How the World Survived the Population Bomb: An Economic Perspective

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How the World Survived the Population Bomb

An Economic Perspective

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The population of the world doubled between 1960 and 2000, growing from 3 billion to 6 billion people. This is by far the largest increase in world population over a period of two generations in human history, measured in either absolute numbers or percentage increase. In terms of the world's ability to meet increasing demands on resources, the second half of the twentieth century offered an experiment unlike anything seen before. As we think about issues of sustainable development facing the world today, it is instructive to look back on the lessons of this unique period of human history.

It is entirely appropriate to think of the rapid growth of world population between 1950 and 2000 as a "population explosion." Viewed from the perspective of the 1960s, when the rate of growth reached its peak, it is not surprising that there were concerns that this population explosion would put enormous pressure on the world's economic resources. Many predicted mass starvation, large increases in poverty, and depletion of key resources in the decades to follow. We now have accumulated more than three decades' worth of data since many of these predictions were made, and more than four decades' worth since the population growth rate reached its peak. This chapter will survey several key economic indicators related to some of the worst fears about the impact of population growth on humans. The data on economic variables, including food production, commodity prices, and poverty, suggest that the world not only survived the population explosion but was in better condition by most of these indicators in 2000 than it was

in 1960. The past four decades have been a period of rising per capita food consumption, with significant declines in both the percentage and the absolute number of people in poverty. While poverty rates remain unacceptably high in many countries, with especially disappointing progress having been made in Africa, the global picture of the latter half of the twentieth century presents the surprising combination of an unprecedented population explosion occurring at the same time as rapid declines in poverty.

If we have the hindsight to say the world survived the population bomb, it follows that the population explosion is over. In addition to looking at trends in key economic indicators, this chapter examines the demography of the population explosion. As demographers have long pointed out, the population explosion resulted from rapid declines in mortality that produced a relatively short period of extremely high growth. While the world's population continues to grow, fueled in part by the inertia of rapid growth during the peak of the population explosion, rapidly declining birth rates imply that growth rates will continue to fall in coming decades, moving the world into a period of much slower growth. Growth has already dropped below the rate of 1950. With the growth rate in 2000 returning to roughly the level of 1950, it seems appropriate to consider 1950 and 2000 as convenient bookends for the population explosion in examining both its demography and its economics. An economic perspective helps us understand how the world avoided mass starvation; it also helps explain why birth rates have fallen so rapidly throughout the developing world.

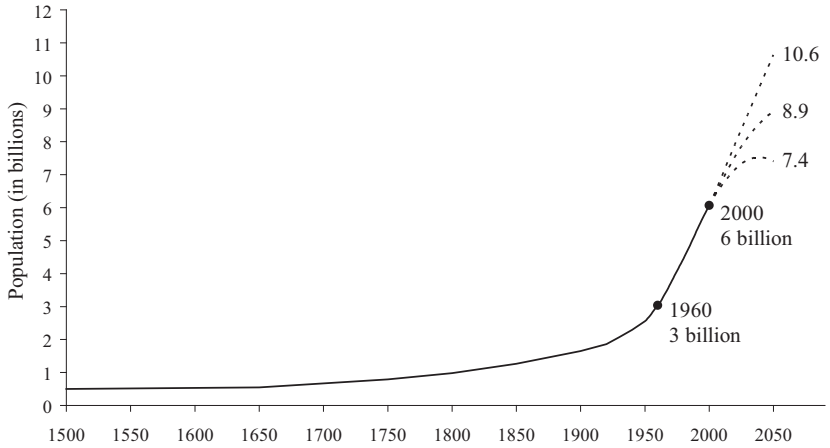
This chapter will take a broad look at the world, with examples from many different countries, but in addition, its last part will look in detail at fertility decline in Brazil. Brazil is an interesting case study because it had a rapid decline in birth rates in the absence of a significant national family planning effort. The fertility rate in Brazil is now about the same as the fertility rate in the United States. This chapter argues that the response of parents to falling infant mortality and the impact of rising parental education levels played an important role in Brazil's incredible fertility decline. An economic model of optimizing behavior based on tradeoffs between the quality and quantity of children (the former term refers to the quality of their lives and the investments made in them) provides a framework for explaining these responses at the household level.

THE HISTORY OF WORLD POPULATION GROWTH

We begin with a historical overview of world population growth. Figure 5.1 shows estimates of the total population of the world from 1500 to 2000, along with projections from 2000 to 2050.[1] It demonstrates that the population growth of the twentieth century, and especially of the second half of the twentieth century, skyrocketed. The world did not reach 1 billion population until 1800, reached 2 billion around 1930, and then added another 4 billion people in the next 70 years.

If we work backward from the 2000 population of 6 billion, an interesting benchmark would be the time when the world population was $^{1}/_{32}$ (2^{-5}) this size, or 187.5 million, meaning that the world has subsequently doubled in population five times. A common estimate for the population of the world in 1 AD is 300 million, although estimates range from 170 million to 400 million (U.S. Census Bureau 2003). The estimates reported by the Census Bureau suggest that a population of 187.5 million might have existed around 300 BC. A population twice this large, 375 million, may have been reached around 1200 AD, a doubling time

Figure 5.1 Total World Population from 1500 to 2000 and U.N. High, Medium, and Low Variant Projections to 2050



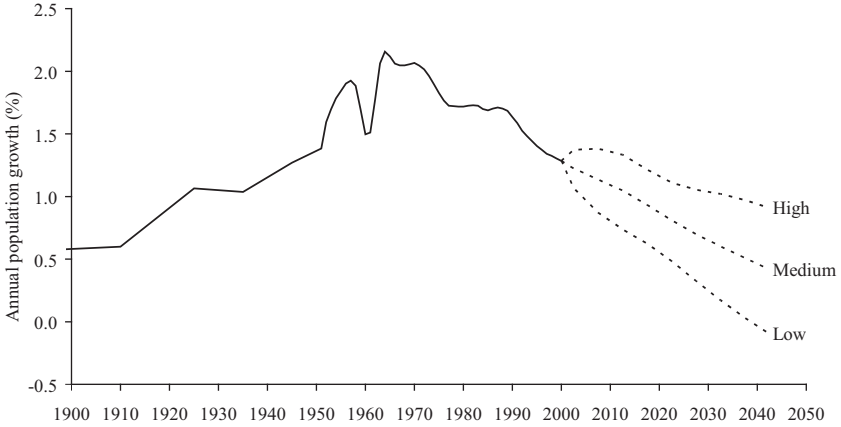
SOURCE: Estimates for 1500–1950 are from U.S. Census Bureau (2003); estimates for 1950–2000 and high, medium, and low variant projections for 2000–2050 are from United Nations Population Division (2003). See Note 1.

of 1,500 years. Continuing with subsequent doublings of population, the world reached 750 million around 1700, 1.5 billion around 1860, and 3 billion around 1960. In round numbers, then, the sequence of five doubling times since the world was $^1/_{32}$ of its 2000 population is roughly 1500 years, 500 years, 150 years, 100 years, and 40 years.

Given this sequence of doubling times, it is natural to ask what the next doubling time will be—that is, when will world population reach 12 billion? While the answer obviously requires conjecture, it is virtually impossible that the next doubling time would be less than 40 years, and very unlikely that it would be less than 100 years. Figure 5.1 shows three population projections from 2000 to 2050 made by the United Nations Populations Division. Even the high variant projection only reaches 10.6 billion by 2050, a rate of increase far short of the previous doubling (although it would be a larger absolute increase than took place between 1960 and 2000). The medium variant projection does not even reach 9 billion by 2050. In fact, many forecasts predict that world population will never again double. The United Nations Population Division (1999, p. 5) has projected that world population will reach about 9.5 billion in 2100, 9.75 billion in 2150, and will stabilize sometime after 2200 at just above 10 billion. Lutz, Sanderson, and Scherbov (2001) use a model of probabilistic population projections in which their median forecast predicts that world population will peak in 2070 at 9 billion. They estimate that there is an 85 percent chance that the world will reach population stability by 2100.

