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The link between population growth and economic development is among the older issues in social science, particularly because of its association with the name of Robert Malthus. His famous *Essay on Population* of 1798 argued that population growth inevitably led to poverty – fundamentally, he claimed, because it would always outstrip the means of subsistence. Populations would always increase so that the supply of labour pressed on wages, to the point where they reached subsistence level. Beyond that point population would only be held back by war, starvation or disease, but people would remain poor. While in later editions Malthus modified his views considerably, his name is mainly associated with the thesis of his original *Essay*.

This association has hardly been helpful to our subject. Malthus's early views were linked to harsh social philosophies, and in the past anyone who believed that population growth had any kind of negative impact on development was commonly labelled as 'Malthusian', and often condemned as a result. Things have changed. Today there is a growing consensus that rapid population growth in poor countries under conditions of high fertility can have negative, non-Malthusian, consequences for economic and social development. But they are not necessarily large, nor are they irremediable. And Malthus was wrong about food supplies, which have consistently outgrown population globally and in most individual countries – with some, mainly African, exceptions.

Development influences population growth and vice versa. We will treat the issues separately, though very summarily with the impact of development on population.

Development and population

Fertility

For a long period in human history populations grew very slowly, with quite high fertility but also high mortality, and episodes of extraordinary mortality such as the Black Death, which killed one-third of Europe's population in the fourteenth century. The first key to lower fertility was usually improvements in mortality. People do not want just babies, but surviving children, and when child survival is low, families will 'insure' by

having large numbers of babies. Once confident of their children's survival, parents may begin to limit the number of children they have.

The first widespread decline in fertility occurred in France in the eighteenth century. It began to decline in Europe generally in the nineteenth century, commonly – though not universally – preceded or at least accompanied by declining mortality. The fact that historical fertility decline mainly coincided with increasing prosperity, and is lower today in better-off than in poorer countries, gives the (broadly correct) impression that economic development is associated with fertility decline. But it is very far from a simple relationship. On the contrary, while the decline usually starts with better-off, urban and educated parents, it can spread to those who do not have these characteristics. In the developing countries today there is an association between falls in fertility and mortality improvements, rising education (especially female education) and the spread of contraception. But in some countries today there is significant fertility decline among the uneducated and the poor (Bhat, 2002; McNay et al., 2003). At some point the pace of fertility decline often outruns that of the spread of its correlates (Van de Kaa, 1996).

Mortality

Much the same may be said of mortality improvement. Historically mortality has responded to the gradual disappearance of major causes of death – famines, epidemics, contagious diseases – as well as to more fundamental forces such as improving nutrition, hygiene and public health measures. On the whole until relatively recently curative medicine has been a weaker force. Again broadly there is an association between increasing prosperity and mortality decline, since prosperity typically brings with it the things that reduce mortality. But it is a far from straightforward process. Infant mortality in particular can respond to very specific interventions, and throughout history there have been long periods in different countries where living standards have improved but infant mortality has not, and conversely times when infant mortality has fallen without widespread improvements in levels of living. (See for example Woods, 2000.)

Mortality in general in developing countries has often fallen rapidly due to medical and public health interventions; many countries have achieved in a few decades the kinds of declines in mortality that took a century or more in countries that are now industrialized. For this reason they have experienced rates of population growth greatly in excess of those in the history of the industrialized countries. There is still, though, high mortality in many developing countries and this is a drag on development. A number of studies have shown that healthier countries grow faster (Easterlin, 1996; Bloom and Canning, 1999), and Robert Fogel (1994)

claimed that synergies between technological and physiological improvements in health account for about one-half of the economic growth in Europe over the previous two centuries. HIV/AIDS is taking a large toll in many countries, and has still to reach its peak in several. It too has a negative impact on development, often killing men and women in their prime working years, placing huge burdens on health services, and creating millions of orphans. It has been estimated that in the 1990s, AIDS reduced per capita annual growth in Africa by 0.8 percentage points. In the worst-affected countries the reduction in growth was one to two percentage points. After two decades, the economies of these countries would be about 20 to 40 per cent smaller as a consequence of AIDS (Loewenson and Whiteside, 2001).

Fertility decline itself contributes to improvements in mortality and health. Death in childbirth is still a significant cause of female mortality in many developing countries, and high fertility is often associated with higher rates of child malnutrition in the family.

