsewhere can no

doubt be unsettling to many, but it can also give people ideas that are salutary. To the extent that reproductive behavior is based on conformism, modern communication channels, by linking the village to the outside world, have a powerful effect. But the media are likely to be hampered in arbitrary ways except in politically open societies. I have shown elsewhere (Dasgupta 1990; Dasgupta and Weale 1992) that in poor countries political and civil liberties are congruent with improvements in other aspects of life, such as income per head, life expectancy at birth, and infant survival. Subsequently, Przeworski and Limongi (1995) have shown that these liberties are negatively correlated with fertility rates. We therefore have several reasons for thinking that political and civil liberties have instrumental value, even in poor countries; they are not merely desirable ends. But each of the prescriptions offered by the new perspective presented here is desirable in itself and commends itself even when we do not have fertility rates of poor countries in mind. To me this is a most agreeable fact.

Admittedly, in all this I have looked at matters wholly from the perspective of parents. This is limiting.[50] But developing the welfare economics of population policies has proved to be extremely difficult.[51] Our ethical intuition at best extends to actual and future people; we do not yet possess a good moral vocabulary for including potential people in the calculus. I have tried to argue in this article that there is much we can establish even if we left aside such conceptual difficulties. Population policy involves a good deal more than making family planning services available to the rural poor. It also involves more than a recognition that poverty is the root cause of high fertility rates. The problem is deeper, but as I have tried to show, it is possible to subject it to analysis.

Appendix: The village commons and household size

The observation that increases in population size bring in their wake additional pressures on the local natural-resource base is, no doubt, a banality. So, in what follows I study the reverse influence: the effect of a deterioration of the local natural-resource base on desired household size.

I argued above that villagers' free-riding on the commons can impoverish households in such a way as to create an additional need for household labor. Such a need would translate itself into a demand for more surviving children if having more surviving children were the cheapest means of obtaining that additional labor. Of course, this is only one possibility; another is that the receding commons impoverishes households in such a way that, at the margin, children become too costly, with the result that the number of surviving children declines. In this Appendix I offer a formal account of both possibilities. The model outlined enables us to identify parametric conditions under which the various outcomes would be expected to occur. I then compare the noncooperative village to a cooperative one.

The model is timeless. Adjustments over time can then be analyzed in terms of comparative statics.

The single household

I consider an agriculture-based village economy consisting of N identical households. N is taken to be sufficiently large that the representative household's size does not affect the economy. The model is deterministic. Household size is assumed to be a continuous variable, which is a way of acknowledging that realized household size is not a deterministic function of the size the household sets for itself as a target.

Let n be the size of a household. Members contribute to production, but they also consume from household earnings. I aggregate inputs and outputs and assume that household production possibilities are such that net income per household member, y(n), has the quadratic form,

$$y(n) = -\alpha + \beta n - \gamma n^2, \text{ where } \alpha, \beta, \gamma > 0, \text{ and } \beta^2 > 4\alpha\gamma. \tag{1}$$

The quadratic form enables us to capture certain crucial features of a subsistence economy in a simple way, thereby permitting us to draw conclusions easily. For example, equation (1) presumes fixed costs in running a household, which is altogether realistic: in order to survive, a household must complete so many chores on a daily basis (cleaning, farming, animal care, fetching water and collecting fuelwood, cooking raw ingredients, and so forth) that single-member households are not feasible. Equation (1) also presumes that when the household is large, the costs of adding new members begin to overtake the additional income that is generated. This too is clearly correct.[52]

It follows from equation (1) that y(n) = 0 at

$$\underline{n} = \left[\beta - \sqrt{(\beta^2 - 4\alpha\gamma)}\right] / 2\gamma \tag{2a}$$

and

$$\overline{n} = \left[\beta + \sqrt{(\beta^2 - 4\alpha\gamma)}\right] / 2\gamma. \tag{2b}$$

$\underline{n}$ is the "fixed cost" of maintaining a household, while $\overline{n}$ could be interpreted to be the environment's "carrying capacity." I assume that the household "chooses" its size so as to maximize net income per head. Let n* denote the value of n at which y(n) attains its maximum and let y* denote the maximum. Then