While it is obviously difficult to forecast world population, there is nonetheless quite a bit of information to use for such forecasts, given current age distribution, trends in fertility and mortality, and past experience (Bongaarts and Bulatao 2000). The picture of population growth becomes clearer if we look at growth rates rather than totals. Figure 5.2 shows the annual rate of population growth from 1900 to 2000, with United Nations projections to 2050.[2] The annual growth rate of 0.6 percent at the beginning of the twentieth century was already quite high by historical standards. From there, we see that growth rates rise to a level of 1 percent a year around 1930. They then increase dramatically in the 1950s, reaching about 1.4 percent in 1950 and rising to 1.9 percent by 1958. The sharp short-term drop around 1960 and 1961 is due to the Great Famine in China, which killed more than 18 million Chinese, causing such a jump in death rates that it dropped the world

Figure 5.2 Annual World Population Growth Rate, Actual and Projected, 1900 to 2050[a]



[a] Rates to 2000 are three-year moving averages; rates after 2000 are based on five-year projections (see Note 2).

SOURCE: Estimates for 1900–1950 are from U.S. Census Bureau (2003); estimates for 1950–2000 and high, medium, and low variant projections for 2000–2050 are from U.N. Population Division (2003).

population growth rate by almost half a percentage point. The world reached its peak growth rate according to these estimates in 1964, at 2.16 percent a year (implying a doubling time of about 32 years if the rate remained constant). The growth rate declined fairly rapidly in the 1970s, remained fairly stable in the 1980s, and has been falling steadily since around 1990. The world's growth rate in 2000 was about 1.3 percent, lower than in 1950. Even the high variant U.N. projection shows steadily falling growth rates from 2000 to 2050. The medium variant projection has the growth rate dropping below 1 percent by 2015, dropping below 0.5 percent by 2040, and continuing to fall after that.

WHAT CAUSED THE POPULATION EXPLOSION?

These figures suggest that the world will almost surely never again see population growth of the magnitude experienced in the past half-century. In order to understand how the world survived this population explosion and why it is unlikely to ever be repeated, it is necessary to

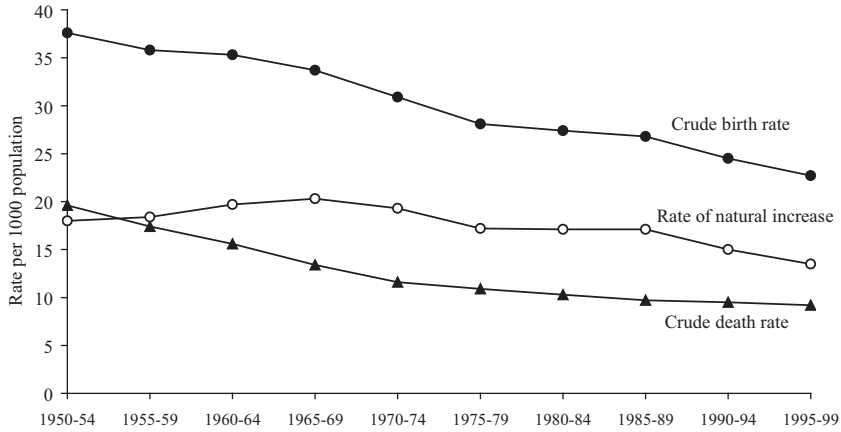
understand what caused it in the first place. The demographic explanations for the dramatic increase in the world population growth rate in the 1950s and 1960s are well understood. The annual percentage increase in world population in a given year (the measure shown in Figure 5.2) is entirely determined by the difference between birth rates and death rates. Demographers define the crude birth rate (CBR) as the number of births in a year per 1000 population, and the crude death rate (CDR) as the number of deaths per 1000 population. The crude rate of natural increase (CRNI) is simply the difference between these. If the CRNI is 10 per 1000, the population growth rate is 1 percent a year. Given these standard measures, we can analyze the extent to which either changes in the crude birth rate or changes in the crude death rate were responsible for producing the increase in the population growth rate in the 1950s and 1960s.

The Demographic Transition

Figure 5.3 shows the crude birth rate, crude death rate, and crude rate of natural increase for the world between 1950 and 1999, based on United Nations Population Division estimates (2003). These are five-year averages, in contrast to the single-year estimates shown in Figure 5.2. The peak growth rate occurs at just above 2 percent a year in the 1965–1969 period. (Since these data are averaged over five years, they do not show the sharp drop associated with China's Great Famine that was seen in the annual estimates in Figure 5.2.) One of the striking features of Figure 5.3 is that both the crude birth rate and the crude death rate fall over the entire period shown. The reason the population growth rate increased between the periods of 1950–1954 and 1965–1969 is that the death rate fell faster than the birth rate. Falling infant and child mortality played a major role in the falling death rate. Not only did the birth rate not increase during this period, it was already falling in the 1950s and continued falling throughout the period that population growth rates were increasing.

Statistics are not available, but if we extended Figure 5.3 back several decades, we would find that crude birth rates were probably in the range of 40–45 per 1000, not significantly higher than observed around 1950. Crude death rates, on the other hand, would have been considerably higher than the 20 per 1000 level observed in 1950. We know that

Figure 5.3 Crude Birth Rate, Crude Death Rate, and Rate of Natural Increase for the World, 1950–1999



SOURCE: U.N. Population Division (2003).

crude death rates must have been close to crude birth rates earlier in the twentieth century since the population growth rate was close to 0.5 percent (5 per 1000). Death rates had already fallen substantially by 1950, producing the growth rates of over 1.5 percent shown in Figure 5.3.

The pattern shown for the world as a whole would have been broadly similar to the pattern observed in most developing countries. Beginning from a regime with high birth rates, high death rates, and relatively low population growth, developing countries saw their death rates decline during the first half of the twentieth century. Birth rates initially remained at their previous level, generating a gap between birth rates and death rates that caused increased population growth. The population growth rate continued to increase until birth rates began to fall fast enough to offset falling death rates. This occurred in the 1965–1969 period for the world (Figure 5.3), beginning a period of declining population growth rates. About this time, death rates stabilized at a low level of around 10 per 1000, with further declines in birth rates leading to further declines in the rate of population growth. This process, known as the demographic transition, has played out in similar fashion throughout the developing world, with variations in the timing and pace of the transition. A century earlier, the demographic transition had occurred

in similar fashion in most of the countries that currently have high incomes. The difference was that death rates fell much more gradually, with the result that peak growth rates during the transition were typically lower than those observed in developing countries 100 years later.

Population Momentum

The other dynamic is population momentum. Since childbearing is concentrated in the 20–35 age range, a large increase in births in a given period will lead to a corresponding increase in the size of the childbearing population 20–35 years later. This creates a powerful mechanism for population momentum, implying that even though there were sharp reductions in fertility in the 1970s and 1980s, the numbers of births in many countries will continue to grow for several decades, the result of increasing numbers of women of childbearing age. This holds true even for countries that have already reached replacement fertility. This dynamic also helps explain why we can predict the path of population growth with some precision. One reason we can be certain the world population growth rate will decline steadily between now and 2050 is that the current growth rate is only as high as it is because of population momentum. The size of the childbearing population can be fairly easily projected for the next 20 years, since many of those women have already been born. While the number of women of childbearing age will continue to increase for several decades, the growth rate of that population is falling rapidly. This must translate into falling population growth rates, even if fertility rates were to stop falling.

