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DISCUSSION PAPERS

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Economic Development and the Demographic Transition: The Role of Cumulative Causality

David E. Bloom
David Canning

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For information contact:
CAER II Project Office
Harvard Institute for International Development
14 Story Street
Cambridge, MA 02138 USA
Tel: (617) 495-9776; Fax: (617) 496-9951
Email: caer@hiid.harvard.edu

**Economic Development and the Demographic Transition:
The Role of Cumulative Causality**

**David E. Bloom
Harvard School of Public Health**

and

**David Canning
Queen's University of Belfast**

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Abstract

We view the links between demographic change and economic growth as an interacting system with feedback in both directions. This framework implies that even relatively small exogenous shocks can ultimately have a powerful effect on income if the endogenous linkages between population structure, capital accumulation, and income are sufficiently strong. For example, public health measures that increase life expectancy can lead to an increase in savings and education rates, thereby setting off economic growth. Rising incomes can lead to a reduction in fertility that can trigger a virtuous spiral of falling dependency ratios, greater investment in education, and further economic growth. This virtuous spiral, linking increasing life expectancy, rising incomes, and falling fertility, must eventually come to an end. But it can, in the interim, account for long periods of sustained improvement in living standards in developing countries, especially in the presence of a policy environment that is favorable to enjoying a "demographic gift."

David E. Bloom
Harvard University
14 Story Street
Cambridge, MA 02138
Tel: 617-495-2165
Fax: 617-495-8685
dbloom@hiid.harvard.edu

David Canning
School of Management and Economics
Queen's University Belfast
Belfast BT71NN, Northern Ireland, U.K.
Tel: 44-1232-273281
d.canning@qub.ac.uk

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1. Introduction

In recent years, studies of economic growth have underemphasized the impact of population issues. Giving demographic variables a prominent place in a framework that treats economic and social development as a complex system considerably strengthens our understanding of economic growth.

There is now strong evidence that demographic change has a major impact on the course of economic growth. Rising life expectancy tends to increase savings and education rates, boosting investment in physical and human capital. The key element is that a longer horizon for the individual makes investing in education more worthwhile and makes saving for retirement essential. However, in addition to this long-run effect of increased life expectancy, there is a significant transitional effect as countries increase their life expectancy. The mortality decline that underlies an increase in life expectancy is not spread evenly across the population. Initially, it is concentrated among the most vulnerable sections of the population, infants and young children, creating a "baby boom".

Subsequently, fertility rates fall, creating a large cohort of young people that steadily works its way through the age distribution. Several factors come into play in this fertility reduction. One is that the reduction in infant mortality in itself reduces the number of births required to achieve a desired number of surviving children. Once economic development gets underway, reductions in fertility can be very rapid. Urbanization and industrial production tend to reduce the number of children to a household relative to rural agriculture, where children's labor may be significant. The development of financial systems can reduce the parents' dependence on children for support in their old age. In addition, the increasing value of women's time, associated with high levels of female education and labor market participation, increases the relative cost of children. These changes in the demand for children can produce very large effects on fertility rates if contraception is available. The sudden increase in surviving children, followed by this reduction in fertility, creates the baby boom.

When this baby boom cohort enters the labor force, it produces a period of 40 to 50 years in which there is a relatively high ratio of workers to dependents, thus creating a potential boost to income per capita. Eventually, this effect disappears as the cohort ages, but it can have a notable significance while it lasts. In 1965-1990, for instance, the working-age population of East Asia grew nearly ten times faster than the dependent population, a substantial factor in creating the East Asian "miracle".

While we argue that demographic change has important economic implications, it is also clear that fertility and mortality rates follow income levels. In other words, causality runs in both directions, from the economy to demography and from demography to the economy. The interaction is a dynamic process, with each side affecting the other. This makes it imperative to understand the causal links in each direction and not just look at correlations.

The relationship between demography and economic growth is not necessarily constant over time. The very rapid demographic transition that we see today in developing countries is a fairly modern phenomenon. Before 1870, birth rates within marriage were uniformly high, independent of economic conditions,[1] though in Europe birth rates did respond to economic conditions through variations in the marriage rate (Wrigley and Schofield 1981). However, after 1870, economic conditions had very large effects on fertility rates throughout Europe, reflecting widespread availability and cultural acceptance of contraceptive techniques (Coale and Watkins 1986). This sensitivity of fertility rates to economic conditions now seems a worldwide phenomenon, though the pace of fertility change varies from country to country.[2]

Equally, income levels have an effect on mortality rates. Before 1800, income

1 The exception was in France, where contraceptive practices were common from around 1790.
2 For example, rapid fertility decline in Ireland only started in 1980, much later than in similar European

levels seem to have had little effect on mortality rates, with any nutritional advantages of higher income being counteracted by the high levels of urbanization, and associated infectious disease, in high-income countries. The first half of the twentieth century saw the emergence of a very striking reduction in mortality rates in developed countries. In the second half of the twentieth century, mortality reductions have been extended to developing countries. Mortality rates still fall with income, but the effect is now much less pronounced. Over the last fifty years, there has been a substantial increase in life expectancy throughout the world, even in countries that have been economic failures. The reductions in mortality in developing countries therefore seem to be due mainly to better health care, particularly improved public health measures, with economic growth being a somewhat less important factor.

The Malthusian model (Malthus 1798) saw population pressure as having an essentially dampening effect on economic growth. We agree with this view as it relates to a high birth rate and a high youth dependency ratio. However, the world population explosion in the twentieth century has not been because of an unusually high birth rate. In fact, birth rates in the twentieth century were much lower than before. A reduction in mortality rates and an increase in life expectancy have caused the population explosion. In this paper, we argue that population growth from increased life expectancy generally has positive economic effects and must be distinguished from the usual negative effects of a high birth rate.

Changes in health technology, particularly the cheap and effective control of infectious diseases, have produced an enormous change in the demographic structure of modern populations. This demographic change has a positive exogenous effect on economic growth, noticeable in its effect on savings and education rates. Once growth is underway, an endogenous multiplier effect may develop, with positive feedback between economic growth and reductions in fertility. This produces rapid economic growth,

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countries, and is probably due to the legalization of contraception in 1979.

especially during the baby boom cohort's working lives when the ratio of workers to total population is exceptionally high. This can allow substantial gains to be achieved in a short period of time, with an economy switching rapidly from an undeveloped to a developed state.

Historically, the demographic transition in Europe took around two hundred years. Steady improvements in health from 1800 were matched by slowly rising living standards and, after 1870, declining fertility. The same process in East Asia has been completed in around fifty years, from the end of the Second World War to the present time. Conversely, there is the possibility of being held down by a poverty trap, in which high mortality rates and high fertility keep incomes persistently low. Sub-Saharan Africa has recorded impressive increases in life expectancy over the last fifty years, though from a very low base. Despite these health improvements, the persistent problem of infectious disease in Africa, notably malaria, tuberculosis and now HIV/Aids has kept life expectancy in the region significantly below the levels found in other developing countries.

Fertility in Africa remains exceptionally high, and incomes consequently stagnate. As long as income levels and female education remain so low, and agriculture remains the dominant sector of production, it is hard to see fertility falling in Africa. The problem is high desired fertility, not lack of contraception. This high fertility combined with low life expectancy creates a very high youth dependency rate, giving low levels of workers per capita, low savings rates, and low school enrollment rates.

A key question for the future is whether improvements in health and life expectancy are required before economic success in Africa is possible. Our view is that economic growth is a system with many different entry points. Technological advances, demographic change, or capital accumulation can all give economic growth an important initial impetus. Western Europe, for instance, provides an example where income growth triggered a demographic transition. In East Asia, however, it seems that advances in public health may have triggered a demographic shift that, in turn, generated the dramatic economic growth of the latter half of the twentieth century.

Section 2 begins with an overview of the traditional role demography has played in studies of economic growth. In section 3, we lay out and explore the "new demography" that suggests that demographic variables may be much more important than were traditionally thought. Section 4 addresses the size, speed, and causes of the demographic transition in developing countries. In section 5, we examine the feedback between demographic change and economic development, and the issues of cumulative causality and poverty traps. In section 6, we discuss the policy implications of our analysis.

2. The Role of Population in Economic Growth

Approaches to understanding economic growth have varied widely, dating back at least as far back as Adam Smith. For many years population pressure was seen as a key, if not *the* key, force determining income levels. Thomas Malthus (1798) conjectured that population growth, if unchecked, would be geometric, due to our inability to limit the number of our offspring. In a world with fixed resources for growing food, and slow (arithmetic) technical progress, food production would quickly be swamped by population pressure. The available diet would then fall below the subsistence level, until population growth was halted by a high death rate.

This model implies that sustainable income growth cannot be achieved. While technological advances or the discovery of new resources will increase income per capita temporarily, this will trigger rapid population growth, forcing income levels back down to subsistence levels, according to this model. This bleak outlook led economics to be labeled "the dismal science."

For many years, this view seems to have been a reasonably good description of how the world actually worked. The introduction of high yielding crops and new technologies in agriculture, such as irrigation in China and the potato in Ireland, accompanied vast increases in population, with little or no increase in living standards. Up until 1700, income gaps between countries were fairly small, and even by 1820 the "advanced" European countries enjoyed real income levels only about double those found in Africa, Asia, and Latin America (Maddison 1995).

However, the phenomenal sustained economic growth of many countries over the last three centuries cannot be explained in the Malthusian model. We now live in a world where growth in living standards is so commonplace as to be the norm. In the industrialized countries, population pressure is not seen as a barrier to growth. Indeed, the opposite is true: the threat is a low birth rate and too few workers relative to the number of retirees.

Although the Malthusian trap is not operating at present in developed countries, the situation is less clear in the developing world, where some argue that increases in population density will depress income per capita in the long run. In addition, population pressure and economic growth may lead to the depletion of natural resources, creating environmental pressures that act to increase poverty. This "population pessimist" school of thought continues to uphold the Malthusian premise that population increases reduce economic well being (see, for example, Coale and Hoover 1958, Ehrlich 1968).

An alternative view is that a higher level of population actually increases income per capita. The pressure of increasing population may inspire the invention or adoption of more efficient technologies (see Boserup 1981, Simon 1981). There are two other mechanisms through which increases in the size of the population may have a beneficial effect on incomes: an increasing number of geniuses, who are assumed to be a constant proportion of the population, subsequently increases the stock of scientific knowledge; and increasing returns to scale (see Kuznets 1967 and Simon 1981).

A middle ground, which has come to be known as "population neutralism", asserts that population growth rates do not matter. This theory arises from the neoclassical growth model (Solow 1957), which attempts to explain the historically unprecedented economic growth seen since the industrial revolution. The key assumptions in the simple Solow model are that population behavior is determined outside the model and that all factors of production are reproducible. Solow argued that technological progress and savings can raise income levels in the long run, since any increase in income generated has no feedback into population growth. The absence of a fixed factor means that the level of population has no effect – countries with higher populations simply need to accumulate more capital.

The Solow model shifts the focus away from the size of the population and concentrates, instead, on the rate at which the population is growing. Population growth *does* depress income levels as existing capital is shared among a greater number of workers. However, this effect is only temporary. As the population stabilizes, capital adjusts to the new population level.

These effects have been examined empirically in dozens of studies over the past half-century (see, for example, Coale 1986, Bloom and Freeman 1986, Kelley 1988, and Kelley 1995). Some of these studies focus simply on cross-country and time-series correlations between population growth and economic growth. Others use multiple regression analysis to estimate the correlation between these variables, holding constant the effect of other factors that might influence economic growth. Although the empirical specifications vary quite widely, most of the studies done over the past fifteen years report a similar finding: population growth has a small and statistically insignificant effect on the rate of economic growth.

This empirical result has had a considerable influence on policymakers in developing countries and on the international development community. It has also steered economic development literature away from serious consideration of demographic factors as a major factor in economic growth. We believe that it is now appropriate to challenge population neutralism and to create a more carefully nuanced theory. This theory relies on moving beyond the growth of the population as a whole and placing an increased emphasis on the age structure of the population.

3. The New Demography and Economic Growth

The importance of the age structure of a population can be seen in various ways. Perhaps the simplest is to consider separately the effects of fertility and mortality on economic growth, and then to compare these with the effect of population growth as a whole. The population growth rate is, of course, equal to the crude birth rate minus the crude death rate, plus net immigration. In what follows, we ignore the effect of international migration; while migration is important in a small number of countries, for most countries it is not a significant factor.