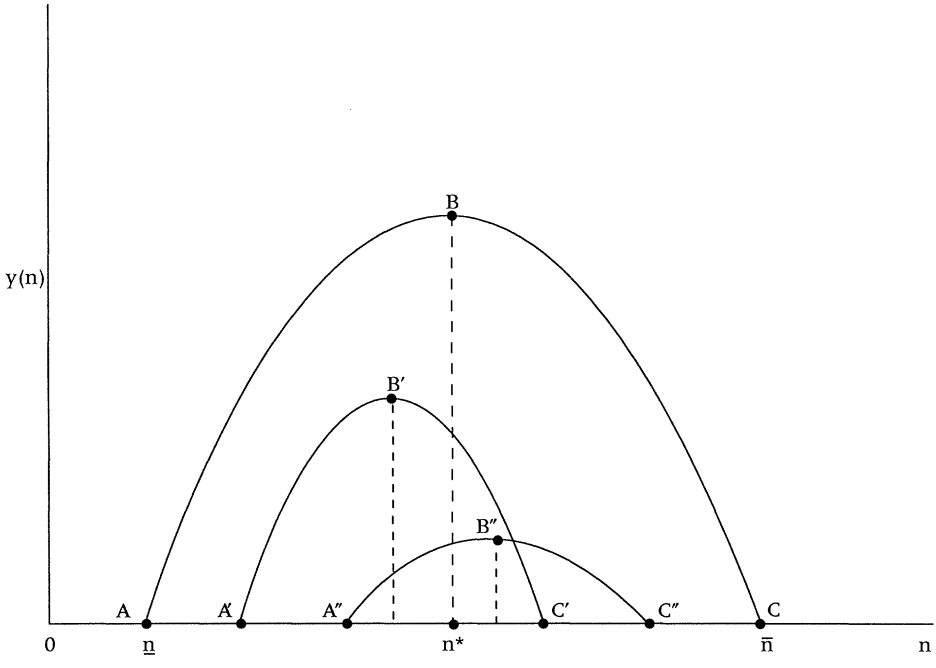
$$n^* = \beta / 2\gamma \tag{3a}$$

and

$$y^* = -\alpha + \beta^2 / 4\gamma. \tag{3b}$$

y(n) is depicted as the curve ABC in Figure A-1, where B is the point $(\beta/2\gamma, -\alpha + \beta^2/4\gamma)$.

FIGURE A-1 Household income per head, y(n), as a function of household size, (n)



Imagine now that the household faces an increase in resource scarcity. We are to interpret this in terms of receding forests and vanishing water holes. The index of resource scarcity could then be the average distance from the village to the resource base. So, an increase in resource scarcity would mean, among other things, an increase in $\underline{n}$.

But it would typically mean more. For example, equations (2a,b) tell us that the household would face an increase in resource scarcity if α, γ, and α/γ were to increase and β were to decline in such a way that $\bar{n}$ declines. Note too that in this case, both n^* and y^* would decline (equations (3a,b)). The resulting $y(n)$ is depicted as the curve A′B′C′ in Figure A-1. In short, the increase in resource scarcity shifts the curve ABC to A′B′C′.

Consider instead the case where each of α, β, and γ increases, but in such ways that $\underline{n}$ and n^* increase, while $\bar{n}$ and y^* decline. This is the kind of situation in which a household finds that its best strategy against local resource degradation is to increase its size even while finding itself poorer. The resulting $y(n)$ is depicted as the curve A″B″C″ in Figure A-1. In short, the increase in resource scarcity shifts the curve ABC to A″B″C″. This sort of case was noted originally in Dasgupta and Mäler (1991) and Nerlove (1991).

Social equilibrium

I now construct an equilibrium of the village economy. The state of the local natural-resource base is taken to be a function of the village population, which I write

as M. So I assume that α, β, and γ in equation (1) are functions of M. Write $\alpha = \alpha(M)$, $\beta = \beta(M)$, and $\gamma = \gamma(M)$. A symmetrical equilibrium of the village economy is characterized by $M^* = Nn^*$. That is, n^* and y^* are the solutions of

$$n^* = \beta(Nn^*)/2\gamma(Nn^*) \tag{4a}$$

and

$$y^* = -\alpha(Nn^*) + \left[\beta(Nn^*)\right]^2/4\gamma(Nn^*). \tag{4b}$$

I assume that a solution exists and that $n^* > 1$.

The optimum village

Consider next an optimizing village community.[53] It chooses n so as to maximize

$$y(n) = -\alpha(Nn) + \beta(Nn)n - \gamma(Nn)n^2. \tag{5}$$

Let $\hat{n}$ be the optimum household size. Then $\hat{n}$ is the solution of

$$\left[\beta(Nn) - 2n\gamma(Nn)\right] - N\left[\alpha'(Nn) - n\beta'(Nn) + n^2\gamma'(Nn)\right] = 0. \tag{6}$$

A comparison of equations (4a) and (6) tells us that $\hat{n} < n^*$ if

$$-\alpha'(Nn^*) + n^*\left[\beta'(Nn^*) - n^*\gamma'(Nn^*)\right] < 0. \tag{7}$$

That is, if equation (7) holds, the village is overpopulated in social equilibrium. An alternative way of thinking about the matter is to say that an institutional reform which reduces the "freedom of access" to the commons would lower fertility.