THE IMPACT OF THE POPULATION EXPLOSION

Given the unprecedented rates of population growth that appeared in the 1950s and 1960s, it is understandable that there were concerns about the potential social and economic consequences of this rapid growth. Paul Ehrlich's *The Population Bomb*, which came out in 1968, was one of the best-known books expressing alarm over the high rates of population growth. Ehrlich focused particularly on the challenge of feeding the increasing numbers of people in developing countries. He wrote, "The world, especially the developing world, is rapidly running

out of food . . . In fact, the battle to feed humanity is already lost, in the sense that we will not be able to prevent large-scale famines in the next decade or so" (1968, p. 36). Lester Brown struck a similar note when he wrote in a 1967 article in *Science* that "conventional agriculture now provides an adequate and assured supply of food for one-third of the human race. But assuring an adequate supply of food for the remaining two-thirds, in parts of the world where population is increasing at the rate of 1 million weekly, poses one of the most nearly insoluble problems confronting man" (1967, p. 604). The computer simulations of the Club of Rome's well-known *The Limits to Growth* (Meadows et al. 1972) focused attention on depletion of nonrenewable resources and resulting increases in commodity prices.

Trends in Economic Indicators

There have been extensive debates about trends in economic, social, and environmental indicators in recent decades. It is far beyond the scope of this chapter to provide an exhaustive review of those debates, or to propose resolutions to the complex issues involved. Some of these debates have been closely tied to discussions about the impact of rapid population growth, with many going back to the predictions made by Ehrlich and others who gave early warnings. In this section, I provide a broad description of trends in several key economic indicators during recent decades. These include food production, commodity prices, and poverty.

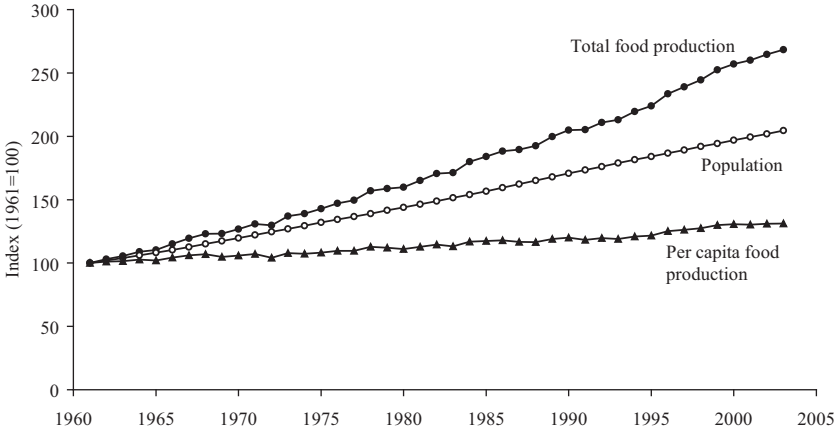
These variables go to the heart of many of the worst fears about the potential impact of rapid population growth. Mass starvation, exhaustion of nonrenewable resources, and increased poverty were certainly some of the major concerns among a wide variety of observers who considered the impact of rapid population growth during the 1960s. It is hard to imagine a more challenging test of the world's capacity to absorb population than for it to double its population in 40 years, especially when this doubling means the addition of 3 billion people. As Lester Brown wrote in his 1967 *Science* article, in which he (accurately) predicted the addition of at least 1 billion people by 1980, "The world has never before added 1 billion people in 15 years."

Trends in Food Production

In the 1960s, there was probably no more daunting challenge associated with rapid population growth than that of feeding the growing population. The prologue to *The Population Bomb* began, "The battle to feed all of humanity is over. In the 1970s the world will undergo famines—hundreds of millions of people are going to starve to death in spite of any crash programs embarked upon now" (Ehrlich 1968).

Data on agricultural production are provided by the Food and Agriculture Organization of the United Nations (FAO) and are readily available on that organization's Web site (FAO 2004). Figure 5.4 presents indices of total food production, per capita food production, and total population for the world from 1961 to 2003, setting the 1961 levels to 100 as a baseline for all three indices. As the figure indicates, the world has experienced steady and dramatic increases in food production since 1961. Total food production in the world roughly doubled between 1961 and 1990, and by 2003 it had reached a level 2.7 times the amount in 1961. The average rate of growth of food production between 1961 and 2003 was 2.4 percent a year. Significantly, Figure 5.4 shows that the line for total food production is always above the line for total population,

Figure 5.4 Indices of World Food Production and Population, 1961–2003 (1961=100)



SOURCE: Food and Agriculture Organization (FAO) of the United Nations (2004).

even during the period of the most rapid population growth, the 1960s. Thus, at any point between 1961 and 2003, food production increased faster than world population relative to the 1961 baseline. The average growth rate of world population from 1961 to 2003 was 1.7 percent a year, yet per capita food production grew at an average annual rate of 0.7 percent. Per capita food production in 2003 was 31 percent higher than it was in 1961.

One reason for the world's remarkable increase in agricultural output since the 1960s has been the green revolution's technological advances in developing new high yield crops. While we cannot assume that the growth rates of the past 40 years in food production can be maintained, it is interesting to look at forecasts of food production made at various points between the 1960s and today. Lester Brown concluded in a 1975 article in *Science* that "the scarcity of basic resources required to expand food output, the negative ecological trends that are gaining momentum year by year in the poor countries, and the diminishing returns on the use of energy and fertilizer in agriculture . . . lead me to conclude that a world of cheap, abundant food with surplus stocks and a large reserve of idled cropland may now be history. In the future, scarcity may be more or less persistent, relieved only by sporadic surpluses, of a local and short-lived nature" (1975, p. 1059). In addition to his dire prediction about overall food production, Brown expressed concern that the world was becoming increasingly dependent on North America as its food producer. In fact, however, FAO data indicate that between 1965 and 1975, food production increased at an annual rate of 2.9 percent in developing countries, compared to a rate of 2.4 percent in North America.

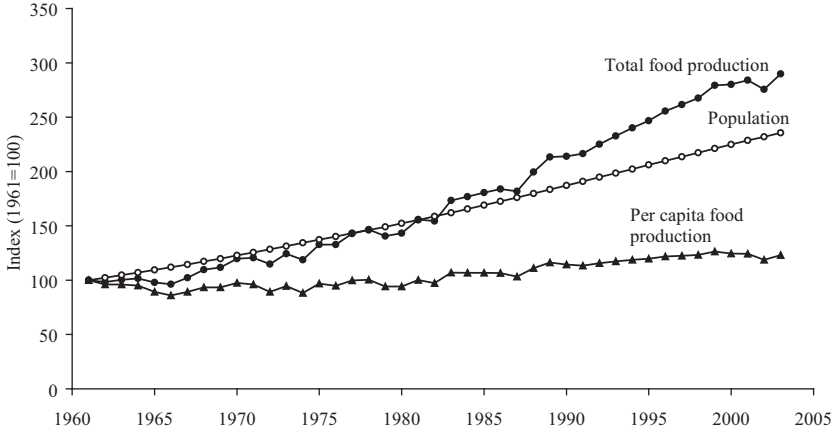
Although impressive growth in food production continued through the late 1970s, Brown (1981) again expressed concern in another *Science* article: "As the 1980s begin, the growth in world production is losing momentum and its excess over population growth is narrowing" (p. 1001). But in fact the annual growth rate of world food production in the 1980s turned out to be 2.5 percent, slightly higher than the growth rate between 1965 and 1980 and a full percentage point greater than the growth rate of world population. Additional concerns were raised at the end of the 1980s. Paul and Anne Ehrlich (1990) wrote in *The Population Explosion*, a follow-up to *The Population Bomb*, that "world grain production peaked in 1986 and then—for the first time in forty years—

dropped for two consecutive years . . . Global food production peaked in 1984 and has slid downward since then" (p. 15).

A couple of years after the Ehlichs' book, Robert McNamara (1992) wrote that "The early gains of the Green Revolution have nearly run their course. Since the mid-1980s, increases in worldwide food production have lagged behind population growth." It is not clear exactly what data the Ehrlichs and McNamara were referring to, although it is possible that their comments were consistent with the data available at the time they wrote. The FAO data shown in Figure 5.4 clearly tell a much different story. Figure 5.4 shows that both total and per capita food production for the world increased throughout the 1980s, although there are occasional years when per capita food production declined, such as a 1 percent decline between 1986 and 1987. The record after these prognostications is even more positive, with food production growing significantly faster than population in the 1990s. While it is easy to find observers in the 1970s, 1980s, and today warning that the success of the green revolution cannot last forever, the data indicate remarkable and sustained success in food production for more than four decades, with no evidence that future food production will not keep pace with population growth, especially given the declining rate of growth.