Population and development

Macroeconomics

One of the major debates in development economics has been over the macroeconomic role of population growth. In the twentieth century the seminal work was Coale and Hoover's 1958 study using the example of India. It compared two paths for the economy, one with higher fertility than the other, and reached a powerful conclusion: not only was the growth of per capita income lower under the high-fertility variant, but also even the growth of aggregate gross national product (GNP) was lower. The result derived from two assumptions in their model: one was that the burden of dependency, the ratio of non-workers to workers in the population, was greater under high fertility and led to reduced savings; and the other was that investment had to be spread over larger numbers instead of raising the amount of physical or social capital per worker. This was called 'capital widening versus capital deepening'; that is, if the population were growing more slowly, the same amount of capital would be used to improve the quality of schooling or health services received by each individual, instead of being diluted by having to extend coverage to more people; or else there would be more or better capital for each worker in the workplace.

These findings were hotly disputed; attempts to measure the burden-of-dependency effect on savings suggested it might be quite small, and similar questions were raised about the capital-dilution argument. Most attempts to measure the effect of population on economic growth (either in the aggregate or per capita) suggested the impact was small or non-existent

(Temple, 1999) and empirical estimates were fragile, dependent on model specification and data used (Levine and Renelt, 1992). Recent studies have criticized Coale and Hoover's assumption that investments in education and health did not promote economic growth – these investments have been highlighted in the 'new growth economics' literature (for example Barro, 1997) – as well as their focus on short-run impacts of population and without consideration of longer-run impacts.

Research in the last two decades has brought a swing of the pendulum in the macroeconomic discussion. Bloom and Freeman (1988) and Blanchet (1991) showed that mortality and fertility declines had different impacts on economic growth, so models that considered only aggregate population were misspecified. A series of cross-country studies by Kelley and Schmidt (1996, 2001) followed. Their initial work indicated that the positive and negative effects of population probably offset each other in the 1960s and 1970s but that a net negative effect in the 1980s was likely. In their more recent work they conclude that about 20 per cent of economic growth over the period 1960 to 1995 can be attributed to mortality and fertility declines, with the larger contribution coming from mortality.

Rapid decline in population growth, and even more the dramatic economic growth in East Asia in 1960–85, gave a further boost to the study of population and development. The keys to the relationship were thought to be decreased dependency burden (commonly known as the 'demographic bonus') leading to higher savings and more investment in education. An influential study by the World Bank (1993) argued that a large proportion of that growth was due to improvements in education, in turn made possible by lower population growth. Although the magnitude of the contribution of education to increasing economic growth has been challenged, most models of economic growth now include education as a contributing factor. Analysis of the East Asian experience also focused not just on the short-run effects of population growth, as had Coale and Hoover, but also on the intermediate effects where a rising number of young people enter the labour force, and the long-run effects that occur as they retire. Savings (and wealth) rise in the intermediate period and although they may fall in the long run, overall the demographic bonus may account for as much as one-third of the rapid economic growth in East Asia (Bloom and Canning, 1999).

It should be noted that these recent studies do not show a relationship between the rate of population growth per se and economic growth; it is rather certain demographic features and the timing of their change which may matter: fertility, the age distribution and life expectancy. Some of the models incorporate simultaneous relationships, with economic growth affecting the demographic variables and vice versa, giving rise to virtuous

or vicious circles of rapid or slow growth (Bloom and Williamson, 1997; Bloom et al., 2000; Bloom and Canning, 2001). The 'demographic bonus', if real, does not confer an automatic boost to growth. Countries can use the bonus wisely or unwisely, as evidence from Asia shows. It translates into higher economic growth if supportive policies, markets and institutions exist. If they do not, then the bonus will be squandered.

Poverty

It is widely believed that more rapid population growth increases poverty by reducing real wages. However, as noted by McNicoll (1997), the relationship with poverty is 'neither obvious nor well established'. For example, Eastwood and Lipton (2001) identify at least 60 effects of population on poverty, and a recent study has questioned the assumption that an increase in the labour force (from an increase in population) necessarily reduces wages (Ahlburg, 2002). The poverty measure in these studies is generally income poverty, rather than a broader definition such as in Sen's capability approach (Sen, 1985).