Now equation (7) certainly holds if

$$\alpha', \gamma' > 0 \text{ and } \beta' < 0 \text{ at } n = n^*. \tag{8}$$

But it holds also if

$$\alpha', \beta', \gamma' > 0,$$

and

$$\left[-\alpha' + \left(\beta\beta'/2\gamma\right) - \beta^2\gamma'/4\gamma^2\right] < 0 \text{ at } n = n^*. \tag{9}$$

The effect of increased resource scarcity

Let us study the implications for equilibrium household size and the standard of living consequent upon small exogenous shifts in the functions $\alpha(M)$, $\beta(M)$, and $\gamma(M)$. We assume that, prior to these shifts, the inequality depicted in equation (7) holds. The perturbations are taken to be sufficiently small so that equation (7) continues to hold in the new equilibrium.

Consider first the case where the perturbation consists of small upward shifts in $\alpha(M)$ and $\gamma(M)$ and a small downward shift in $\beta(M)$. Notice that if equation (8) holds, both n^* and y^* would be marginally smaller as a consequence of the perturbation. This is the case we would expect intuitively: a small increase in resource scarcity results in poorer but smaller households.

Now consider the case where equation (9) holds. Suppose the perturbation consists of small upward shifts in each of the functions $\alpha(M)$, $\beta(M)$, and $\gamma(M)$. We can set the relative magnitudes of the shifts such that the small increase in resource scarcity results in poorer but larger households—that is, y^* declines marginally but n^* increases marginally. This is the timeless counterpart of the positive feedback mechanism between population size, poverty, and degradation of the natural-resource base that was discussed in the text. Such a feedback, while by no means an inevitable fact of rural life, is a possibility. In this article I have argued that evidence of the experiences of sub-Saharan Africa and the northern Indian subcontinent in recent decades is not inconsistent with it.

Notes

This article synthesizes a class of ideas I have developed in Dasgupta (1992, 1993, 1995, 2000). While preparing the article I benefited greatly from discussions with Kenneth Arrow, Robert Cassen, Sriya Iyer, and Karl-Göran Mäler.

1 See, for example, Cassen (1978), Dyson and Moore (1983), World Bank (1984), Birdsall (1988), Robey, Rutstein, and Morris (1993), Sen (1994), and Bardhan (1996).

2 See, for example, Boserup (1981), Simon (1989), and Bauer (2000).

3 The I=PAT equation of Ehrlich and Holdren (1971), in which Impact on the environment is a function of Population, Affluence, and Technology, is used by many to express this concern.

4 The modern classic is Becker (1981).

5 Jones (1998) contains a review of contemporary growth models.

6 Daily (1997) is a collection of essays on the character of ecosystem services. See also Arrow et al. (1995) and Dasgupta, Levin, and Lubchenco (2000), both of which discuss the implications of the fact that destruction of ecosystems is frequently irreversible.

7 For first-hand accounts of daily life under the stresses of resource scarcity, see Agarwal (1986, 1989) and Narayan (2000). For attempts to develop the economics of such conditions, see Dasgupta (1982, 1993, 1995, 1996, 1997a, 1998a, 2000).

8 One of the rare exceptions is Bardhan and Udry (1999).

9 The early works are cited in Becker (1981). Hotz, Klerman, and Willis (1997) survey the field by studying fertility decisions in developed countries. Schultz (1997) makes thorough use of the new household economics for studying the demand for children in poor countries.

10 Surveying the field, Schultz (1988: 417–418) wrote: "Consequences of individual fertility decisions that bear on persons outside of the family have proved difficult to quantify, as in many cases where social external diseconomies are thought to be important.... The next step is to apply...microeconomic models [of household behavior] to understand aggregate developments in a general equilibrium framework. But progress in this field has been slow."

11 Kelley (1988) contains a review of the findings. See also the survey of empirical growth economics by Temple (1999), who adopts a skeptical view regarding the deleterious consequences of population growth in poor countries.

12 The total fertility rate (TFR) is the number of live births a woman would expect to

have if she were to live through her childbearing years and to bear children at each age in accordance with the prevailing age-specific fertility rates. If the TFR were 2.1 or thereabouts, population in the long run would stabilize.