While the experience of the world as a whole is one important summary statistic, it is also interesting to look at the experience of individual countries. India was singled out by Ehrlich for particular attention in *The Population Bomb*. Ehrlich quoted one expert on Indian agriculture who predicted that India had reached its maximum level of food production in 1967–1968. At that time, India's population was growing at more than 3 percent a year (implying a doubling time of less than 25 years), and it was one of the places where Ehrlich and many others predicted mass starvation. Figure 5.5 shows food production in India from 1961 to 2003 based on the same FAO data used for Figure 5.4, once again using 1961=100 as the baseline. India's food production over the period actually grew faster than food production for the world as a whole, and 2003 production was 2.9 times greater than the level in 1961. Even so, the line for per capita food production in Figure 5.5 indicates that India's food production did not grow fast enough to keep up with its population during some periods in the 1960s and 1970s—per capita food production fell by about 10 percent between 1961 and 1966. These were temporary shortfalls, however, and per capita food produc-

Figure 5.5 Indices of Food Production and Population in India, 1961–2003 (1961=100)



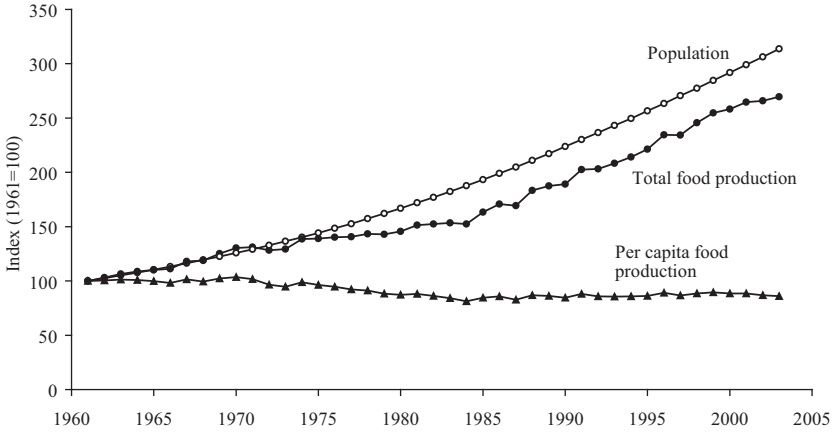
SOURCE: FAO (2004).

tion returned to its 1961 level by 1970. It fell again slightly in the mid-1970s, returned to its 1961 level in 1980, and then remained above its 1961 level in the 1980s and 1990s.

As with the world data, India's impressive increases in food output in the late 1960s and the 1970s were followed by numerous predictions that the success could not be sustained. Ehrlich and Ehrlich (1990) acknowledged India's "dramatic increases in wheat production between 1965 and 1983" but noted that "since 1983, India's rising grain production has lost momentum" and warned that "the country appears to be facing a catastrophic problem in the 1990s, if not earlier" (pp. 70–72). The FAO data indicate that food production in India actually grew by 2.3 percent a year between 1990 and 2003, 0.5 percent faster than the growth rate of the population. By 2003 India's per capita food production was 23 percent above its 1961 level (and 43 percent above the low observed in 1966), even though the Indian population in 2003 was 2.4 times larger than in 1961.

While India has done much better at producing food than almost any observer could have predicted in the 1960s, as has the world as a whole, not all regions of the world have done so well. Sub-Saharan Africa has been much less successful at feeding itself over this period. Figure 5.6 shows total food production, per capita food production, and population

Figure 5.6 Indices of Food Production and Population in sub-Saharan Africa, 1961–2003 (1961=100)



SOURCE: FAO (2004).

for sub-Saharan Africa from 1961 to 2003. Total food production for sub-Saharan Africa in 2003 was 2.7 times the level of 1961. This is in many respects an impressive increase, but it was not sufficient to keep pace with Africa's rapid population growth: per capita food production in sub-Saharan Africa in 2003 was 14 percent below the level of 1961. Most economists looking at the disappointing performance of agriculture in Africa agree that the problems are not fundamentally related to resource constraints or rapid population growth.

"In the case of sub-Saharan Africa," writes Gale Johnson (1999), "the failure to achieve a significant increase in per capita food supplies has been due, not primarily to limitations of natural resources, but to wholly inappropriate national policies that exploited agriculture in the name of promoting economic development as well as by ethnic and civil strife in several countries" (p. 5915). As an example of the policies that have discouraged food production in Africa, Johnson mentions the World Bank study of agricultural pricing policy, which estimated that effective returns to African farmers declined by 51.6 percent between 1960 and 1984 as a result of governmental interventions in agricultural markets (Krueger, Schiff, and Valdes 1988).

While the decline in per capita food production in Africa shown in Figure 5.6 is a very serious problem, it does not negate the relatively optimistic picture of global food capacity provided by the evidence from other regions. The disappointing African experience also points to some of the reasons for the positive experience of the past 40 years in the rest of the world. The rapid increases in global food production are not simply the result of technological innovation in agriculture. As frequently pointed out by agricultural economists, getting economic incentives right in agricultural sectors within countries and liberalizing agricultural trade across countries are key factors in generating world agricultural output. It is also important to recognize the role played by increased human capital. As Johnson (2000) posed the question in his presidential address to the 2000 meeting of the American Economic Association (AEA), "What made it possible for the world to escape from what could be called the Malthusian trap? The answer is simple: the creation of knowledge" (p. 2).

Leaving aside regional imbalances in food production in recent decades, we must recognize that even increased per capita food production within a particular country does not necessarily translate into reductions in hunger in that country. Distribution of food, like distribution of income, is very unequal both within and across countries. Examining the distribution of resources within countries requires household level data. Below I will look at estimates of trends in poverty for the world as a whole and for specific regions and countries. Since these estimates are usually based on measures of consumption at the household level, they are the best evidence regarding trends in hunger in the world.

Trends in Commodity Prices

The impressive story of how world food production kept pace with world population during the population explosion might be considered a story of remarkably good luck, in that green revolution innovations came along at just the right time to keep up with the population explosion. Concerns about the impact of the population explosion were not limited to food, however. Rapid population growth was also predicted to cause scarcity with many other types of commodities. In order to investigate these issues we can look at data on a wide range of other commodities, both renewable (like food) and nonrenewable. This was

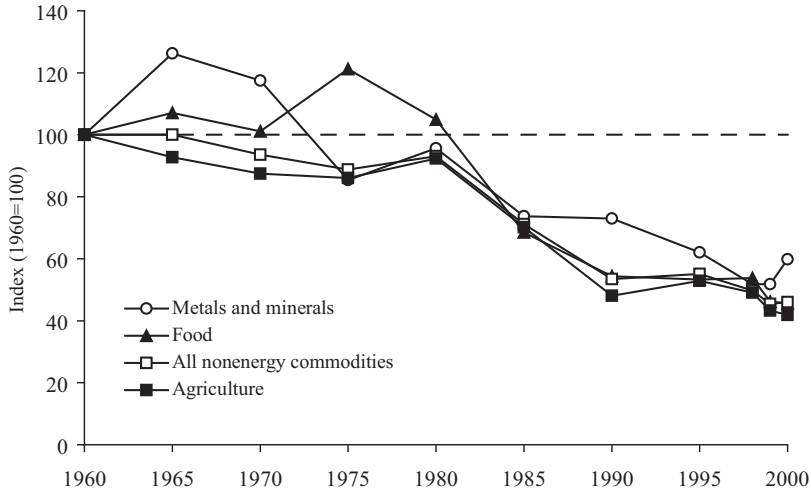
one of the points made by Julian Simon in his book *The Ultimate Resource* (1981). Simon upheld the standard notion of economists that one of the best indicators of whether the world is running out of a resource is whether the price of that resource is increasing. While various nonmarket forces, such as the Organization of the Petroleum Exporting Countries (OPEC) cartel, might create distortions between price and resource supply, it would be difficult to have a situation in which a commodity is nearing depletion at the same time that the price of the resource is declining.