Bloom and Freeman (1988), Barlow (1994), Brander and Dowrick (1994), and Kelley and Schmidt (1995) find that while the overall population growth rate has little effect, the birth rate and death rate entered separately into growth regressions do have effects on economic growth. Countries with low death rates and low birth rates tend to do well in terms of economic growth, while those with high death rates and high birth rates do badly. However, both types of countries could have similar population growth, so emphasizing this as a factor could mask important changes. It is also quite possible that population growth arising from increases in the birth rate may have a quite different effect on the economy than that arising from decreases in the death rate.

In practice, theorists tend to treat birth and death rates separately when they are thinking about population pressure. Most focus on reductions in fertility as the way to decrease population growth, with few arguing that the answer is to raise the death rate.

However, during the Irish famine of 1845-1850, economists did advise against famine relief on Malthusian grounds[3]. They argued that famine relief would simply prolong the agony, as deaths were needed in order to allow survivors' incomes to rise to subsistence levels. Even in the Solow model, a high death rate has the same beneficial influence on income as a low fertility rate.

There is some evidence to support the view that high death rates lead to an income boost. Herlihy (1997) and Hirshleifer (1987) argue that the plague of 1348-50 in Europe reduced the population by over 25 percent, but caused a spurt in living standards due to an increase of resources, particularly land. However, it should be equally obvious that this view does not hold true in current circumstances. There are few people arguing that the AIDS crisis now facing many developing countries will lead to a rise in living standards (Bloom and Mahal 1997).

The basis of Malthusian pessimism has proved weak on two grounds. We have the emergence of low birth rates and also exponential (rather than, as Malthus assumed, arithmetic) growth in productivity through technical progress. The fundamental structure of production has changed: technological progress has led to an emphasis on industry and services, and lowered the importance of agriculture. Traditionally, it is in agriculture that the problem of fixed resources looms largest. Even here, though, the "Green Revolution" led to substantial improvements in productivity, while biotechnology promises much for the future. In the 1970's, there was a great deal of worry about fixed natural resources of raw materials at the global level, though this problem now seems less urgent. The main argument supporting the modern Malthusian view today revolves around the environment: increases in population may lead to irreversible damage to the

[3] Jonathan Swift (1729) satirized these views a century before the Irish famine in his "Modest Proposal for preventing the children of poor people in Ireland, from being a burden on their parents or country, and for making them beneficial to the publick". Swift proposed that infants should be eaten at the age of one, relieving population pressures, increasing the ratio of working age people, and providing a valuable resource.

environment through global warming and depletion of the rain forest.

The importance of age structure can be seen still more clearly when one considers the difference between the impact of the birth of a baby and the survival of a 30-year-old worker. Each adds one to the population, but will have very different economic effects. We explore three mechanisms: (1) a labor market effect; (2) an effect on savings and capital accumulation; and (3) an effect on educational enrollment and human capital.

The labor market effect looks at how populations with different age structure have more or less people available to work. Clearly, having a greater number of workers in the prime working age group relative to dependents (the young and the old) raises inputs into production per capita, and so raises income per capita. A reduction in the number of young or old should lead to a proportional improvement in income per capita. An increase in the numbers of workers, meanwhile, is likely to dilute the amount of capital available per worker and lead to less than proportional gains, at least in the short term.

Exploring this area empirically presents some difficulties. Births, of course, increase the number of youth dependents (for a period at least) and it is possible to measure whether these depress income per capita. The effects of death rates, however, are more difficult to ascertain; is the person dying young, of working age, or elderly? A more direct way of looking at labor market effects has been by adopted by Sheehey (1996), Bloom and Williamson (1997), Williamson (1997), Bloom and Williamson (1998), Bloom, Canning, and Malaney (1999), and Kelley and Schmidt (1995, 1999). This uses the dependency ratio directly, rather than birth and death rates separately. It then compares the effect of the growth rate of working age population against that of the total population. From this approach, significant age structure effects on economic growth have been demonstrated.

It is important to realize that these changes cannot simply be explained by the "accounting effect", whereby economic growth results purely from the growth in the number of workers. If income per worker were steady, there would be a one-for-one effect of increasing workers per capita. Bloom and Williamson (1998) find a much larger effect on growth over a twenty- five year period from reductions in the dependency ratio than suggested by the accounting effect. Furthermore, Bloom, Canning, and Malaney (1999) show this effect persists even if we exclude the reverse causality from economic growth to the age structure.

The accounting effect seems to be joined by a strong behavioral element, though the mechanisms by which this is achieved are unclear. One possibility is that reduction in dependency ratios may free home-carers to enter the formal labor market. As people shift from unpaid work in the home to paid work in the formal labor market, measured income will rise. Note, however, that this is more of a measurement issue than substantive increase in welfare.

Changes in the age structure of the population may also reflect changes in the ages at which people are dying, which in turn is an indicator of their health. By including age structure effects, therefore, we are also including a proxy for the overall health of workers. Strauss and Thomas (1998) have shown that healthier workers are more productive, so as death rates fall, not only do we have more workers, but we also have more productive workers.

The savings and capital accumulation effect is the second mechanism through which age structure has an impact on economic growth. The East Asian example is instructive, with its exceptionally high rates of physical and human capital accumulation seen as a major factor behind its economic success (see Krugman 1994, Young 1994, 1995). If this is so, the question remains as to why East Asian savings and education rates were so much higher than in other developing countries. In fact, while savings rates in East Asia were remarkably high, education levels in Latin America are comparable with those in East Asia, while sub-Saharan Africa has made substantial progress in education, despite its low income level.

First, it is important to remember that higher savings do not necessarily translate into higher local investment. With completely open international capital markets, only worldwide demographic factors should have an impact on worldwide investment, with investment always flowing to where it can find highest returns. Markets are far from perfect, however, and there is strong evidence that national savings and national investment are roughly equal.

Given that savings facilitate local investment, the life-cycle hypothesis argues that age will have an impact on saving rates. This assertion is modestly backed by data from household surveys (see Paxson, 1996 and Deaton and Paxson, 1997), which show peak savings rates among people of around 45 years of age. There is also a dip in savings rates for people in their early thirties, which may be due to the consumption needs of people with young families, as suggested by Coale and Hoover (1958).

However, even very old people save a significant proportion of their income. This contradicts the simple life cycle model, in which people save when young, and consume their savings when old. The old may be saving to leave bequests to their children, or because the age of their death is uncertain and they are protecting themselves against using all their savings before they die. The variations in savings rates by age are therefore not large, and by themselves cannot account for large swings in saving rates. Deaton and Paxson (1998) find that if the amount people save at a specific age is assumed to remain constant, then changes in the age structure can account for only a small proportion of Taiwan's very large rise in the savings rate over the last thirty years.

The relationship between age structure and aggregate savings has been studied extensively (see Leff 1969, Mason 1981, 1987, Webb and Zia 1990, Kelley and Schmidt 1996, Higgins and Williamson 1997, and Higgins 1998). These studies take into account changes in the distribution of income between generations, as well as shifts in the population's age structure. Higher income for age groups that have higher savings rates will increase aggregate savings, for example. In this way, researchers can show significant age structure effects, particularly when they take account of expected economic growth, which tends to raise the lifetime expected income of the young relative to the older generation. While these studies find significant effects of age structure on aggregate savings, the magnitude of these effects is quite small and cannot explain the very rapid increases in savings we have seen in East Asia.

In recent work, Mason (1998) has proposed a different demographic mechanism for explaining the increase in savings rates in East Asia – a very rapid increase in life expectancy. If the retirement age is constant, this creates a greater need for retirement income and may lead to higher savings rates at all ages for those in work. A simulation model of this effect for the Taiwanese economy, calibrated using plausible parameter values, explains most of the rapid increase in observed saving. Importantly, this is a temporary effect, which will only last for one generation. The sudden increase in life expectancy makes the young save at high rates, while previously low level of life expectancy means there are few old people in the population who are spending their savings. As time passes, aggregate savings return to equilibrium as the savings of the young is counterbalanced by the spending of the old . Aggregate savings in East Asia in the next fifty years are therefore likely to become much more like those seen in Western Europe and North America today.

One caveat to this approach is that it assumes that the retirement age is fixed. A reasonable argument could be made that higher life expectancy should lead people to work longer, postponing retirement. If this happens, there is no need for savings rates for workers to rise. However, empirically, there is a tendency for life expectancy to rise over time, while average retirement ages tend to fall. It seems unlikely, therefore, that demand for higher retirement savings is being met by a longer working life. In addition, Kalemli-Ozcan, Ryder, and Weil (1998) show that, in theory, the optimal response to longer life expectancy, particularly when it is rising from low levels, may be to retire earlier. He argues that when life expectancy is low, death rates are high, and it is optimal not to plan for a retirement one has a small chance of reaching. People in low life expectancy countries may simply work indefinitely and not take retirement. As life expectancy rises, however, the prospect of reaching old age becomes more likely and planning for retirement at a future, and perhaps fixed, date becomes sensible.

The story that life expectancy and the need for retirement income mainly drive savings rates is plausible, and is likely to be an important part of the wider picture. This explanation needs to be tested against alternative explanations, however. For example, reductions in fertility and increased labor mobility may increase savings rates, as people are unable to rely on their family to supply old age security. Non-demographic explanations may be important, too. For instance, the development of financial markets and regulations aimed at protecting depositors may be needed in order to encourage people to save. Further study is clearly needed to understand how important the role of age structure is on investment and to identify different mechanisms more precisely.

Finally, we turn to the third possible mechanism: the effect of demographic changes on education. A high youth dependency ratio may reduce parents' ability to finance educational investments. There is some microeconomic evidence showing a negative effect of family size on school enrollment rates and educational attainment (see Knodel, Havanon, and Sittitrai 1990, Rosenzweig 1990, Knodel and Wongsith 1991, and Hanushek 1992). Cheng and Nwachukwu (1997), meanwhile, attempt to find a causal link from education to fertility in Taiwan, but instead find evidence that the causality runs the other way, from fertility to education rates. However, the evidence is not universally all in favor of this hypothesis (Kelley 1996) and, despite its plausibility, one should view it as a conjecture rather than an established fact.

Longer life expectancy may also affect rates of return to education, a possibility examined by Meltzer (1995) and Kalemili-Ozcan, Ryder, and Weil (1998). The value of education depends on future earnings gains which can only be realized if a person lives long enough. Psacharopolos (1994) finds that estimated rates of return to education are broadly similar across countries. However, these estimates are calculated under the unrealistic assumption that people are infinitely long-lived (see Mincer 1974). Kalemli-Ozcan, Ryder, and Weil (1998) have shown that having a finite lifetime, with uncertain time of death, can have a significant impact on the rate of return to education. Meltzer (1995) uses empirical age-specific mortality profiles to calibrate the effect of mortality on the rate of return to education and goes on to argue that enrollment rates are quite sensitive to the rate of return. Behrman, Duryea and Szekely (1999) find that life expectancy is a robust predictor of school enrollment rates in a cross-country study. While it is clear that mortality rates will affect the rate of return to education, the magnitude of this effect on school enrollment rates needs further study.

Taken together, these three mechanisms suggest that reductions in the death rate, particularly the death rate of adults, have a significant positive effect on economic growth. Reductions can increase the labor force per capita, generate higher levels of savings for retirement, and increase the returns to education. Eventually, a low death rate leads to a higher proportion of old age dependents, but this need not be a drain on income per capita if old people live off their accumulated capital, and is even less of a threat if they continue to save. In fact the presence of an old generation living off their capital increases the wages of young workers, whose productivity rises due to the high level of capital intensity. Of course, this rosy picture may be reversed in a pay-as-you-go pension system where the old live off transfer payments from the young and consequently represent a burden on those working (see Bloom and Williamson 1997).

On the other hand, high rates of population growth due to high fertility or low infant mortality may depress the growth of income per capita: they can increase the number of people to be fed, clothed, and housed in the short run, at least, while adding little to the productive capabilities of the economy. In agricultural settings, children can work from a young age and may represent a net income gain for parents (Caldwell 1982).

This may help explain the high rate of desired fertility in Africa. However, in more urban settings, children usually represent a net cost to their parents.

While the new demography focuses on age structure, it also includes developments on the effect of population density with respect to resource constraints and economies of scale. Most studies find population density has little effect on long-run economic growth; the success of countries with low population density such as the United States and Australia is matched by successes in some high density countries such as Japan, and particularly Singapore and Hong Kong.