There have been surprisingly few attempts to estimate the impact of population on poverty directly, and most have been at the macro level. Three studies of Indian states found a small positive impact of population growth on income poverty (van de Walle, 1985; Evenson, 1993; Chelliah and Sudarshan, 1999). In cross-country regressions Ahlburg (1996) found no relationship between population growth and poverty. Other similar studies found that the major variables explaining cross-country variation in poverty were the rate of economic growth and the degree of income inequality. In contrast, Eastwood and Lipton (2001) did find a considerable effect of population on poverty: 'The average (developing) country in 1980 had a poverty incidence of 18.9 per cent; had it reduced its fertility by 5 per 1000 throughout the 1980s (as did many Asian countries), this figure would have been reduced to 12.6 per cent' (p. 218). This estimate must be viewed with caution for, as DeHaan and Lipton (1998) have shown, the relationship between population and poverty varies considerably across regions, countries, growth sectors and policy environments.

At the level of the household, one must take care to identify the source of population change and the timing of the measurement of the association between population and poverty. If family size increases because of a birth, poverty may rise because more mouths are trying to consume the same amount of resources. For example, in a study of 211 agricultural households from 1975 to 1983 Gaiha and Deolalikar (1992) found that larger families were more likely to be poor at any given point in time, and also more likely to experience persistent poverty. But resources may not remain constant. Members of the household may increase their labour

supply or leave the household, assets may be sold, or the family may receive income from relatives. All of these effects (and the many more noted by Eastwood and Lipton) influence the estimate of the relationship between population change and poverty. The timing of the measurement of the association is also important. Children may be the best investment the poor can make for their old age, so that increasing current household size may increase poverty in the short run with the expectation that it will reduce poverty in the long run – though this expectation may be defeated if children die early, fail to become gainfully employed, or fail to contribute income to the household. While some attention has been paid to the impact of an additional birth on poverty at the household level, much less attention has been paid to the impact of a death on poverty. The death of an adult may increase the likelihood of the family becoming poor unless there are offsetting factors, such as increased resources flowing in from relatives or increased work by other family members. The empirical evidence suggests that household income and asset ownership decline with the death of an adult. For example, it was estimated that in Botswana from the mid-1990s to the mid-2000s the poverty rate would increase by up to eight percentage points due to AIDS and average household income would fall by 10 per cent (Loewenson and Whiteside, 2001). The negative impacts of a parental death can have far-reaching implications. In a study of ten African countries, Case et al. (2004) found that orphans were less likely to be enrolled in school than non-orphans. This reduction in human capital formation raises concerns about higher poverty and lower growth in the next generation.

While the study of the direct relationship between population change and poverty has proven to be quite difficult, there have been a large number of studies of the effects of population change on aspects of well-being other than income poverty. There are quite a number of household studies which show reasonably strong correlations between measures of fertility and measures of women's and children's health and survival (Montgomery and Lloyd, 1996), and between number of surviving siblings and children's education, especially for female children (Lloyd, 1994). While these authors accept the fact that their studies can be criticized on methodological grounds, they claim that they do identify underlying causal connections.

Environment

Energy, transport and industry

The main sources of air, soil and water pollution are – apart from agricultural chemicals – energy, transport and industry. As developing economies grow, they substitute modern forms of transport and energy production for

traditional ones: cars, trucks and trains replace horse and bullock transport, and coal, gas and oil take over from vegetable matter and animal products as fuels. Manufacturing, processing, heavy industry and services become the dominant production sectors, and even agriculture uses more chemicals and mechanization. All these release chemical pollutants and particulate matter into the atmosphere, soil and water courses.

But what is the role of population? In most of these productive activities it is mainly one of derived demand, and it frequently plays a relatively modest part. The economy and the pattern of development are the powerful factors, with commercial energy use and modern forms of transport often growing at several times the rate of population growth. (Dyson et al., 2004 gives many examples for India.) At the same time, population is itself an underlying demand factor: as populations grow there are more people and goods to be transported, more demand for the products of manufacturing and the like. How these factors interact is no simple matter.

A common mistake is to take the per capita consumption for, say, energy, and multiply by population growth to project energy consumption. Per capita consumption will change as population and the economy grow together; and a key aspect is the household. Since there are economies of scale in household energy consumption, the pattern of household formation will greatly affect demand. O'Neill et al. (2001) show the very considerable difference between household-based and population-based assessments of energy demand. There are of course also important scale factors at levels beyond the household.

In addition, technology changes. Most industrial processes are subject to technological change which can reduce emissions, and the cost of reducing them falls over time (Anderson 2001a and 2001b). Modelling the likely output of various pollutants over time, Anderson (2004) has shown that the early introduction of 'clean' technology far outweighs the influence of population growth on a variety of emissions in energy, industry and transport. The one main exception to such optimism is the small-scale sector, which can be highly polluting, and where clean technological progress is less apparent.