Simon's emphasis on the tendency of most commodity prices to decrease over time led to a famous bet between himself and Paul Ehrlich (Tierney 1990). Simon challenged any taker to pick any natural resource and any future date, and he would bet that the real price of the resource would decline. Ehrlich and a group of colleagues selected five metals—chrome, copper, nickel, tin, and tungsten—for the period from October 1980 to October 1990. The outcome was that the real price of each of these five commodities declined between 1980 and 1990, and the bundle of five metals that cost $1000 in 1980 (in quantities that cost $200 each) could be bought for $618 in 1990 (adjusted for inflation). To settle the bet, Ehrlich sent Simon a check for $576.07, the decline in the total cost of the five metals using 1990 prices.

Data on commodity prices are relatively easy to come by, since commodities are the focus of very active and highly competitive international markets. The data presented here are taken from the World Bank's World Development Indicators (2001). Figure 5.7 shows real commodity price indices from 1960 to 2000, using 1960=100 as the baseline. All prices are adjusted for inflation. Four broad indices are shown—food, agricultural products, metals and minerals, and all nonenergy commodities. Although each index has periods of price increases over the four decades, the clear trend is downward for all four indices. The price decline between 1960 and 2000 is 40 percent for metals and minerals, 54 percent for food, 60 percent for agricultural commodities overall, and 54 percent for the combined index of all nonenergy commodities. For this last category, the combined index of all nonenergy commodities, the price is lower in every period between 1960 and 2000 than it was in 1960.

Petroleum prices, which are not shown in Figure 5.7, are the one major exception to the trend of falling commodity prices. Movements

Figure 5.7 Indices of World Commodity Prices, 1960–2000 (1960=100)



SOURCE: World Bank (2001).

in petroleum prices are driven predominantly by actions of the OPEC cartel; the highest real prices were observed in the late 1970s. According to World Bank data, the price of petroleum in 1980 was 6.7 times higher than the price in 1960. The petroleum price in 2000 was 3.6 times the 1960 price. While these higher petroleum prices have an impact on all economies in the world, they would seem to have little to do with actual resource scarcity.

The results shown in Figure 5.7 provide a powerful piece of data in support of sustainable development. During a period in which world population doubled, real commodity prices, excluding petroleum, fell by more than 50 percent. Many economic forces help explain this fairly remarkable outcome. Technological innovations have increased efficiency in the use of resources and have often produced substitutes for resources when price increases have appeared. As Johnson emphasized to the AEA in the case of agricultural production, human knowledge has been instrumental. Trade liberalization and increased efficiency in global transport and communication have also played an important role. While a separate story could be told about the price trends in every major commodity, the common theme is one of falling prices and de-

creasing resource pressure, in spite of the enormous increase in world population.

Trends in Poverty

It is frequently, and appropriately, pointed out that increased food production or rising per capita incomes do not improve the lives of all people equally. Some segments of the population may be excluded from economic progress completely, or may even suffer declining living standards at the same time that aggregate measures indicate improvement. The increase in food production shown above would be less reassuring if we discovered that all of the increase in consumption went to high-income consumers. One of the concerns about rapid population growth has been that it would lead to increased poverty, both because poor countries were those with the highest growth rates and because higher population growth rates might have negative distributional consequences within countries (Birdsall, Kelley, and Sinding 2001; Cassen 1994; Lam 1987, 1997).

Data on poverty rates are much more difficult to come by than data on agricultural output or commodity prices, since poverty estimates require data at the level of individual households. Measuring poverty in developing countries is a complex and challenging task that has been the focus of extensive research. The absence of reliable and consistent data to estimate poverty was one of the main motivations for the World Bank's effort to collect comparable household surveys on income and consumption in a large number of countries (Grosh and Glewwe 2000).

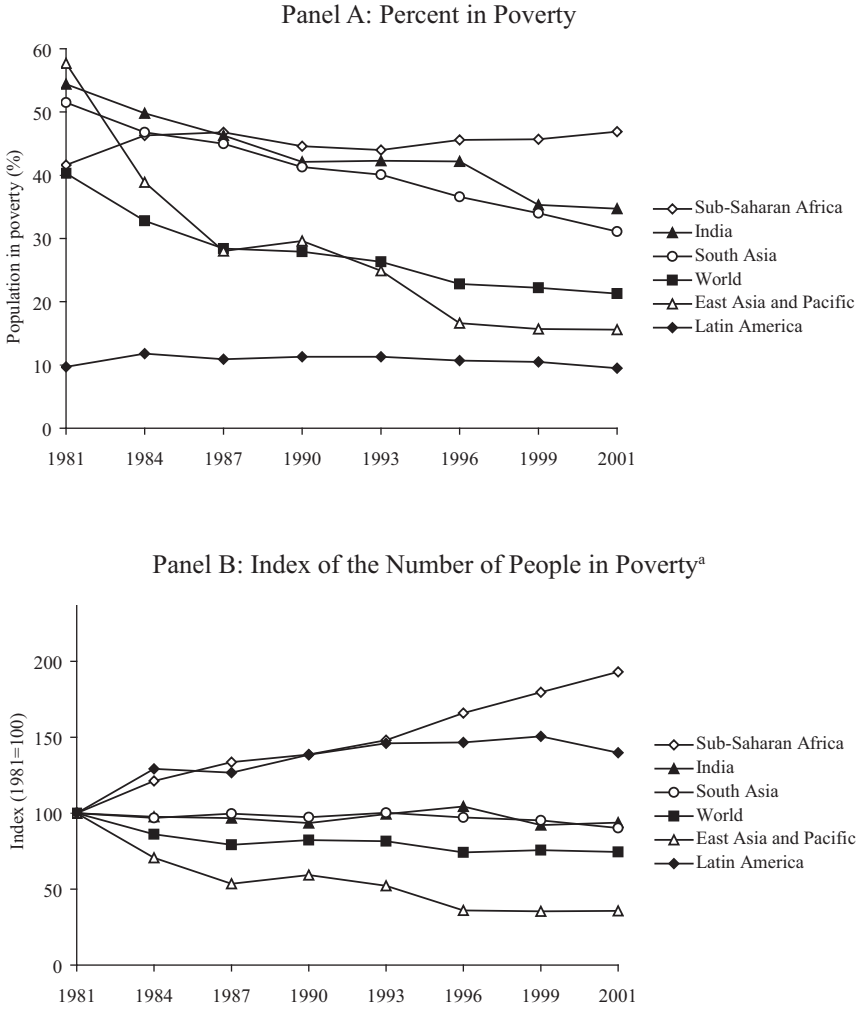
The issue has produced extensive debate over matters of measurement, analysis, and interpretation, much of which has played out in the context of larger debates about the impact of globalization, international trade, and the actions of international agencies. The ideal way to measure trends in poverty in any country would be to have a consistent series of large, nationally representative household surveys with detailed information on income and consumption for a number of years. Very few developing countries met this ideal before the mid-1980s, and even after the launching of the World Bank's ambitious Living Standards Measurement Study (LSMS) surveys in the 1980s, many issues of incomplete coverage and data comparability remained. As is discussed

by Ravallion (2003) and Deaton (2001, 2002, 2003), most estimates of poverty use a combination of household survey data and national accounts data.[3] The survey data are used to provide detailed information on the distribution of income or consumption across households, but are often only available for one or two points in time. National accounts statistics can be used to estimate changes in mean income for every year, with the combination of the survey data and national accounts being used to estimate the percentage below a given poverty line in years when complete survey data are not available. An additional key methodological issue is the comparison of incomes across countries. It is standard to use Purchasing Power Parity (PPP) indices, which are based on the cost of purchasing a comparable basket of goods in each country to compare income and consumption across countries.