While population density does not seem very significant averaged over all countries, Gallup and Sachs (1999) and Bloom and Sachs (1998) find that high population density does seem to promote economic growth in coastal regions, and conversely, to impede growth in inland areas. Coastal regions (those near the sea or navigable rivers) have greater access to trade routes and can relieve resource constraints quite cheaply by exchange with other countries. They then exploit the scale economies that come from specialization, without the impediment of local resource constraints. For example, Singapore is so densely populated that it needs to import not only food but also fresh water, but this has not seemed to impose any real resource constraint on its growth.

This result can be compared to what we know about the income advantages enjoyed in cities relative to rural areas. Cities essentially enjoy the benefits of specialization while acquiring raw materials through trade. Since trade is cheaper by sea or river, large cities tend to be located on coasts or rivers, or near raw materials with high transport costs. Countries, too, benefit from the same advantages when their location is favorable and they are open to trade.

In a world of low transport costs and free trade, the natural resource constraint and Malthusian problem occurs only at a global level. While coastal countries may find high population density beneficial, inland areas may face the Malthusian problem. Specifically, trade may be more costly, causing a greater reliance on local resources (Limao and Venables (1999). This, in turn, may limit their ability to enjoy economies of scale and specialization, both through their lack of access to markets and the constraints of local resources. Interestingly, there is evidence that an abundance of resources can actually impede growth. When natural resources, other than land, are studied, there is evidence that countries with greater natural resource abundance per capita do worse in terms of economic growth (Sachs and Warner 1995). While abundance of natural resources clearly raises *potential* wealth, in practice, it may reduce average income by generating rent-seeking activities that may benefit the individual but add nothing to total output. People may attempt to benefit from the royalties on the natural resource, rather than undertake productive employment; more time is devoted to fighting over the division of the pie than creating the pie. Natural resource abundance may also lead to high exports of raw materials, promoting exchange rate overvaluation and thereby reducing competitiveness in the labor-intensive manufacturing sectors which often lead the process of economic growth.

4. The Size and Speed of the Demographic Transition

The size of the impact of demographic change on income depends on two factors. First, the total impact on income increases as the size of the demographic changes increase. Second, the impact increases as the sensitivity of economic outcomes to demographic change increases. The claim that demographic factors exert a large influence on economic performance requires both these factors to be present.

There *has* been enormous change in the demographic structure throughout the world over the last 50 years. Figure 1 shows life expectancy in Africa, Latin America, south central Asia, and East Asia between 1950 and 1995. Life expectancy has increased rapidly in all regions, though this process has happened particularly fast in East Asia and Latin America. Life expectancy has also risen substantially in Africa, though from a much lower base.

Figure 2 shows total fertility rates in the same regions over the same period. Fertility rates have come down most sharply in East Asia and Latin America, with evidence of the start of a decline in south central Asia. However, fertility rates remain high in Africa.

Figure 1. Life Expectancy

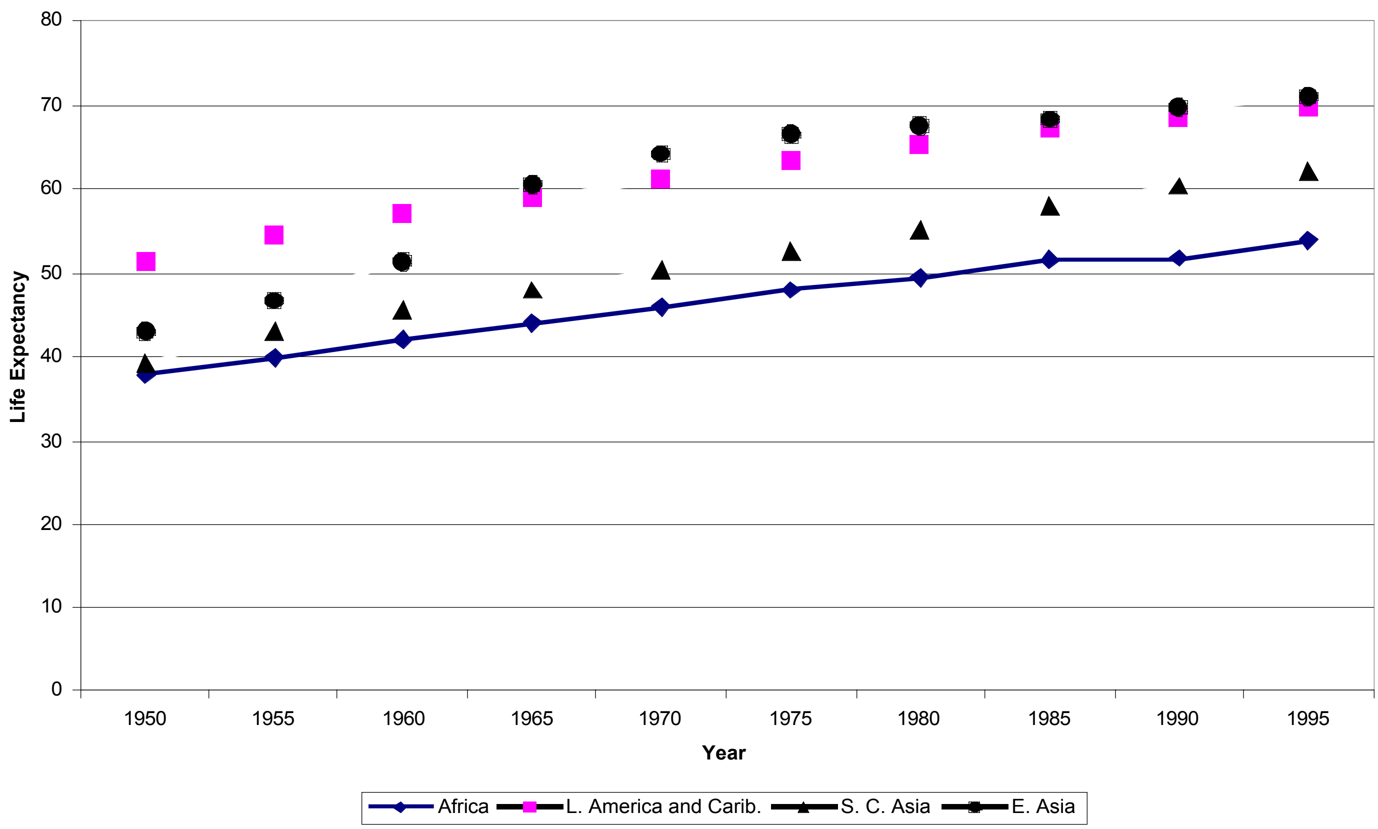
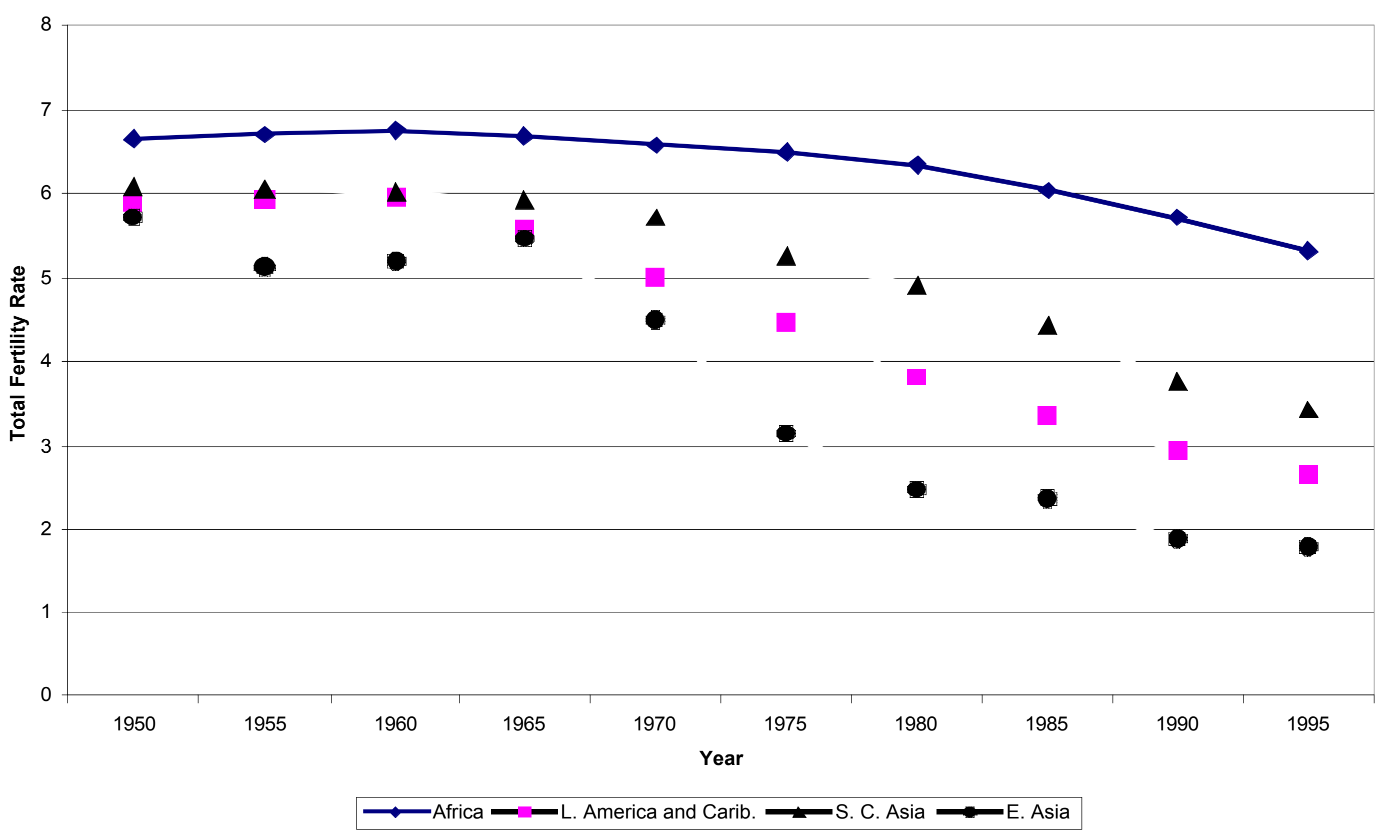
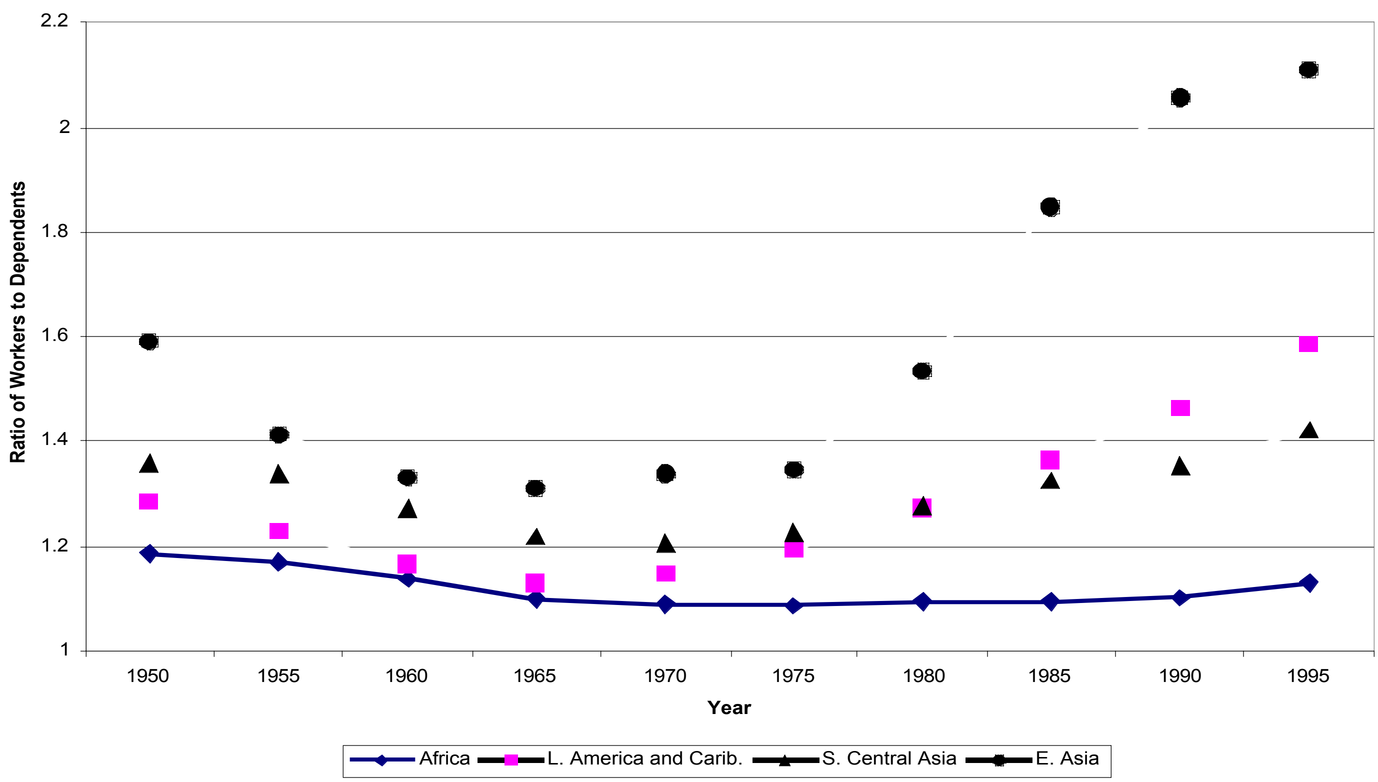


Figure 2. Total Fertility Rate



The consequences of these changes on the age distribution are shown in Figure 3, where we plot the ratio of working age (15-64) to dependent population (both young, 0-

Figure 3. Ratio of Workers to Dependents



14, and old, 65 and over) over the period.