Undoubtedly population growth plays a part but how important this is depends upon other factors. If cleaner technologies continue to be developed, and go down in price at past rates, societies in the main can enjoy higher standards of living and modern economic growth while protecting their environments from chemical pollution. To say that they can, however, is not to say that they will. Where 'dirty' technologies are already installed and the investments have significant economic lives left, or where the costs of cleaner technologies are such that government policies are required to

ensure their introduction, but these policies are not in place, the combination of modern economic growth with rapidly growing populations can indeed be a recipe for rising pollution.

The urban environment is subject to much the same analysis. Population growth adds to demand for environmental resources, but often less slowly than the pace and pattern of economic growth. Waste is a particular problem for cities. There is much valuable experience from developing countries in waste management, which can often be a paying proposition. Municipal finances are, however, often weak, and planning capacity limited. Very few cities in the developing world have coped satisfactorily with the combination of economic growth and population growth, the latter often at very high rates, especially where natural growth is added to by inward migration from rural areas. Extremes of income inequality only add to the difficulties. The problems are not unmanageable in principle, but are frequently poorly managed in fact.

Water

Water differs from other environmental issues. The growth of demand for energy, manufactures and modern forms of transport is only partially affected by population growth, and there are commonly technological 'fixes'. The demand for water, though, is strongly influenced by population growth, and the role of technology is limited. Every additional person requires their own water supply; but more importantly for water, they have to be fed, and in economies that are self-sufficient in agriculture, about four-fifths of water demand comes from agriculture, while residential use takes up about 5 per cent, the rest being required for industry and ecological services. If such economies wish to remain self-sufficient in food, they either have to use more water, or achieve greater water efficiency. (Exporting other goods and importing food is of course an option. It is tantamount to importing water, and several countries are likely to be forced to go down this route.)

In many countries, water is already scarce, at least regionally, or seasonally, if not nationally or chronically. Water pollution and climate change may also be reducing availability. While there are potential technological means for conserving water and increasing the amount of crop yield per unit of water, they typically offer relatively small gains. It may be that desalination of seawater will become more economic in future; at present it is only economic where alternative sources are highly expensive. But that apart, and then only for areas close to the sea, there is little alternative to water regulation and pricing. These are often feasible, but politically and socially difficult. For such reasons, water is likely to be the greatest environmental challenge of population growth.

Ecology

Studies undertaken in the 1980s indicated that population growth may have had a detrimental impact upon renewable resources such as rainforests and fishing areas. Since the mid-1990s researchers have reached more conditional conclusions. While increasing numbers inevitably place pressure on such resources as forests, grazing land, animal habitats and the like, it would be wrong to 'blame' population growth for much of the diminution in these resources that has taken place all over the world. Much depends on the nature of management of the resources, development of property rights, development or adaptation of technology, land tenure relations, population mobility, and markets and other institutions and organizations. Many traditional systems of management have been successful in conserving natural resources over long periods, even with growing populations. There have been well-documented cases in Africa where increasing population density and labour availability have led to sustainable agricultural intensification, rather than degradation. Such cases have usually been where land and tree tenure have been satisfactory, good market conditions for produce have been available, and tax regimes have not punished success (Tiffen et al., 1994). But the opposite has also been the case, in Africa and elsewhere (Baland and Platteau, 1996; Jodha, 1986). Traditional systems have often been better at sharing resources equitably than in raising their productivity to match rising numbers.

Population growth is likely to lead to the degradation of resources where there is open access to the resource and real rural incomes are stagnating or falling, land tenure is insecure and there is lack of access to credit, where alternative forms of employment are lacking, and where low levels of education and skill limit labour mobility (Panayotou, 1996). This is not to say that population growth typically helps; on the contrary, *ceteris paribus* there will usually be less strain on resources if populations grow slowly or not at all.

This literature can be set in a wider account of a potential beneficial influence of population growth when it leads to agricultural intensification and improved technology, and economies of scale. Should this occur, population growth could be a positive factor even macroeconomically. Boserup made a strong claim for the importance of these effects in a much-cited study (Boserup, 1965). But while having valuable insights on such a role for population in the long sweep of history, her account did not deal with more negative experience in the shorter term, and Boserup herself changed her views in later work (Boserup, 1981). It is perfectly clear from much African experience that population growth there has commonly failed to induce countervailing technological change in agriculture.

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