The most comprehensive attempts to estimate poverty in this way have been done by researchers at the World Bank. Estimates covering the period 1981–2001 are presented in Figure 5.8, based on data taken from the World Bank's PovertyNet Web site (World Bank 2004). Methodological details and additional estimates are provided in Chen and Ravallion (2001). Figure 5.8 reports estimates of poverty based on one of the simple benchmark poverty lines that is often used—$1 a day in per capita household consumption. Note that the estimates are typically based on direct measures of consumption and therefore speak to the issue of changing trends in hunger as well. The top panel of Figure 5.8 shows the percentage in poverty (the population headcount ratio); the bottom panel shows the absolute number in poverty, using 1981=100 as a baseline for each region. For the total developing country population, the "World" line in Figure 5.8 indicates that the percentage of the population in poverty in all developing countries by the $1 a day measure declined from 40.3 percent in 1981 to 21.3 percent in 2001. Impressive declines in poverty in China play a large role in the overall trend, although the poverty rate still declines from 31.6 percent to 22.8 percent when China is excluded (not shown). This world decline was large enough to more than offset the substantial population growth in developing countries during this period, leading to a decline in the absolute number in poverty in all developing countries of about 25 percent (from 1.48 billion to 1.10 billion).

Figure 5.8 also shows poverty trends for major regions of the developing world and for the specific case of India.[4] Looking at the regional

Figure 5.8 Percentage and Absolute Number in Poverty by Region, 1981–2001 ($1 Per Day Poverty Line)



[a] The index represents the absolute number of people in poverty in each region in each year, divided by the number who were in poverty in that region in 1981. Using an index makes it possible to do a simple comparison of regions with very different population sizes.

SOURCE: World Bank (2004).

breakdowns in Figure 5.8, we see that the largest decline in poverty over this period took place in East Asia and the Pacific, where the $1 a day poverty rate plummeted from 58 percent to 16 percent between 1981 and 2001. Estimates for India indicate that the poverty headcount ratio fell from 55 percent in 1981 to 35 percent in 2001. The absolute number of poor people in India is estimated to have stayed almost constant over this 20-year period, showing small declines in the late 1990s. The declining poverty rates in India shown in Figure 5.8 are consistent with estimates of Deaton and Drèze (2002).

Latin America and sub-Saharan Africa had more disappointing performances over this period. The percentage of the population in poverty in Latin America remained roughly constant at around 10 percent, implying about a 50 percent increase in the absolute number in poverty. Africa had by far the worst experience of any region, with the percentage in poverty rising from 42 percent to 47 percent. Combined with rapid population growth, this resulted in almost a doubling of the number of people in poverty in 20 years, an increase of 150 million.

In addition to the large regional differences in both levels and trends in poverty shown in Figure 5.8, there are often large differences within a given country. A detailed examination of poverty in India by Deaton and Drèze (2002) shows significant declines in poverty in the 1990s but also shows regional differences in poverty increasing over the period, including no reduction in poverty in some of the states that already had the highest levels of poverty. A number of studies also indicate that income inequality has increased in India and China even though poverty has declined. Higher income growth occurred in the highest income deciles (Chen and Wang 2001; Deaton and Drèze 2002).

Although data on poverty rates before the 1980s are much more limited, most evidence indicates that the declines in poverty shown in Figure 5.8 for the period after 1980 were a continuation of declines in poverty over several decades. Sala-i-Martin (2002) combines national accounts data from 1970 to 1998 with the available data on individual country income distributions to estimate changes in the distribution of income in each country and for the world as a whole. Applying the $1 per day poverty line to these distributions, he estimates that there have been substantial declines in poverty rates for the developing world as a whole over the entire period. His estimates of the levels of poverty are considerably lower than those estimated by Chen and Ravallion, but

the trends show a similar pattern: poverty fell rapidly in Asia, fell more slowly in Latin America, and increased substantially in Africa.

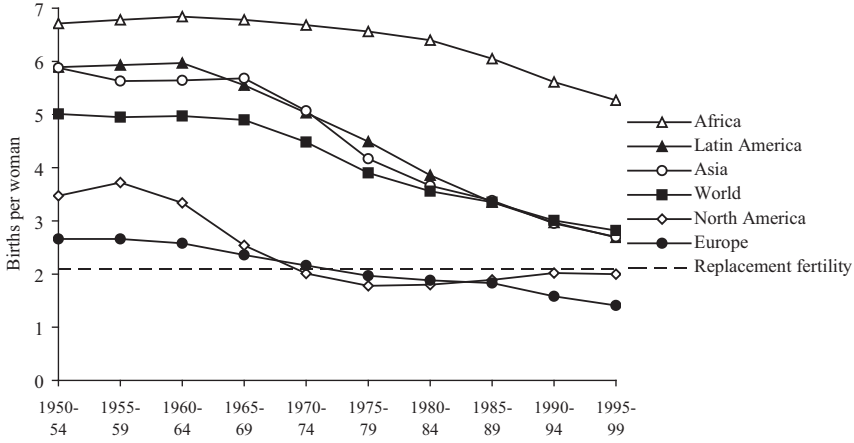
In summarizing the data on world poverty trends in recent decades, we find that the overall picture is quite positive. The evidence since 1980 indicates that the percentage of the world in extreme poverty (falling under the $1 a day measure) has been cut almost in half. The absolute number of people in poverty has declined by about 25 percent. This good news must be balanced by a couple of sources of concern. First, these estimates imply that one in five people in the world continue to live in extreme poverty. Second, the trends have varied enormously across regions, with poverty increasing rather than decreasing in Africa. The percentage of the African population in poverty has risen to almost 50 percent, and the absolute number of Africans in poverty roughly doubled between 1981 and 2001.

THE RAPID DECLINE IN FERTILITY

The impressive ability of the world economy to absorb the population growth of the last four decades is matched by equally remarkable declines in fertility rates. It is instructive to look at these declines in some detail and to consider their causes from an economic perspective. This section will pay particular attention to the case of Brazil, where fertility fell rapidly in the absence of significant family planning programs.

Figure 5.9 shows the total fertility rate (TFR) for major world regions from 1950 to 1999, based on United Nations Population Division (2003) estimates. The total fertility rate is the sum of the age-specific fertility rates in a given year and can be interpreted as the number of births a woman would have in her lifetime if she was exposed to the age-specific birth rates for that year. The total fertility rate for the world was around 5 births per woman for the five-year periods beginning in 1950–1954 and ending in 1965–1969, then began to fall rapidly in the 1970s. By the 1995–1999 period the world TFR had fallen to 2.8. Demographers use a TFR of 2.1 as a benchmark for replacement fertility, a rate that would have each couple replacing itself on average, with some additional births to compensate for those that didn't survive to childbearing age.[5] Freedman and Blanc (1992) found it useful to measure the percentage decline in fertility toward replacement level as a measure of

Figure 5.9 Total Fertility Rate for World Regions, 1950–1999



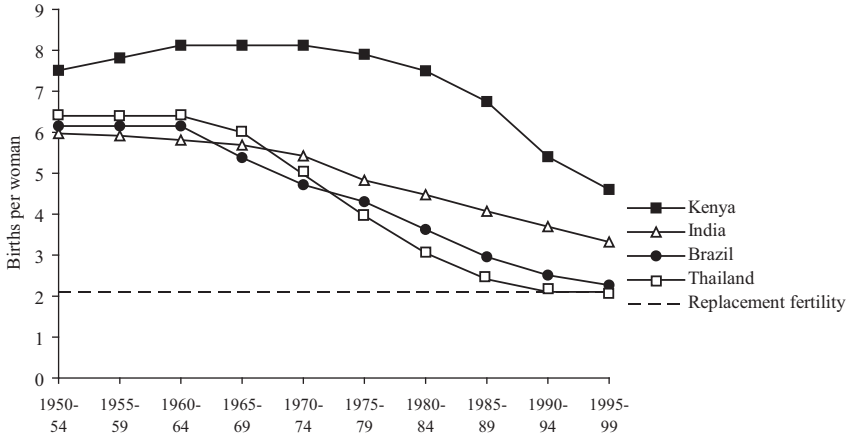
SOURCE: U.N. Population Division (2003).

fertility decline. The difference between the TFR and replacement fertility for the world fell from 2.9 to 0.7 between 1965 and 1999, meaning that fertility fell by 75 percent of the amount required to reach replacement fertility.