In developing countries, dependents are primarily the young, with a significant number of old people only now starting to appear in East Asia. It can be seen that increases in life expectancy, which come mainly from reductions in child and infant mortality, tend, initially, to increase the dependency ratio. The population as a whole is increasing, but the number of young people is increasing more rapidly. However, as fertility rates fall, the number of the young being born declines, creating a "baby boom" generation which is exceptionally large. As this baby boom generation enters the labor market, we see an increase in the ratio of workers to non-workers, which continues for around 45 years.

They then leave the labor market and enter retirement. This demographic pattern lies behind the enormous growth in the ratio of workers to dependents in East Asia, from around 1.3 in 1965 to about 2.1 by 1995.   No other region has seen anything comparable, though Latin America and south-central Asia are clearly experiencing the start of this process. It is possible that the reduction in fertility in East Asia was purely exogenous, causing age structure and labor market effects which, in turn, created rapid growth. However, it is more likely that the causality runs both ways, with the rapid fall in fertility in part a consequence of rapid economic growth.[4]

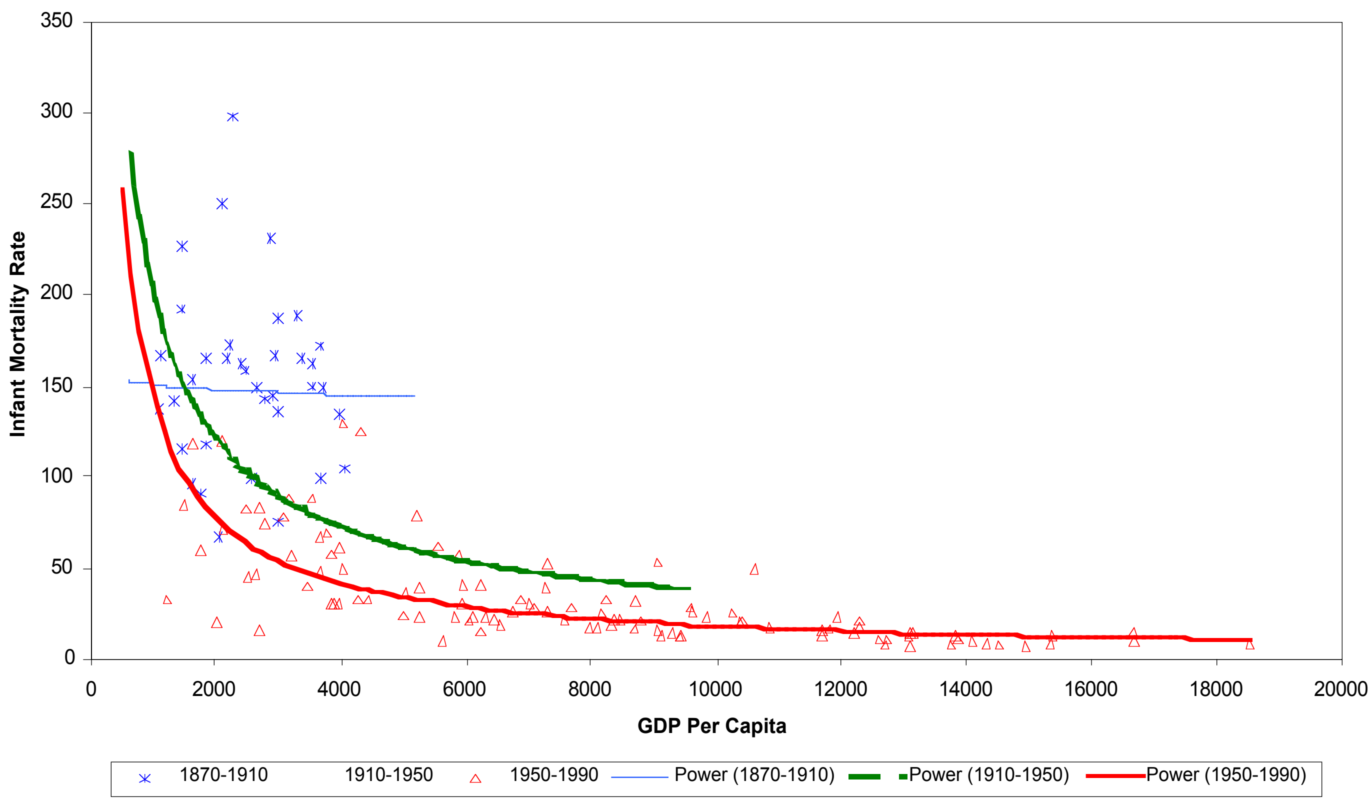
To explore this situation in greater detail, we first look at mortality. Fogel (1993) has argued that the declines in European mortality during the industrial revolution followed economic growth. However, the twentieth century experience seems quite different. Preston (1975, 1980) attributes only a very small portion of the decline in death rates observed around the world between 1930 and 1970 to economic growth. Exogenous factors, such as advances in health care, are seen as being much more important. This debate is by no means settled. Pritchett and Summers (1996) work with data from 1960 for developing countries and find a significant effect on infant mortality from both income and education. They argue that this is a causal relationship, though they find overall life expectancy seems to evolve exogenously. Wang and Jamison (1997), meanwhile, find an independent effect for female education levels, in addition to the overall impact of education and income. They emphasize the changing nature of the relationship between the factors affecting infant mortality over time. More work is clearly needed to understand the direction of causation within the system.

Our own analysis uses data spanning the period 1870-1988 for a cross-section of countries. The data on real GDP levels are from Maddison (1995) while the data on population, vital statistics, and age structure are from Mitchell (1992, 1993, and 1995). A

4 Fertility and mortality are more likely to be linked to the level of income than the growth rate. However, over the 30 year time period we consider, differences in growth rates between countries lead to large differences in income levels.

problem with looking at crude death rates is that it is difficult to disentangle the effects of falling mortality rate at each age from the effects of a changing population age structure. While it would be possible to overcome this problem by using age-specific death rates, these data are generally unavailable. However, data are available for infant mortality rates (up to age one). Figure 4 plots infant mortality rates against GDP per capita for the three time periods, again pooling data from each period. During the period 1870-1910, infant mortality rates are high and decline only slightly with rising incomes. Between 1911 and

Figure 4
Infant Mortality Rate by GDP Per Capita



1950, there is a sharp steepening of the relationship as infant mortality rates fall in high-income countries. After 1950, infant mortality rates appear to be low for all countries, with dependence on income level for the lower income countries. These results again point to the importance of improvements in public health that initially had an impact on richer countries but have eventually become widespread.

Our statistical analysis follows the model of Jamison, Wang, Hill, and Londono (1996) and Jamison, Bos, and Vu (1997), in that we try to establish how the relationship between income and mortality changes over time. Our analysis, however, is carried out with data spanning a much longer time frame. One important factor in interpreting Figure 4 is that the number of countries in the data set increases over time, so when looking at differences between time periods, there may be variation induced by changing the set of countries under consideration. This problem can be overcome by using a fixed effects framework to allow for country-specific differences in mortality rates.

Table 1 shows the results of regression analysis using log infant mortality as the dependent variable, with the independent variables being decade dummies and log income per capita interacted with the decade dummies. This model assumes the relationship is constant within each decade, but changes between decades; it amounts to pooling observations from different years within a decade. We investigate three different specifications: ordinary least squares (OLS), which pools all the data and assumes that the same relationship holds in all countries; a fixed effects specification, which allows each country to have its own intercept in the relationship; and a random effects specification, which allows each country to have its own intercept, but assumes these intercepts are uncorrelated with the other explanatory variables in the model. Testing the three specifications suggests that a random effects model is most appropriate; an F test decisively rejects OLS against fixed effects, but the Hausman test of random effects against fixed effects gives a chi-square value of 0.76, with 5 degrees of freedom, which is not significant. The regression results indicate that a significant negative relationship between income levels and infant mortality only occurs after 1900, and that the slope of the relationship has become steeper since then.

It should be noted that the regression analysis in Table 1 uses the logarithms of the variables, while the graph in Figure 4 plots levels of the variables. While a logarithmic specification appears to fit the data better, plotting the data in levels emphasizes how big the absolute differences are in infant mortality between developed and developing countries. The relationship between income and infant mortality shown in Figure 4 appears to flatten out in the period 1950-1988, while the regression results in Table 1 indicate an increasing sensitivity of infant mortality to income over time. This means that while infant mortality rates are getting closer in levels (and are approaching zero in richer countries), the ratio of infant mortality rates in poor countries to that in rich countries is increasing.

Table 1: Results of Infant Mortality Regressions

Dependent Variable: log of infant mortality per 1000 births

Independent Variables	OLS	Fixed effects	Random effects
D(1870)	4.46 (1.52)	3.48 (0.900)	3.71 (1.17)
D(1880)	3.56 (1.08)	3.35 (0.700)	3.51 (0.932)
D(1890)	4.21 (1.17)	3.71 (0.723)	3.90 (0.857)
D(1900)	4.61 (1.26)	3.11 (0.796)	3.40 (0.875)
D(1910)	6.49 (1.44)	3.85 (0.878)	4.20 (0.886)
D(1920)	6.13 (0.712)	3.63 (1.49)	4.05 (0.690)
D(1930)	6.34 (0.467)	3.79 (1.13)	4.21 (0.524)
D(1940)	7.39 (0.599)	4.42 (1.17)	4.85 (0.533)
D(1950)	6.36 (0.741)	4.40 (0.845)	4.76 (0.433)
D(1960)	6.66 (0.696)	4.72 (0.764)	5.13 (0.459)
D(1970)	7.19 (0.731)	4.69 (0.832)	5.15 (0.495)
D(1980)	8.96 (0.824)	5.55 (0.918)	6.07 (0.541)
D(1870) x ln y	-0.2655 (0.198)	-0.1030 (0.120)	-0.1368 (0.155)
D(1880) x ln y	-0.1399 (0.137)	-0.0767 (0.091)	-0.1011 (0.121)
D(1890) x ln y	-0.2359 (0.147)	-0.1379 (0.093)	-0.1650 (0.110)
D(1900) x ln y	-0.2813 (0.158)	-0.0630 (0.101)	-0.1026 (0.112)
D(1910) x ln y	-0.5298 (0.176)	-0.1802 (0.108)	-0.2262 (0.111)
D(1920) x ln y	-0.5044 (0.087)	-0.1750 (0.183)	-0.2286 (0.086)
D(1930) x ln y	-0.5486 (0.057)	-0.2244 (0.136)	-0.2769 (0.065)
D(1940) x ln y	-0.6910 (0.073)	-0.3200 (0.140)	-0.3739 (0.066)
D(1950) x ln y	-0.5926 (0.089)	-0.3515 (0.099)	-0.3958 (0.053)
D(1960) x ln y	-0.6579 (0.080)	-0.4258 (0.087)	-0.4754 (0.054)
D(1970) x ln y	-0.7329 (0.080)	-0.4471 (0.091)	-0.4998 (0.056)
D(1980) x ln y	-0.9517 (0.088)	-0.5736 (0.097)	-0.6312 (0.060)
Constant	2.62 (0.120)		2.64 (0.068)
R^2	0.81	0.95	0.94

Number of observations	621	
Number of countries	39	

The variable "y" represents income per capita and standard errors are reported in parenthesis below coefficient estimates.