13 Schultz (1997) confirms this effect for a pooled set of cross-country data.

14 For a fuller discussion see Daily et al. (1998).

15 Wealth per head is the correct index only if production processes are subject to constant returns to scale. If they are not, the statement in the text needs to be modified (see Dasgupta and Mäler 2000). I am ignoring such refinements here. For many years environmental and resource economists argued that GNP should be replaced by net national product (NNP) as a measure of social wellbeing so as to accommodate environmental concerns. This argument was wrong: NNP is not an adequate welfare measure; wealth is.

16 See also World Bank (1998). Serageldin (1995) reported on the World Bank's research program on sustainable development.

17 Drèze and Murthi (2000) have found no effect of income on fertility in a pooled set of district-level data from India.

18 In this respect, the literature I am alluding to resembles much contemporary economic theory.

19 Brock and Durlauf (1999) and Levin (1999) offer useful accounts of that structure in a technical and nontechnical manner, respectively.

20 Myrdal (1944) called such forms of feedback "cumulative causation."

21 Lutz and Scherbov (1990) offer a thoughtful review of why and how.

22 See Cleland (1996) for a demonstration of this.

23 To illustrate, with a random but representative example, I quote from a letter to the *Guardian* newspaper written by Anthony Young of Norwich, UK, on 24 April 2000. Tracing the prevailing famine in Ethiopia to overpopulation relative to Ethiopia's resource base, he writes: "There is an ethically acceptable set of measures for reducing rates of population growth: improvement in the education and status of women, coupled with making family planning services available to all."

24 Above low levels of education and contraceptive use, however, women's education and family planning outreach activities appear to be substitutes.

25 Subsequent to Cochrane's work, studies have found a positive association between maternal education and the wellbeing of children, the latter measured in terms of such indicators as household consumption of nutrients, birth spacing, the use of contraceptives, infant and child survival rates, and children's height (see Dasgupta 1993: ch. 12, for references). As an indication of orders of magnitude, the infant mortality rate in households in Thailand where the mother had no education was found to be 122 per 1,000 live births, compared with rates of 39 and 19 per 1,000, respectively, for women with primary and secondary education; see World Bank (1991). However, a common weakness of many such empirical studies is their "bivariate" nature.

In pooled cross-section data for poor countries in the 1970s and 1980s, Schultz (1997) has found that the total fertility rate is negatively related to women's and men's education (the latter's effect being smaller), as well as to urbanization and agricultural employment; and positively related to unearned income and child mortality. This is what the new household economics would lead one to expect.

26 In their careful analysis of district-level data in India from the 1981 and 1991 censuses, Drèze and Murthi (2000) have come the closest to claiming that a causal link exists between women's education and fertility. But their study was not designed to test the kind of theoretical reasoning I am pursuing here.

27 Hess (1988) has conducted time-series analysis that attests to a positive association between primary education and fertility in parts of sub-Saharan Africa.

28 Anthropologists have argued, however, that in parts of western sub-Saharan Africa prolonged breastfeeding is not a birth control measure, but a means of reducing infant mortality: traditionally, animal milk has been scarce in the region.

29 I am grateful to John Bongaarts for helpful conversations on this matter.

30 Chen, Huq, and D'Souza (1981) is a pioneering quantitative study on the behavioral antecedents of higher female than male

mortality from infancy through the childbearing ages in rural Bangladesh. See Dasgupta (1993) for further references. It should be noted that stopping rules governing fertility behavior based on sex preference provide a different type of information regarding such preference than do sex ratios within a population. To see this, suppose that in a society where sons are preferred, parents continue to have children until a son is born, at which point they cease having children. Assume that at each try there is a 50 percent chance of a son being conceived. Now imagine a large population of parents, all starting from scratch. In the first round 50 percent of the parents will have sons and 50 percent will have daughters. The first group will now stop and the second group will try again. Of this second group, 50 percent will have sons and 50 percent will have daughters. The first subgroup will now stop and the second will have another try. But at each round the number of boys born equals the number of girls. The sex ratio is 1.

The argument also implies that population remains constant. To confirm this, note that because each couple has exactly one son, couples on average have one son. But because the sex ratio is 1, couples on average have one daughter also. Therefore, the average couple has two children. This means that in equilibrium the size of the population is constant.