As shown in Figure 5.9, declines in fertility have been observed in all regions of the world. Asia and Latin America have had the fastest declines, following very similar patterns over the 50 years shown. In both regions the TFR fell from around 6.0 in 1950 to about 2.7 in 1999. This decline is 82 percent of the decline necessary to reach replacement fertility. The pace of fertility decline has been significantly slower in Africa. While the TFR has clearly been declining in Africa, especially after 1980, the TFR for the region as a whole was still 5.3 in 1995–1999, almost twice as high as for Asia and Latin America, the next-highest regions. The decline from the 1960 peak of 6.8 represents 32 percent of the decline necessary to reach replacement fertility.

Figure 5.10 shows the TFR for four specific countries for the period 1950–1999—Kenya, India, Brazil, and Thailand—based on United Nations estimates. Thailand is an example of a country experiencing rapid fertility decline, having dropped from a TFR of well over 6 in 1960–1964 to near replacement level fertility by 1990–1994. Brazil's fertil-

Figure 5.10 Total Fertility Rate for Selected Countries, 1950–1999



SOURCE: U.N. Population Division (2003).

ity decline is slightly slower, but Brazil had fallen to near replacement level fertility by 1995–1999. India began its fertility decline somewhat later than Brazil and Thailand and has had slower rates of decline. The TFR in India in 1995–1999 was about 3.3. Kenya, like most sub-Saharan African countries, continued to have high fertility into the 1980s, with a TFR of over 7.0 in the 1980–1984 period. Fertility began to fall at a rapid rate later that decade, however, reaching about 4.5 in 1995–1999.

Fertility Decline, Investments in Human Capital, and Quantity-Quality Tradeoffs

The patterns of fertility decline over the last 50 years are much clearer than are the determinants of the decline. While it is beyond the scope of this chapter to survey the vast literature that has analyzed the determinants of fertility decline in developing countries, I will address a few issues that I believe are fundamental to understanding the economics of fertility. As in the case of rising agricultural output and falling commodity prices, optimizing responses to changing incentives and

tradeoffs has played an essential role in the fertility declines of the last 40 years.

Declines in fertility across the developing world have coincided with substantial increases in the health and schooling of children. The negative relationship between fertility and children's schooling is a strong empirical regularity, whether observed across populations, across time in a given population, or across families at a given point of time in a population. Not only are couples in developing countries having significantly fewer children than they were four decades ago, they are investing a great deal more in the human capital of those children. The tradeoff between the quantity and quality of children is one of the central features of economic theories of fertility (Becker and Lewis 1973; Willis 1973; Lam 2003). Since his early writings on the economics of fertility, Becker has pointed out that rising incomes lead to substitutions away from quantity of children and into quality of children, where quality is indicated by expenditures on children, including investments in schooling and health. Lam and Duryea (1999) applied the models of Becker and Lewis (1973) and Willis (1973) to the case of rising parental schooling, noting that falling infant mortality and increased parental schooling could easily lead to a similar substitution of quality in place of quantity of children. This mechanism helps explain why the fertility decline has been so universal and why it has been combined with rapid increases in schooling.

THE BRAZILIAN EXPERIENCE

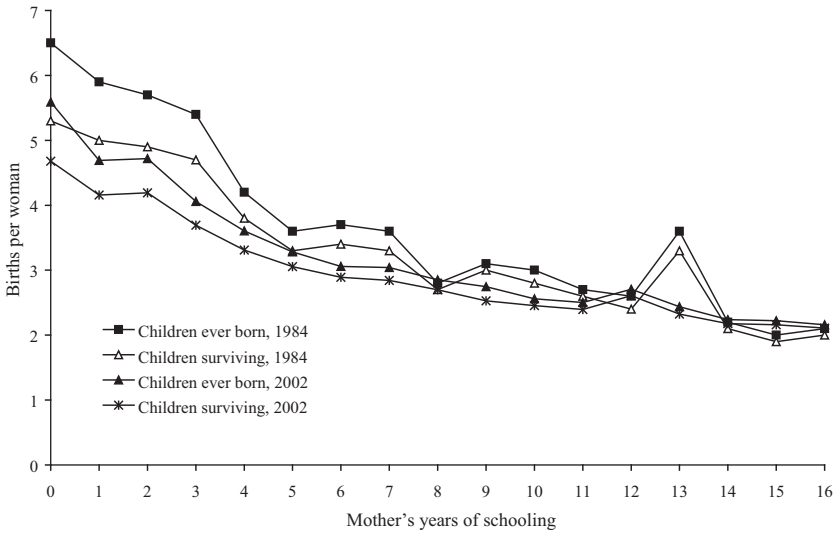
Brazil's fertility decline makes for a particularly interesting case study. It is probably the best example of a developing country experiencing rapid fertility decline in the absence of a major family planning effort. Brazil is also a country for which we have excellent census and survey data going back to 1960, making it possible to analyze the fertility decline in great detail. As indicated in Figure 5.10, Brazil's fertility decline was well underway by the late 1960s, and fertility fell rapidly in the 1970s and 1980s. This was a period in which the country was ruled by a military government that gave little support to family planning programs (Merrick and Berquó 1983; Martine 1996; Potter, Schmertmann, and Cavenaghi 2002). It is also noteworthy that the fertility de-

cline began during the rapid economic growth of the 1960s and 1970s but continued at a similar pace during the recessionary 1980s. Research suggests that increases in schooling, especially for women, played a major role in this decline (Merrick and Berquó 1983; Lam and Duryea 1999).

Lam and Duryea use the cross-sectional relationship between women's schooling and fertility to estimate the decline in fertility that would have resulted from increasing women's schooling prior to 1984. They estimate that increases in women's schooling could account for roughly 70 percent of the large decrease in fertility that occurred in the 1960s and 1970s in Brazil. Figure 5.11 shows the relationship between women's schooling and fertility in 1984 and in 2002. The 1984 relationship is taken from Lam and Duryea (1999); the pattern for 2002 is estimated using the 2002 PNAD survey, which includes roughly 10,000 women aged 45–59.[6]

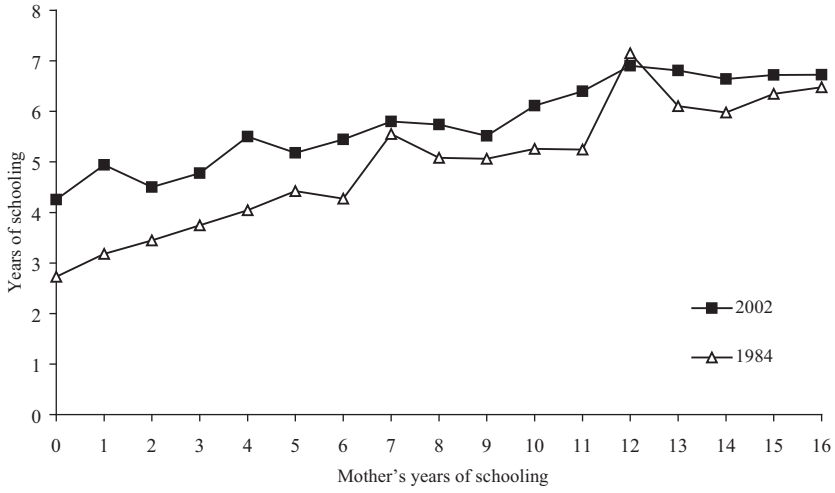
The mean number of children that had been born to women aged 45–49 fell from 5.0 in 1984 to 3.5 in 2002 (not shown).[7] This is a considerably larger gap than the varying distance between the two lines for

Figure 5.11 Number of Births by Years of Schooling, Women Ages 45–49, Brazil, 1984 and 2002



SOURCE: Author's estimates using Brazil's PNAD (National Household Survey).