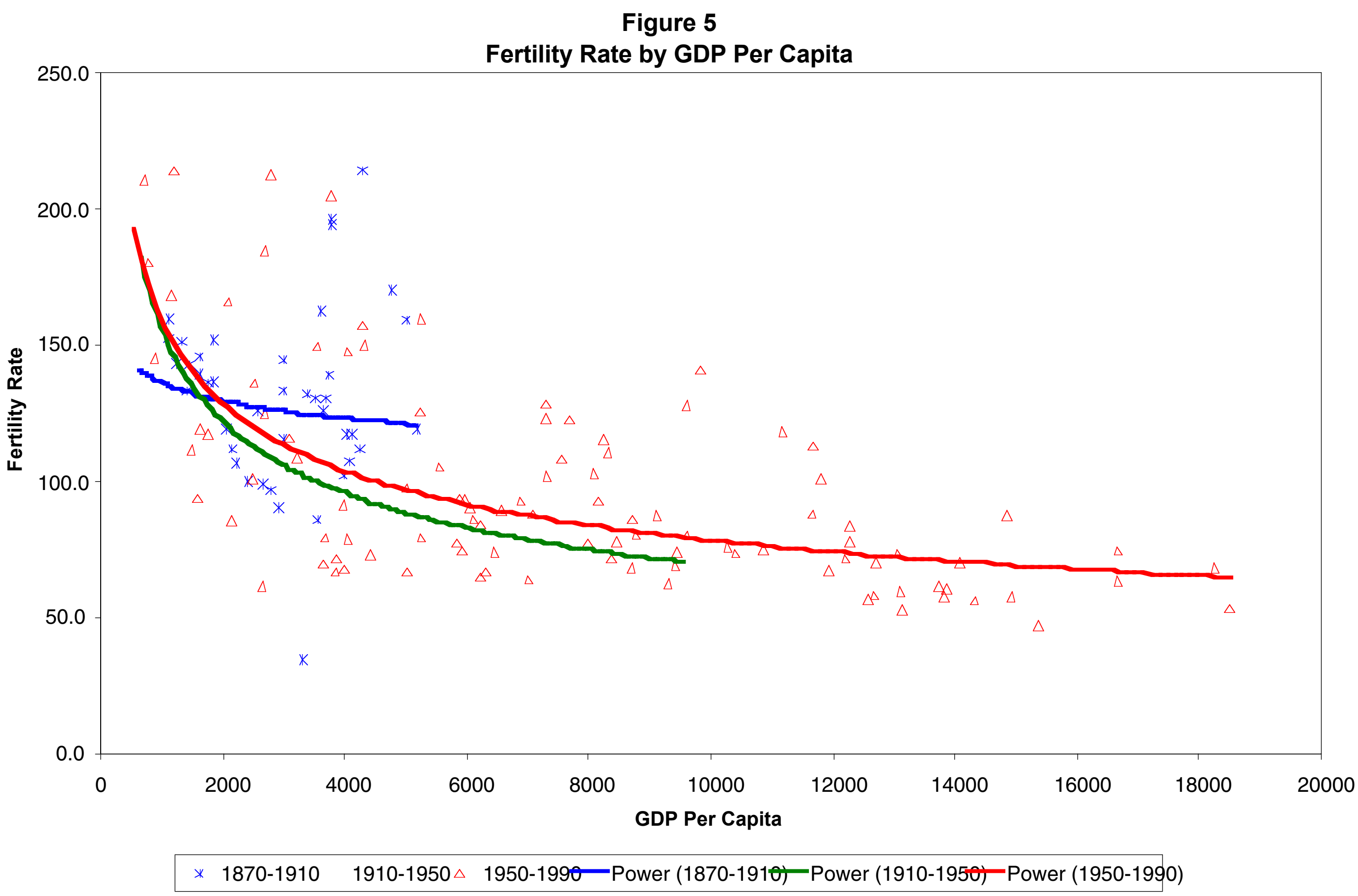
The most important point about Figure 4 and Table 1 is the decline in infant mortality rates over time, apparently independent of the effect of rising incomes. The results suggest that infant mortality in poor countries is now 10 to 30 times lower than in countries at comparable levels of income in 1870. This points towards both an exogenous shift, and an endogenous component in the determination of mortality rates. One story that might fit the data is the discovery of new techniques that are applied first in developed countries and then diffuse slowly to developing countries.

There appears to be an upward movement of the intercept over time in the infant mortality regressions in Table 1, which may give the misleading impression that infant mortality is increasing in very poor countries. However, what is really happening is that the relationship is becoming steeper over the actual range of incomes we observe. It is easy to show that the results imply rising infant mortality over time only in countries with annual incomes less than one cent per year (in 1985 dollars at purchasing power parity). It follows that even in very poor countries (which are well above this threshold), there has been a tendency for infant mortality rates to fall over time.

We can compare the magnitudes of the effect of income on life expectancy with the exogenous changes in life expectancy taking place over time. To do this we calculate the increase in income that would have been required to generate the same reduction in infant mortality as the exogenous reduction that took place between 1870 and 1980. Using the relationship between income and infant mortality in 1980, we can calculate that the downward shift in the curve between 1870 and 1980 has had roughly the same effect as that of increasing income by a factor of 50. This is just about the limit of the range of income levels we see today between the richest countries in the World (U.S.A, Sweden and Switzerland) and the poorest (Mozambique and Chad).

Turning to births, there has been debate on the relative importance of family planning programs versus economic development in determining fertility. Gertler and Molyneaux (1994), Schultz (1994), and Pritchett (1994) show that desired fertility, as determined by economic forces such as the education levels and wage rates of women, play a significant role in a fixed effects framework, while family planning activity seems less important. If these results are correct, fertility decline may be an endogenous factor, following economic growth rather than causing it. Nonetheless, changes in fertility still have the potential to play apart in an important multiplier effect, as the charts demonstrate

Figure 5 shows the relationship between fertility rates (births per thousand



women aged 15-45) and GDP per capita in the three time periods.

While income levels seem to have little effect on fertility in the nineteenth century, there is a strong negative relationship between fertility and income after 1910. However, the lack of a clear relationship in the data before 1910 may well be because the range of incomes across countries in this time period was fairly small. Table 2 shows regression results using log fertility rates as the dependent variable.

Table 2: Results of Fertility Regressions

Dependent Variable: Log Total Fertility Rate

Independent Variables	OLS	Fixed effects	Random effects
D(1870)	3.52	-1.44	-1.55
	(0.705)	(0.726)	(0.890)
D(1890)	5.86	0.5688	0.4394
	(0.505)	(0.685)	(0.766)
D(1910)	6.98	0.3241	0.2513
	(0.361)	(0.505)	(0.495)
D(1930)	7.89	1.06	0.9949
	(0.437)	(0.458)	(0.437)
D(1950)	6.58	-0.8284	-0.7988
	(0.483)	(0.444)	(0.394)
D(1970)	7.41	0	0.3209
	(0.398)	0	(0.311)
D(1870) x ln y	0.1945	-0.0773	-0.0452
	(0.088)	(0.081)	(0.106)
D(1890) x ln y	-0.1315	-0.3561	-0.3219
	(0.066)	(0.085)	(0.091)
D(1910) x ln y	-0.2808	-0.3336	-0.3072
	(0.046)	(0.075)	(0.062)
D(1930) x ln y	-0.4098	-0.4424	-0.4177
	(0.542)	(0.068)	(0.054)
D(1950) x ln y	-0.2315	-0.1950	-0.1824
	(0.056)	(0.063)	(0.049)
D(1970) x ln y	-0.3352	-0.3015	-0.2865
	(0.043)	(0.0606)	(0.048)
Constant			6.88
			(0.471)
R^2	0.53	0.82	0.79
Number of observations	245		

Number of countries	33	

The variable "y" represent income per capita and standard errors are reported in parenthesis below coefficient estimates.

Due to a smaller data set, the explanatory variables in this regression are dummy variables for 20-year periods, and these dummies interacted with log income per capita. Again, statistical analysis finds random effects to be the preferred model. (We can once again decisively reject OLS against fixed effects, but a Hausman test of random effects against fixed effects gives a chi-square value of 0.95 [with 3 degrees of freedom], which is not significant). Fertility appears not to have had a significant relationship with income before 1890, but there is a significant negative association thereafter. While there appear to be movements in the intercept, these do not follow a regular pattern. Surprisingly, there does not seem to be any clear evidence of technological progress in birth control having an exogenous impact on fertility rates. There is no downward trend in the relationship over time; in particular, the introduction of significant new birth control methods in the 1970s and 1980s are not reflected in reductions in the fertility level.

These suggestive results should be qualified in two important ways. A more comprehensive study would require the inclusion of further explanatory variables such as education levels, particularly for females, and the availability of contraception. The regressions are mainly intended to demonstrate the existence of feedback from income levels to fertility and mortality; they are not intended to imply that we believe that only income matters in determining fertility. In addition, it would be desirable to find an instrument for income levels, in order to ensure the robustness of the results to the presence of reverse causation. Bloom, Canning, and Malaney (1999) adopt an instrumental variables approach to do this, using only data from after World War II, but find similar results to those presented here.

Bearing these caveats in mind, these empirical results suggest that the relationship between fertility, mortality and income levels has changed over the last 130 years. A possible cause for these changes has been technological developments in both health care and contraceptive methods. Such changes will tend to reduce mortality and allow actual fertility to more closely approximate desired fertility. Such technological effects are not likely to impact on all countries equally. Rich countries may be alone in being able to afford the improvements offered by health technology, while desired fertility may vary across countries. It follows that technological advances can change the slope, as well as the intercept, of our relationships.

It would be a simpler story if demographic change was exogenous, and had an economic impact; or if economic development were exogenous, and determined demographic change. But the truth appears to be that each affects the other. The relationship between economic development and the demographic shift can only be understood as a process, in which causality runs in both directions.

5. Models of the Demographic Transition and Economic Development

The richest countries of the world have around 50 times the income per capita of the poorest, in purchasing power parity terms. Even ignoring the very poorest countries such as Chad and Mozambique, whose problems have been compounded by civil war, rich countries have about 20 times the income levels of the poorer developing countries. A central question is why such a large gap exists. Two types of answers are possible. One argues that countries are fundamentally different and these differences account for their different economic performance. For example, Gallup and Sachs (1999) emphasize the role of geography in economic growth. The second (e.g. Myrdal) argues that countries are really quite similar, but that economic development involves positive feedbacks: countries that do well tend to get further gains, creating wide gaps in outcomes across countries, from very small differences in initial conditions.

The neoclassical Solow model assumes diminishing returns to capital, and so predicts relatively small differences in income levels for countries with different savings rates. Rich countries may have higher levels of capital per worker, but diminishing returns imply that this has only a small impact on income levels. It is difficult for the model to generate the vast differences in real income levels we observe across the world.

Endogenous growth theory is another response to this problem. If the elasticity of output with respect to capital is one, so that a one percent increase in capital stock leads to a one percent increase in output, capital accumulation becomes a very powerful force in the growth process. With no diminishing returns to capital, economies need not slow down as they get richer and growth can continue indefinitely. Klenow and Rodriguez-Clare (1997) and Prescott (1998) argue that, based on microeconomic evidence exploring the returns on physical capital and education, the elasticity of output with respect to aggregate capital is one-half. If this is true, we lack an explanation of the wide differences in income levels across countries.

An alternative approach to explaining the wide income differences is to argue that there may be cumulative causality between income growth, mortality decline, and declines in fertility. To understand this process, we require a model in which demographic factors can affect economic growth, and income levels can have an impact on demographic variables. In many ways, this is a return to the basic approach used by Malthus, who had a theory of production and technological progress, and a theory of fertility and mortality. It is the interaction of these mechanisms that makes the Malthusian model so rich.