31 Writing about West Africa, Fortes (1978: 125–126) says "a person does not feel he has fulfilled his destiny until he or she not only becomes a parent but has grandchildren.... [Parenthood] is also a fulfillment of fundamental kinship, religious and political obligations, and represents a commitment by parents to transmit the cultural heritage of the community.... Ancestry, as juridically rather than biologically defined, is the primary criterion...for the allocation of economic, political, and religious status." See also Goody (1976). Cochrane and Farid (1989) remark that both the urban and rural and the educated and uneducated in sub-Saharan Africa have more, and want more, children than do their counterparts in other regions. Thus, even younger women there expressed a desire for an average of 2.6 more children than women in the Middle East, 2.8 more than women in North Africa, and 3.6 to 3.7 more than women in Latin America and Asia.

32 Between 1965 and 1987 the infant mortality rate in a number of the poorest countries in sub-Saharan Africa declined from about 200 per 1,000 live births to somewhere on the order of 150 per 1,000 live births (World Bank 1989).

33 Sundstrom and David (1988) apply this reasoning to parents in the United States prior to its Civil War.

34 This hypothesis could be tested by comparing the age structure of households that foster out with those that foster in.

35 To see that there is no distortion if the share of benefits and costs was the same, suppose c is the cost of rearing a child and N is the number of couples within a kinship. For simplicity, assume that each child makes available y units of output to the entire kinship, which is then shared equally among all couples. Suppose also that the cost of rearing each child is shared equally by all couples. Let n^* be the number of children each couple other than the one under study chooses to have. (I presently endogenize this.) If n were the number of children this couple produces, it would incur the resource cost $C=[nc+(N-1)n^*c]/N$, and eventually the couple would receive an income from the next generation equaling $Y=[ny+(N-1)n^*y]/N$. Denote the couple's aggregate utility function by the form $U(Y)-K(C)$, where both $U(.)$ and $K(.)$ are increasing and strictly concave functions. Letting n be a continuous variable for simplicity, it is easy to confirm that the couple in question will choose the value of n at which $yU'(Y)=cK'(C)$. The choice sustains a social equilibrium when $n=n^*$. It is easy to check that this is also the condition that is met in a society where there is no reproductive free-riding. It is a simple matter to confirm that free-riding occurs if the couple's share of the benefits from having children exceeds their share of the costs.

36 Among the prominent Nayyars of the southern state of Kerala, descent is matrilineal. Kerala is noteworthy today for being among the poorer Indian states even while attaining a TFR below 2.

37 n^* is taken to be a continuous variable as a way of acknowledging that realized household size is not a deterministic function of the size the household sets as a target for itself.

38 Because households are identical in this stylized model, by a socially optimal state I mean a Pareto optimum.

39 In game theory Figure 2 is called a coordination game.

40 Formally, the above is a model of demographic transitions viewed as "relaxation phenomena." The mathematical structure I have invoked is similar to one that has recently been used by oceanographers and ecologists in their exploration of tipping phenomena in ocean circulation and lake turbidity, respectively. See Rahmstorf (1995) and Scheffer (1997).

41 In this connection, the Indian state of Andhra Pradesh offers an interesting example. Female illiteracy there is a high 55 percent, but some 75 percent of the population has access to radio or television. The fertility rate is now 2.3.

42 I am grateful to Lincoln Chen for a helpful 1996 correspondence on this point.

43 This is the setting studied in the theory of repeated games. See Fudenberg and Tirole (1991).

44 I am thinking of countries in sub-Saharan Africa and the Indian subcontinent. In those countries the agricultural labor force as a proportion of the total labor force is on the order of 60–70 percent, and the share of agricultural-value added in GNP is on the order of 25–30 percent.

45 In his work on south Indian villages, Seabright (1997) has shown that producers' cooperatives, unconnected with the management of local commons, are also more prevalent in the drier districts.

46 See Thomson, Feeny, and Oakerson (1986) and Baland and Platteau (1996).

47 Filmer and Pritchett (1996) summarize empirical findings on children's time allocation to household activities in rural areas of poor countries.

48 However, Deon Filmer has informed me that his colleagues at the World Bank have found in a sample of Nepalese villages a positive relationship between (primary) school attendance and the availability of local natural resources.

49 Crook (1996) questions the poverty–population link. But because he treats population density and land productivity as exogenous variables, his is not quite a test of the thesis.

50 Enke (1966) is a notable exploration of the value of prevented births when the worth of additional lives is judged to be based entirely on their effect on the current generation. As a simplification, Enke took the value of a prevented birth to be the discounted sum of the differences between an additional person's consumption and output over the person's lifetime.

51 I have addressed some of the difficulties elsewhere (Dasgupta 1998b).

52 The analysis that follows can be developed more generally, without recourse to the quadratic function.

53 I avoid rigor here and assume (without justification) that the optimum is symmetric in households.

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Notes

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