Figure 5.12 Mean Schooling of 14-Year-Olds by Years of Schooling of Mother, Brazil, 1984 and 2002



SOURCE: Author's estimates using Brazil's PNAD (National Household Survey).

children ever born in 1984 and in 2002 in Figure 5.11. This indicates that the increased schooling of women, which shifts the distribution of women to the right along the horizontal axis in Figure 5.11, plays an important role in explaining the fertility decline. Mean years of schooling for women aged 45–49 rose from 3.5 in 1984 to 6.4 in 2002. Importantly, this involves a shift away from the lowest levels of schooling, the levels associated with the highest fertility.

The percentage of women aged 45–49 with zero years of schooling fell from 30 percent in 1984 to 14 percent in 2002, while the percentage going beyond the fourth grade rose from 24 percent to 53 percent. Given the strong relationship between schooling and fertility in Figure 5.11, especially at the lowest schooling levels, these shifts in the schooling distribution imply large declines in fertility.

Figure 5.11 also shows the number of surviving children by years of mother's schooling. Several features should be noted about the relationship between the number of surviving children, the number of children ever born, and years of schooling. First, there is the large gap between the number of children ever born and the number of children still alive

at the time of the 1984 survey for women with low schooling. Women with zero schooling, a large part of the sample, had lost 1.2 children on average, a mortality rate of 18.5 percent. Part of the high fertility of women with low schooling levels appears to have been a response to high infant mortality. Figure 5.11 also shows the large improvement in child survival as schooling increases: women with schooling of eight years or more had very few children die. These relationships suggest that as increased schooling leads to higher infant survival, women respond by having fewer births.

As noted above, it has been an empirical regularity around the world that falling fertility has been associated with increased investments in children's human capital. Parental schooling can play an important role in this relationship, as suggested by economic theories of quantity-quality tradeoffs. Figure 5.12 shows the relationship between mother's schooling and the schooling of 14-year-olds in Brazil in 1984 and 2002, using the same household survey data as was used in Figure 5.11. Figure 5.12 shows a strong positive relationship between mother's schooling and children's schooling, with an especially strong relationship at low levels of schooling. In the 1984 data, 14-year-old children whose mothers had 15 or more years of schooling (university completion) were more than three grades ahead of 14-year-olds whose mothers had zero schooling. The 2002 relationship shows a slightly flatter slope to this curve, although there is still a gap of well over two grades between the highest and lowest schooling levels.

Although Figure 5.12 gives the impression that there has been relatively little improvement in schooling between 1984 and 2002, there was in fact a large increase in mean schooling over this period. The mean years of schooling of 14-year-olds grew from 3.5 years to 5.4 years, a 54 percent increase. As can be seen in Figure 5.12, the increase in schooling of 14-year-olds, holding mother's schooling constant, is significantly smaller than this 1.9 year overall improvement. As with the fertility relationship discussed above, this indicates that the increased schooling of women is an important factor in explaining increased schooling of their children over this period. The improvements at the bottom of the schooling distribution are once again important, since moving women from zero to four years of schooling has a big impact on the schooling of their children. Lam and Duryea show that the strong relationship between parental schooling and children's

schooling continues to be observed when regressions are estimated with additional controls for variables such as region and urban or rural location, with the effect of father's schooling almost as large as the effect of mother's schooling.

While many factors, including the increased provision of family planning services, play a role in explaining the rapid declines in fertility in the last 40 years, improvements in child survival and in the schooling of parents clearly are key parts of the story. Brazil's case is particularly strong evidence of this, since there was very little increase in family planning. The fact that investments in children's schooling and health increased at the same time fertility declined is one of the most important signs of the changing behavior of parents, since it means that today's generation of young people is the best educated in human history. Given the importance that increases in human knowledge have had in helping the world survive the population explosion, it is reassuring to know that the next generation of adults will be even better educated than the generations that dealt with the challenges of the last 40 years.

CONCLUSION

The years from 1950 to 2000 form one of the most interesting periods of demographic change in history. The 1950s saw the annual growth rate of world population begin a dramatic increase that peaked at over 2 percent a year in the mid-1960s, followed by a return to the 1950 level of 1.4 at the end of the 1990s. The doubling of world population between 1960 and 2000 was by far the shortest doubling time in human history, a phenomenon that will almost surely never be seen again. This population explosion essentially played itself out within a half-century, and as it did so it presented an unprecedented challenge to the world's ability to feed itself and provide resources necessary for modern human existence.

This chapter has argued that the world has already survived the population explosion. While the demographic impact of the rapid population growth of recent decades will continue for several more decades, the population growth rate of the world will continue to fall rapidly, returning the world to the kind of growth rates seen in the early twentieth century and even earlier. During this population explosion the world

managed to increase per capita food production, decrease poverty, and reduce the prices of most commodities, both renewable and nonrenewable. This is an amazing accomplishment that we should not lose sight of as we move beyond the late twentieth century.

Understanding how the world survived the population explosion requires an understanding of both the demography and the economics at work during these decades of rapid population growth. Demographically, it is important to recognize that it was rapidly falling mortality that began the population explosion and that it was unexpectedly rapid falls in fertility that brought it to an end. The economics of markets, individual responses to incentives, and returns to human capital are important aspects of the story. The fact that per capita food production was 31 percent higher in 2003 than it was in 1961 reflects both innovations in agricultural technology and responses by farmers to economic incentives. The fact that an index of nonenergy commodity prices fell 54 percent between 1960 and 2000 reflects technological advances and the impact of international trade. And the fact that the world's total fertility rate fell from 5.0 to 2.8 between 1965 and 2000 reflects the rational responses of couples to increased child survival and increased parental schooling. Parents not only chose to have fewer children but also chose to invest more in the health and schooling of those children, making this current cohort of young people the best educated in history.

In considering issues of sustainable development and the world's ability to meet increasing resource pressures, the history of the past 50 years must be a source of optimism. At the same time, challenges remain. While world poverty rates fell impressively in recent decades, with the percentage of people living on less than $1 a day being cut in half between 1980 and 2001, poverty increased substantially over this period in Africa. Nor has Africa been able to increase food production fast enough to keep pace with population. Beyond that, this chapter has not dealt with the many environmental concerns that are often raised by those who are less optimistic about the world's future. These issues are critical, especially when markets may do a poor job of creating appropriate incentives, as in the case of ocean fishing or global warming. In considering whether the world will be able to meet these challenges of the twenty-first century, however, we should not forget how bleak prospects looked in the 1960s. The world's ability to survive the population explosion may be one of the most important lessons about human adaptability that we will ever receive.

Notes

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1. Estimates before 1950 are taken from the U.S. Census Bureau's "Summary Estimates," which are based on a number of historical sources (2003). Estimates and projections from 1950 to 2050 are taken from United Nations Population Division (2003). See Bongaarts and Bulatao (2000) for discussion of projections to 2050.
2. The growth rates in Figure 5.2 are based on estimates of the total population for each single year up to 2000. The figure shows three-year moving averages of these growth rates, which serve to remove some of the short-run year-to-year volatility. The growth rates for the period after 2000 are based on United Nations population projections for every fifth year (2000, 2005, etc.). For example, the growth rate centered on 2002.5 for the medium variant is the average annual growth rate implied by the U.N. medium variant estimates for the population in 2000 and 2005.
3. National accounts data are the aggregate data on measures such as GNP and industrial output that are produced by national statistical agencies.
4. Note that India is included in the "South Asia" series, in addition to being represented separately.
5. The actual value of replacement fertility depends on mortality rates between birth and childbearing, and thus is different for every population. The figure of 2.1 is a rough benchmark.
6. PNAD stands for Pesquisa Nacional por Amostra de Domicilios, or National Household Survey.
7. Note that most of these births would have taken place when these women were 20 to 35 years old, so this decline roughly describes the decline in fertility between the 1960s and the 1980s.

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