Modern models go beyond Malthus by describing how fertility can fall as well as rise with income. Barro and Becker (1989), for instance, argue that as wages increase, time has a rising opportunity cost. Maintaining that child rearing is time-intensive, they are then able to introduce the negative effects of income on fertility into a standard neoclassical growth model. This model subsequently generates multiple equilibria, with country income able to settle at a higher or a lower level. Becker, Murphy, and Tamura

(1990) argue that, as wage growth depresses fertility, the investment in education per child rises. If the returns from education are great enough, this in turn leads to further gains in wage income. This model has a poverty trap at low-income levels, where there are large numbers of children, a lack of education, and a relatively low value for time. However, escape from this trap may lead to a phase of endogenous growth based on ever-increasing levels of education and wage income with endogenously declining fertility.

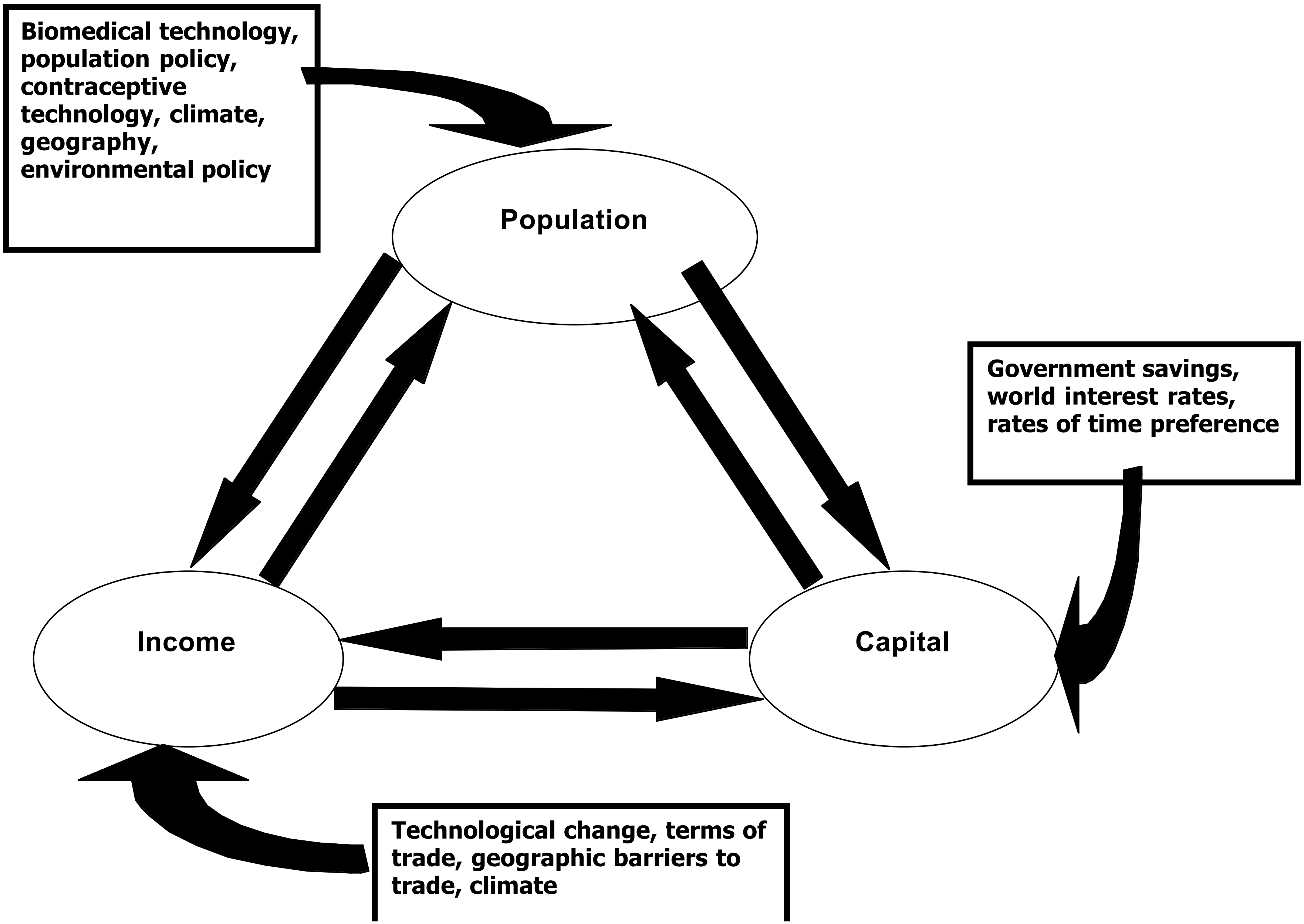
What is needed is an exogenous stimulus to start this endogenous process, and reductions in mortality offer one such mechanism. Ehrlich and Lui (1991) argue that lower child mortality may lead to lower fertility, if parents have a target number of children. In their model, this leads, in turn, to higher levels of education per surviving child, since education is no longer "wasted" on children who die before entering the labor market. This can set off a virtuous spiral of rising income and education. In practice, a decline in infant mortality is likely to lead to an increase in the youth dependency ratio in the short run, until fertility behavior adjusts. However, in the longer run, the reduction in fertility may be more than one for one, since the decline in infant mortality also reduces the uncertainty about the number of surviving children, allowing even greater resources per child to be made available for education.

Quah (1997) supports the idea of a development trap, with growth only occurring after a critical level of income. He shows that there are two distinct groups of countries, the poor and the rich, with very few countries in the middle income range. Many ideas have been put forward as to why these two groups, and the multiple equilibria they imply, should exist (see Azariadis 1996). Most depend on the notion that endogenous growth is possible but is difficult to start at low income levels. For example, the multiple equilibria in models presented by Becker, Murphy, and Tamura (1990), and Ehrlich and Lui (1991) arise from an interaction between fertility and education in models where there are no decreasing returns from education. The endogenous growth phase essentially relies on increasing returns. Strulik (1997), meanwhile, also produces multiple equilibria in a model with endogenous population growth and learning-by-doing, essentially using learning-by-doing to produce dynamic increasing returns to scale, once growth is underway.

We argue that demography plays an important part in understanding the process of economic growth. However, the interaction between demography and economic growth must be approached within a system framework, in which each variable affects the others. To an extent, this is a trivial observation: there is little dispute that these forces do interact. At a deeper level, however, the system approach changes the way we must view causality within the system, but only if the links between variables are sufficiently strong.

Figure 6 sets out a schematic diagram that shows our view. We believe that demography influences output directly, through its effects on labor supply; and indirectly, through its effects on capital accumulation. On the other hand, income levels and capital

Figure 6
Demography and Growth



stock have effects on fertility and mortality. The links at the bottom of the graph, showing the effects of capital accumulation on income and the effects of income on further capital accumulation through savings, are the links that have been most extensively examined by economists.

The schematic could be extended to include other forces. For example, political scientists might see the political process as both a cause and a consequence of economic development and add a box labeled "politics", with arrows connecting it to all the other variables. However, for the moment, we have taken politics and other factors as exogenous to the system and focused on the interaction between capital accumulation, economic growth, and demographic change.

The system approach throws new light on the wide dispersion in income levels that lies at the center of the growth debate. Any changes to the exogenous factors in the model will have repercussions for all the endogenous variables. For example, a family planning program may slow down the rate of population growth. This will have an impact on income per capita directly, through its effects on the dependency ratio and the labor force. The ratio of working age to non-working age populations will rise in the short run, while in the longer run, the lower population may lead to a higher capital-labor ratio. It will also have an indirect impact on income through capital accumulation, perhaps increasing investment in education per child, since there are fewer children. Of course, family planning in the form of contraception distribution programs may itself be endogenous and related to income and education levels. After all, contraception is most demanded where the demand for children is waning, and this occurs at higher levels of income, education, and development.

In order to elaborate on the simple models set out here, it will be necessary to decompose population growth into birth rates and death rates. As incomes rise, both death rates and birth rates tend to decline. However, there may be a threshold effect whereby as mortality falls, a reasonably high level of income is required before fertility is affected. There is also evidence that in the initial stages of a demographic transition, rising incomes actually increase fertility, while also reducing child mortality. Taken together, these effects create a take-off problem, deepening the low-level poverty trap. As in Nelson (1956) and Leibenstein (1978), escape from this Malthusian world may only be possible if income levels are pushed slightly above subsistence levels due to some exogenous factor. Then, fertility begins to decline, positive feedbacks are felt, and endogenous growth can start.

A focus on the system approach also highlights the problem of trying to attribute economic growth to "causes" that are themselves endogenous. For example, Young (1994, 1995) attributes almost all of East Asia's growth to capital accumulation, but this begs the question of why capital accumulation was so high. Higgins and Williamson (1997) argue that the entire rise in savings in East Asia may be due to the demographic shift, but this begs the question of why these countries underwent the transition in this period. Factors can be important whether endogenous or exogenous. Even if the demographic shift was completely endogenous, it would still have provided positive feedback and could still be an important part of understanding the East Asian "miracle". Endogeneity is often seen as a purely technical problem that makes the estimation of each separate effect more complex. However, it also has a conceptual dimension, forcing us to think of the process as a whole rather than looking an each causal link in isolation.

If our view of the East Asian miracle as a period of endogenous growth is correct, there may, in fact, be no ultimate "causes", but only a "process". Once the interactions in Figure 6 become very strong, the final outcome in terms of the endogenous variables may not depend on the exogenous variables in a unique way. We may need to understand growth as a process of cumulative causation rather than a mapping from causes to effects.

The model also serves to highlight a possible difference between the recent economic success of East Asia and the original industrial revolution in the United Kingdom. It may be that the relatively slow population growth rate in the U.K. during the industrial revolution was essentially due to a slow, but steady, increase in income levels over a period of 200 years, as suggested by Crafts (1998). However, improvements in medical technology, our understanding of public health, and advances in contraceptive technology may mean that, in the twentieth century, the feedback from income level to demography is much stronger. The transition from a low-income economy to a high-income economy could now involve a jump between steady states, a jump that may only take one generation.

6. Policy Implications

There are three distinct areas in which the models for the "new demographics", which emphasize age structure effects rather than total population, have potential policy applications.

The first is rooted in the realization that demographic changes only have a *potential* economic impact. The benefits of the "demographic dividend" require that desired changes in labor supply, savings, and educational attainment actually come about in practice. Any adverse effect of population pressure can be mitigated through the smooth functioning of markets and the price mechanism. Appropriate economic policies are therefore essential.

The baby boom generation will certainly increase the size of the workforce, but this will only provide higher output if these people find productive work. If the labor market fails to absorb the large cohort, then the potential gains will probably be wasted. Equally, increases in life expectancy will lead people to save more, but only if they have sufficient trust in a well regulated and efficient financial sector. These savings must then be invested in a way that benefits the economy. Again, demand for education is likely to increase, as people demand schooling for their children and consider returning to education themselves. But this demand may require public intervention, particularly at the primary and secondary school level, since poor families lack the funds to finance educational investments and have difficulty borrowing.

In Table 3, we report fairly standard growth regressions, explaining growth in per capita income over the period 1965 to 1990 for a cross section of countries, including demographic factors. Initial demographic factors, measured at the beginning of the period, are taken to be exogenous. However, all population growth rates measured over

Table 3: Basic specification for growth 1965 to 1990**

	Regression 1.1 (2SLS)	Regression 1.2 (2SLS)	Regression 1.3 (2SLS)
Constant	-0.407	9.777	9.608
	(-0.07)	(2.08)	(2.15)
Log of initial GDP per capita	-2.114	-1.896	-1.913
	(-5.45)	(-5.74)	(-6.18)
Log of ratio of total population	-8.639	4.655	6.117
to population aged 15 to 64	(-1.72)	(0.82)	(2.26)
Percent of land area in	-0.614	-0.850	-0.862
the geographical tropics	(-1.30)	(-2.28)	(-2.39)
Log of average years	0.532	0.204	0.202
of secondary schooling	(1.84)	(0.75)	(0.76)
Openness indicator	1.635	1.332	1.332
	(3.67)	(3.71)	(3.77)
Index of institutional	0.268	0.144	0.145
quality	(2.84)	(1.86)	(1.91)
Log of life expectancy	2.946	1.870	2.065
	(1.43)	(1.19)	(1.75)
Growth rate of total	-1.000	-3.008	
population*	(-1.44)	(-4.38)	
Growth rate of population		2.826	
age 15 to 64*		(3.90)	

Difference between growth rates of total population and population aged 15 to 64*			2.928 (4.62)
R-Squared	0.57	0.72	0.73
NOB	80	80	80
F-Statistic	11.5	20.2	24.5

***Note:** The growth rate of total population, the growth rate of population age 15 to 64, and the difference between the two were instrumented using the 1965 infant mortality rate, the log of the 1965 fertility rate, the 1965 youth dependency ratio, average growth of total population from 1960 to 1965, and average growth rate of population age 15 to 64 from 1960 to 1965.

****Note:** All results were estimated using heteroskedastic-consistent t-ratios.

the period are assumed to be endogenous. However, we can overcome this problem, and ensure that we estimate the effect of population growth on income, and not vice versa, by the appropriate use of instrumental variables. These instrumental variables are designed to capture the exogenous part of population growth, the part that is not due to feedback from income growth. We instrument population growth in the regression with a log of the fertility rate in 1965, the youth dependency rate in 1965, and the lagged growth rates (that is between 1960 and 1965) of working age and total population.

Since demographic change is instrumented with variables measured before the period of growth begins, we can argue that these instruments are immune from reverse causality. There are several problems with treating "prior" variables as exogenous. The first is that economic growth rates may be correlated over time so that countries with high growth rates in the period 1965 to 1990 also had high growth rates over the period 1960 to 1965. If this is the case, even if causality runs entirely from economic growth to demography, our instruments will have a spurious correlation with growth in the period we are trying to explain. However, in practice there is very little persistence in economic growth rates over time and essentially zero correlation between current growth rates and lagged growth rates (see Easterly et al. 1993). The second problem is that, if economic growth is expected, it can have an effect on fertility behavior and demographic change even before it occurs, so that the arrow of causality may run backwards in time. While we cannot rule this effect out, it seems unlikely that, in practice, uncertain predictions of future rates of economic growth have a large effect on current decisions. If we accept these arguments, our instruments control for reverse causality and give estimates of the effect of population growth on economic growth.

We find that total population growth entered on its own does not have a statistically significant effect of economic growth. However, adding the growth of working age population, and retaining the growth rate of total population, gives a significant improvement in the fit. The effects of working age growth and total population growth appear to be equal and opposite; it seems to be the differential growth rate that matters. This is reported in column two of Table 3. In this specification, we also find that growth is higher, the higher the initial ratio of working age population per capita. This implies that the steady state level of income per capita is higher if the ratio of working age population per capita is higher.

When we include demographic factors in growth regressions, as in column three of Table 3, the education variable (log of average years of secondary schooling) tends to become statistically insignificant. We interpret this not as meaning that education does not matter, but rather, that education may be being driven by the demographic factors (life expectancy and school enrollment are highly correlated), so that demographic change is working partly through its effect on enrollment rates. If demographic change explains school enrollment, education levels do not have an independent explanatory role in regression analysis. Of course, it could be that the real problem is that our education data are very poor, measuring quantity rather than quality (see Behrman and Birdsall 1983), or that the relationship between education and growth is more complex (Birdsall and Londono 1997).

Table 4 reports growth regressions in which we include policy variables both on their own and interacted with the differential growth rate of working age and overall population. We use institutional quality and openness to trade as policy variables, though ideally we would like to have included separate indicators for the efficiency of the labor market, the financial market, and the educational system. Even using our simple proxies, however, we see that good policy (as expressed by high quality institutions and openness to trade) leads to higher growth, and the impact of demographic change is greater when institutions are better. It is, of course, always important to get policies right, but it may be more so when the baby boom is occurring.

One caveat to these results is that it is difficult to estimate the interaction of demographic change with multiple policies. In columns one and two of Table 4, when we interact with openness of the economy and institutions separately, we find significant effects. However, when we interact with both policies at the same time, in column three, neither is significant. While the "demographic dividend" is greater when good policies are in place, cross-country data is not rich enough to tell us which policies are most important. Note, however, that when we add interactions between policies and initial

Table 4: Policy interaction specification for growth 1965 to 1990**

	Regression 2.1 (2SLS)	Regression 2.2 (2SLS)	Regression 2.3 (2SLS)	Regression 2.4 (2SLS)	Regression 2.5 (2SLS)
Constant	6.084	8.173	6.043	4.782	2.806
	(1.35)	(1.70)	(1.37)	(1.16)	(0.55)
Log of initial GDP per capita	-1.799	-1.929	-1.792	-1.710	-1.272
	(-6.04)	(-6.36)	(-5.62)	(-5.49)	(-2.30)
Log of ratio of total pop to pop aged 15-64	5.030	5.295	5.048	4.971	4.952
	(1.88)	(1.87)	(1.87)	(1.94)	(1.80)
Percent of land area in the tropics	-1.058	-0.956	-1.059	-1.058	-1.001
	(-3.27)	(-2.82)	(-3.28)	(-3.27)	(-3.06)
Log of average years of secondary school	0.284	0.281	0.282	0.235	0.279
	(1.12)	(1.10)	(1.11)	(0.90)	(1.10)
Openness indicator	0.443	1.188	0.415	3.835	1.335
	(0.93)	(3.24)	(0.70)	(1.34)	(3.81)
Index of institutional Quality	0.106	0.052	0.111	0.156	0.909
	(1.28)	(0.56)	(1.22)	(1.69)	(1.74)
Log of life expectancy	2.666	2.432	2.663	2.791	2.485
	(2.37)	(1.95)	(2.35)	(2.61)	(2.13)
Difference: Growth of total pop and pop aged 15 to 64*	1.449	-0.013	1.621	1.467	-0.730
	(1.48)	(-0.01)	(0.80)	(1.69)	(-0.46)
Log of initial income times Openness				-0.414	
				(-1.14)	
Difference' times openness	2.849		2.977	2.346	
	(2.61)		(1.66)	(2.35)	
Log of initial income times Institutional quality					-0.110
					(-1.67)
Difference' times institutional Quality		0.465	-0.038		0.541
		(1.90)	(-0.10)		(2.81)
R-squared	0.74	0.74	0.74	0.75	0.74
NOB	80	80	80	80	80
F-statistic	22.3	22.1	19.7	20.5	20.1

***Note:** The difference between the growth rate of total population and the growth rate of population age 15 to 64 was instrumented using the 1965 infant mortality rate, the log of the 1965 fertility rate, the 1965 youth dependency ratio, average growth of total population from 1960 to 1965, and average growth rate of population age 15 to 64 from 1960 to 1965. ****Note:** All results were estimated using heteroskedastic-consistent t-ratios.

income level we get some evidence that policies matter more in poor countries, but the interaction between policies and demographic change remains significant.

The interaction effects we estimate are not only statistically significant, but they are large in magnitude. In countries with the worst policies (zero openness and institutions), we find no significant effect of changes in the age structure. In countries with the best policies, we find very large effects. For example, the interaction between demographic change and policies translates into a two percentage point gap between economic growth in East Asia relative to Latin America over the period due to the faster demographic transition and better economic policies in East Asia. This is a substantial part of the observed growth differential of just over five percentage points a year.

In many cases, when we add the interaction effects between policy and demography, the coefficients on the original level terms representing policy and demography become statistically insignificant, and often change sign. This does not mean we have no demographic or policy effects. For example, the effect of an increase in the rate of demographic change (measured as the differential growth of the working age to total population) is the coefficient on the demography variable *plus* the coefficient on the interaction term times the level of the relevant policy variable. In general this will be positive even if the coefficient on the level term is zero. In fact, the "average" effect of demographic change, that is, the effect in a country with "average" levels of the policy variables, is exactly what is calculated in Table 3 when we do not allow policy interactions. In countries with the very worst policies (giving policy values of zero on our measures), we do not find any effect of demography in our specifications, but this should not be especially surprising.

The second implication of the new demographics is for health policy. Better health and increased life expectancy clearly have a direct impact on human welfare. However, if life expectancy promotes economic growth, public health measures may also have an indirect impact on welfare by encouraging economic growth. Our results in Tables

3 and 4 find life expectancy to have a significant impact on economic growth. This is one of the most robust results in the growth literature. While there is a problem that life expectancy may merely be acting as a proxy for the overall level of human development, it may be that health policy should be given a greater priority; it may have a double dividend, increasing welfare directly and also promoting long run economic growth. It is obvious that the AIDS epidemic represents an enormous human tragedy for the people of sub-Saharan Africa, as does the recent decline in life expectancy for the population of Russia. However, we may only just be starting to see the effects of the economic bad news.

Finally, our results have important implications for population policy, which usually translates as family planning through the control of fertility. One view is that there is a tradeoff between the number of children and economic growth, with fewer children leading to greater growth. However, we do not wish to imply that people would be better off with fewer children, as it is essential not to confuse economic growth with human welfare.

One issue is how (and whether) policymakers should calculate a trade-off between potential children and the well-being of those already born. We can sidestep this difficult philosophical question if we follow Becker and Barro (1989) and assume that parents are altruistic towards their children. Parents already calculate a trade-off between having more children and having fewer, being able to provide the fewer with a higher standard of living and education. If they have knowledge of, and access to, family planning, the number of children born will reflect this trade-off. It is therefore unclear what more policymakers can do. This leads to the view that the correct aim for family planning policy is to inform parents of the tradeoffs involved and to provide methods of making actual fertility match desired fertility. Reducing births below the desired level might increase income growth, but would reduce welfare.

The argument for going further with family planning efforts is based on situations where there are externalities to the number of children born. For example, if an extra child in one family reduced the welfare of children in another, perhaps through pressure on scarce public resources, it is possible to make both families better off if birth numbers are restricted. In this situation, each family is in a situation known as the prisoners' dilemma, first formulated by mathematician Albert W. Tucker in the 1950s (see Axelrod 1984). The dilemma is that each family is best off if the other does not have a child and they do, and worst off if the other family has a child and they do not. Between these two poles, they are slightly worse off if both have children and slightly better off if neither do. However, the situation is different when examined globally, with all families better off overall if the number of children is limited. The latter is a co-operative strategy and it may be possible for policymakers to influence more families to choose it for the mutual good.

Macroeconomic analysis is not well placed to decide whether externalities exist or whether benefits of fewer children accrue only to families making that decision. Detailed microeconomic studies at the family level are needed to find the private tradeoff between child quantity and quality, and compare that to the macroeconomic effects. Only if there is a clear social, rather than private, tradeoff can we justify societal intervention to influence the fertility decisions taken by individuals.

7. Conclusion

Why are income levels so different across the world? Why do the differences show no sign of narrowing?

These are fundamental questions. Endogenous growth models in economics have tended to answer them by arguing from the existence of very high returns to capital, and a process of cumulative causation, whereby countries that invest more (in physical capital, human capital, and research and development) grow much faster than others.

There is another possibility, however. The interaction of economic growth with population dynamics can create a poverty trap. There may be two clubs, one with low income and high population growth rates, the other with high income and low population growth rates. Transition between these clubs may be rare, but when it occurs it may happen very fast, due to the positive feedbacks between growth and demographic change, and be seen as a growth "miracle".

This model depends on the interactions between income levels, demographic changes, and capital accumulation being sufficiently strong. Evidence is emerging that these linkages may be fairly strong, but a great deal more empirical research is required. In addition, the overall behavior of the system can only be understood as a whole. This requires an integration of demographic studies of the effect of income and education levels on fertility and mortality, with economic studies of the effect of demographic variables on capital intensity, labor force participation rates, savings rates, and school enrollment rates.

References

Axelrod A. (1984), *The Evolution of Cooperation*, Basic Books.

Azariadis C. (1996), "The Economics of Development Traps," *Journal of Economic Growth*, Vol. 1, pp. 449-485.

Barlow R. (1994), "Population Growth and Economic Growth: some more correlations," *Population and Development Review*, Vol. 20, pp. 153-65.

Barro R.J. and Becker G.S. (1989), "Fertility Choice in a Model of Economic Growth," *Econometrica*, Vol. 57, pp. 481-501.

Becker G.S., Murphy K.M., and Tamura R. (1990), "Human Capital, Fertility and Economic Growth," Journal *of Political Economy*, Vol. 98, pp. S12-S37.

Behrman J.R. and Birdsall N. (1983),"The Quality of Schooling – Quantity Alone is Misleading," American Economic Review, Vol. 73, pp 928-946.

Behrman J.R., Duryea S. and Szekely M. (1999), "Human Capital in Latin America at the End of the 20th Century," mimeo, University of Pennsylvania.

Birdsall N and Londono J.L. (1997), "Asset inequality Matters: An Assessment of the World Bank's Approach to Inequality Reduction," *American Economic Review*, Vol. 87, pp 32-37.

Bloom D.E., Canning D. and Malaney P.N. (1999), "Demographic Change and Economic Growth in Asia," CAER II Discussion Paper No.58.

Bloom D.E. and Freeman R.B. (1986), "The Effects of Rapid Population growth on Labor supply and Employment in Developing Countries," *Population and Development Review*, Vol. 12, pp. 381-414.

Bloom D.E. and Freeman R.B. (1988), "Economic Development and the Timing of Economic Growth," *Journal of Policy Modeling* Vol. 10, pp.57-81.

Bloom D.E. and Mahal A. (1997), "AIDS, Flu, and the Black Death: Impacts on Economic Growth and Well-Being," in D. Bloom and P. Godwin, Eds., *The Economics of HIV and AIDS: The Case of South and South East Asia,* United Nations Development Programme, Oxford University Press, pp. 22-52.

Bloom, D.E. and Sachs, J. (1998), "Geography, Demography, and Economic Growth in

Africa," *Brookings Papers on Economic Activity 2,* pp. 207-273.

Bloom D. E. and Williamson J. G. (1997), "Demographic Change and Human Resource Development," in *Emerging Asia: Changes and Challenges,* Asian Development Bank, pp. 141-197.

Bloom D.E. and Williamson J.G. (1998), "Demographic Transitions and Economic Miracles in Emerging Asia," *World Bank Economic Review*, Vol. 12, No. 3, pp. 419-55.

Boserup, E. (1981). *Population and Technological Change: A Study of Long-Term Trends,* Chicago: Chicago University Press.

Brander J.A. and Dowrick S. (1994), "The Role of Fertility and Population in Economic Growth: Empirical Results from Aggregate Cross National Data," *Journal of Population Economics*, Vol. 7, pp. 1-25.

Cheng B.S. and Nwachukwu S.L.S. (1997), "The Effect of Education on Fertility in Taiwan: A Time Series Analysis," *Economics Letters*, Vol. 56, pp. 95-99.

Coale A.J. (1986), "Population trends and Economic Development," in J. Menken ed., *World Population and U.S. Policy: the Choices Ahead*, Norton, New York.

Coale A.J. and Hoover E. (1958), *Population Growth and Economic Development in Low-Income Countries*, Princeton University Press, Princeton.

Caldwell J.C. (1982), *Theory of Fertility Decline*, London: Academic Press.

Coale A. J. and Watkins S.C. (1986), "The Decline in Fertility in Europe," Princeton University Press, Princeton.

Crafts N. (1988), "Forging Ahead and Falling Behind: the Relative Decline of the First Industrial Nation," *Journal of Economic Perspectives*, Vol. 12, pp. 193-210.

Deaton A.S. and Paxson C.H. (1997), "The Effects of Economic and Population Growth on National Savings and Inequality," *Demography*, Vol. 34, pp. 97-114.

Deaton A.S. and Paxson C.H. (1998), "Growth, Demographic Structure, and National Savings in Taiwan," mimeo, Princeton University.

Easterly W., Kremer_M, Pritchett L. and Summers L.H. (1993), "Good Policy or Good Luck – Country Growth-Performance and Temporary Shocks," Journal of Monetary Economics, Vol. 32, pp 459-483.

Ehrlich P. (1968), *The Population Bomb,* New York: Ballentine.

Ehrlich I. and Lui F.T. (1991), "Intergenerational Trade, Longevity, and Economic Growth," *Journal of Political Economy*, Vol. 99, pp. 1029-1059.

Fogel R.W. (1993), "Economic Growth, Population Theory, and Physiology: the Bearing of Long Term Processes on the Making of Economic Policy," Nobel Lecture, The Nobel Foundation.

Gallup, J.L. and Sachs, J. (1999), "Geography and Economic Development," *CID Working Paper No. 1.*

Gertler P.J. and Molyneaux J.W. (1994), "How Economic Development and Family Planning Programs Combined to Reduce Indonesian Fertility," *Demography*, Vol. 31, pp. 33-63.

Hanushek E.A. (1992), "The Trade-off between Child Quantity and Quality," *Journal of Political Economy*, Vol. 100, pp. 84-117.

Herlihy, D. (1997), *The black death and the transformation of the west,* Cambridge, MA: Harvard University Press.

Hirshleifer, Jack (1987), *Economic Behavior in Adversity*, Chicago: University of Chicago Press.

Higgins M. (1998), "The Demographic Determinants of Savings, Investment and International Capital Flows," *International Economic Review*, forthcoming.

Higgins M. and Williamson J.G. (1997), "Age Structure Dynamics in Asia and Dependence of Foreign Capital," *Population and Development Review*, Vol. 23, pp. 261-293.

Jamison D.T., Bos E. and Vi M.T. (1997), "Poverty and Mortality among the Elderly: Measurement and Performance in 33 Countries*," Tropical Medicine and International Health*, Vol. 2.

Jamison D.T., Wang J., Hill K and Londono J-L (1996), "Income, Mortality and Fertility in Latin America: Country-Level Performance, 1960-1990," *Revista de Analisis Economico*, Vol. 11, pp. 219-261.

Limao N. and Venables A.J. (1999), "Infrastructure, Geographic Disadvantage, and Transport Costs," World Bank, Policy Research Working Paper, No. 2257.

Kalemli-Ozcan S., Ryder, H.E. and Weil, D.N. (1998), "Mortality Decline, Human Capital Investment and Economic Growth," *Working Paper No. 98-18*, Department of Economics, Brown University.

Kelley A.C. (1988), "Economic Consequences of Population Change in the Third World," *Journal of Economic Literature*, Vol. 27, pp. 1685-1728.

Kelley A.C. (1995), "Revisionism Revisited: An Essay on the Population Perspective." Forthcoming in R. Ohlsson, Ed. *Population, Development and Welfare Symposium in Economics*, Berlin: Springer-Verlag.

Kelley, A. C. (1996), "The Consequences of Rapid Population Growth on Human Resource Development: The Case of Education," *The impact of population growth on well-being in developing countries,* A. Dennis, A. Kelley, A.C. Mason, K. Oppenheim, Eds., *Population Economics series,* New York: Springer, pp. 67 - 137.

Kelley A.C. and Schmidt R.M. (1995), "Aggregate Population and Economic Growth Correlations: the Role of the Components of Demographic Change," *Demography*, Vol. 32, pp. 543- 555.

Kelley A.C., and Schmidt R.M. (1996), "Savings, Dependency and Development," *Journal of Population Economics*, Vol. 9, pp. 365-386.

Kelley A.C., and Schmidt R.M. (1999), mimeo, Duke University.

Klenow P.J. and Rodriguez-Clare A. (1997), "The Neoclassical Revival in Growth Economics: Has it Gone Too Far?" mimeo, Graduate School of Business, University of Chicago.

Knodel J., Havanon N., and Sittitrai W. (1990), "Family Size and the Education of Children in the Context of Rapid Fertility Decline," *Population and Development Review*, Vol. 16, pp. 31-56.

Knodel J. And Wongsith M. (1991), "Family Size and Children's Education in Thailand: Evidence from a National Sample," *Demography*, Vol. 28, pp. 119-131.

Krugman, P. (1994), "The Myth of Asia's Miracle," *Foreign Affairs,* Vol.73, pp. 62-78.

Kuznets, S. (1967), "Population and Economic Growth," *Proceedings of the American Philosophical Society,* Vol.111, pp. 170-93.

Leff R.D. (1969), "Dependency Rates and Savings Rates," *American Economic Review*, Vol. 59, pp. 886-896.

Leibenstein, H. (1978), *General X-Efficiency Theory and Economic Development.* New York: Oxford University Press.

Maddison A. (1995), *Monitoring the World Economy, 1820-1992*, Organisation for Economic Co-operation, Paris.

Malthus T.R. (1798), *An Essay on the Principle of Population,* London: W. Pickering 1986.

Mason A. (1981), "A Extension of the Life-Cycle model and its Application to Population Growth and Aggregate Saving," *East-West Institute Working Paper* No. 4, Honolulu.

Mason A. (1987). "National Saving Rates and Population Growth: A New Model and New Evidence," in Johnson D.G. and Lee R. Eds., *Population Growth and Economic Development: Issues and Evidence*, Madison: University of Wisconsin Press.
Mason A. (1998),

Meltzer D. (1995), "Mortality Decline, the Demographic Transition, and Economic Growth," mimeo, Brigham and Women's Hospital and NBER.

Mincer J. (1974), *Schooling, Experience and Earnings*, New York, NBER.

Mitchell B.R (1992), *International Historical Statistics: Europe, 1750-1988*, Stockton Press, New York.

Mitchell B.R. (1993), *International Historical Statistics: The Americas*, 1750-1988, Stockton Press, New York.

Mitchell B.R. (1995), *International Historical Statistics: Africa, Asia and Oceania*, 1750-1988, Stockton Press, New York.

Myrdal G., *Asian Drama.*

Nelson, R.R. (1956), "A Theory of the Low-Level Equilibrium Trap in Underdeveloped Economies," *The American Economic Review,* Vol. 46, pp. 894-908.

Paxson C.H. (1996), "Savings and Growth: Evidence from Micro Data," *European Economic Review*, Vol. 40, pp. 255-288.

Prescott, E. C. (1998), "Needed: A Theory of Total Factor Productivity," *International*

Economic Review Vol. 39, pp. 525-51.

Preston S. (1975), "The Changing Relation Between Mortality and the Level of Economic Development," *Population Studies*, Vol. 29, pp. 231-248.

Preston S. (1980), "Mortality Declines in Less Developed Countries," in R. Easterlin, Ed., *Population and Economic Change in Developing Countries*, Chicago: University of Chicago Press.

Pritchett, L.H. (1994), "Desired Fertility and the Impact of Population Policies," *Population and Development Review* Vol. 20, pp. 1 – 55.

Pritchett L. and Summers L.H. (1996), "Wealthier is Healthier," *Journal of Human Resources*, Vol. XXXI, pp. 883-855.

Psacharopoulos G. (1994), "Returns to Investment in Education: A Global Update," *World Development*, Vol. 22, pp. 1325-1343.

Quah D.T. (1997), "Empirics for Growth and Distribution: Stratification, Polarization, and Convergence Clubs," *Journal of Economic Growth*, Vol. 2, pp.27-59.

Rosenzweig M.R. (1990), "Population Growth and Human Capital Investments: Theory and Evidence," *Journal of Political Economy*, Vol. 98, pp. S38-S70.

Rostow W.W. (1960), *The Stages of Economic Growth: A Non-Communist Manifesto,* Cambridge: Cambridge University Press.

Sachs, J. and Warner, A. (1995), "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity 1,* pp. 1–118.

Schultz T.P. (1994), "Human Capital, Family Planning, and Their Effects on Population Growth," *American Economic Review*, *Papers and Proceedings*, Vol. 84, pp. 255-60.

Sheehey E.J. (1996), The Growing Gap Between Rich and Poor Countries: A Proposed Explanation," *World Development*, Vol. 24, pp. 1379-1384.

Simon, Julian. 1981. *The Ultimate Resource,* Princeton: Princeton University Press.

Strauss J. And Thomas D. (1998), "Health, Nutrition and Economic Development," *Journal of Economic Literature*, forthcoming.

Strulik H. (1997), "Learning-by-doing, Population Pressure, and the Theory of

Demographic Transition," *Journal of Population Economics*, Vol. 10, pp. 285-298.

Summers R. and Heston A. (1991), "The Penn World Table (Mark5): An Expanded Set of International Comparisons, 1950-1988," *Quarterly Journal of Economics*, Vol. 106, pp. 327-368.

Swift J. (1729), *A Modest Proposal for preventing the children of poor people in Ireland, from being a burden on their parents or country, and for making them beneficial to the publick.*

Wang J. and Jamison D.T. (1997), "Education and Income as Determinants and Fertility: Regional and Temporal Variation in Effects," mimeo, World Bank.

Webb S. and Zia H. (1990), "Lower birth Rates = Higher savings in LDCs," *Finance and Development*, Vol. 27, pp. 12-14.

Williamson J. (1997), "Growth, Distribution and Demography: Some Lessons from History," *NBER working paper* No. 6244, Cambridge: National Bureau of Economic Research .

Wrigley E.A. and Schofield R.S. (1981), "The Population History of England 1541-1871," Edward Arnold Ltd., London.

Young A. (1994), "Lessons from the East Asian NIC's: A Contrarian View," *European Economic Review*, Vol. 38, pp. 964-973.

Young A. (1995), "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience," *Quarterly Journal of Economics*, Vol. 110, pp. 641-680.