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Geography, Demography, and Economic Growth in Africa

THE POVERTY of sub-Saharan Africa is one of the most obdurate features of the world economy. Since the industrial revolution, this has been the world's poorest and also its most slowly growing region. The most reliable estimates of world and regional gross domestic products for the period 1820–1992 are those prepared by Angus Maddison.[1] Figure 1 shows estimated long-term growth profiles for selected regions. According to these estimates, sub-Saharan Africa (hereafter, Africa) began the modern era at approximately one-third of the income level of the richest region at that time, Western Europe. In 1992 it had approximately one-twentieth of the income level of the richest region, Maddison's "western offshoots," which includes the United States, Canada, Australia, and New Zealand. Maddison estimates that Africa's per capita income in 1992 was approximately that of Western Europe in 1820:

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1. Maddison (1995).

$1,284 in Africa compared with $1,292 in Europe, in purchasing power parity (PPP) 1990 international dollars.[2] Although this is only a gross approximation, it highlights the extent of Africa's economic plight.

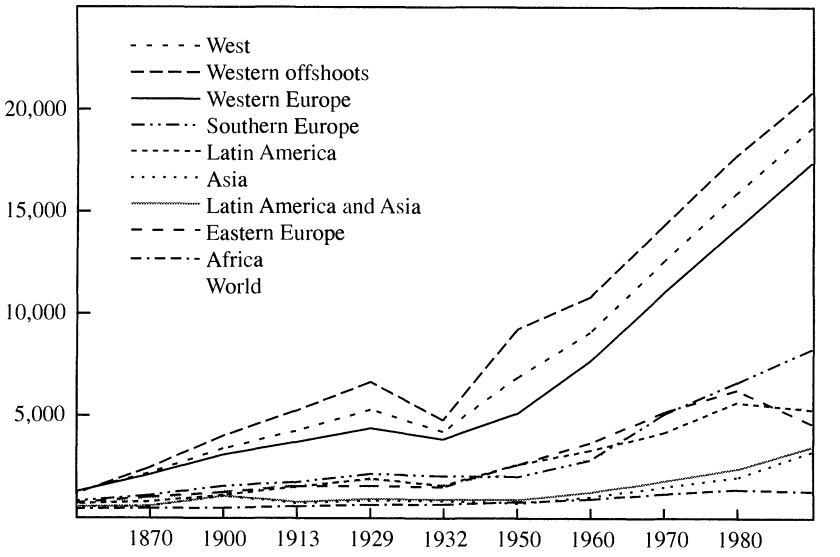
Africa's poor economic growth has been chronic rather than episodic. Maddison examines five major subperiods for Africa: 1820–70 (the precolonial era); 1870–1913 (the onset of colonial rule up to World War I); 1914–50 (the world wars and the Great Depression); 1950–73 (late colonial rule and early independence); and 1973–92 (the recent period). As shown in table 1, he estimates that Africa had slow growth during each of these subperiods. Many observers today point to Africa's growth during 1950–73 and its subsequent slowdown as an argument that postindependence governments severely undermined the potential for rapid economic growth. It is apparent from the table, however, that even in this most successful subperiod Africa's growth lagged behind that of the rest of the world. From a quite different perspective, many observers in the early 1960s, at the start of Africa's independence from colonial rule, argued that Africa's long period of slow growth (relative to the rest of the world) would end once the colonial yoke was removed. This manifestly did not happen. African per capita income growth averaged 1.5 percent in the 1960s, 0.8 percent in the 1970s, and −1.2 percent in 1980s. Output per capita continued to decline from 1990 to 1996 at a rate of 0.9 percent per year.[3] Africa's overall slow growth has continued despite intensive reform efforts during the past decade. This record of growth is perhaps the greatest disappointment and surprise of recent African history.

Over the period 1985–96, per capita economic growth averaged −0.6 percent per year (weighted by population); twenty-one countries out of the forty-two for which data are available experienced negative per capita economic growth. There were a few notable success stories.

2. Maddison's data show that Africa's per capita income increased by a factor of almost 2.5 between 1820 and 1992. Although not negligible, this figure is small compared with those for other regions of the world. For example, over the same period per capita income increased by factors of 14.9, 7.4, and 5.9 among Western countries, Latin America, and Asia, respectively. Likewise, per capita income in Africa was 68 percent of the world average in 1820, but only 24 percent by 1992. Relative to per capita income in Western Europe, income in Africa declined from 35 to 7 percent over this period.

3. The income growth figures are population-weighted averages of purchasing power parity (PPP)-adjusted per capita income data. Through the 1980s, they are drawn from the Penn World Tables, version 5.6. Data for the 1990s are from World Bank (1998).

Figure 1. Economic Growth by Region, 1820–92[a]



Source: Maddison (1995).

a. Note: periods between plotted points are uneven, to highlight certain major disruptions in trends, for example, the Great Depression.

Sample includes fifty-six countries. Regions are defined as follows: *Western Europe* Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, United Kingdom; *Western offshoots* Australia, Canada, New Zealand, United States; *Southern Europe* Greece, Ireland, Portugal, Spain, Turkey; *Eastern Europe* Bulgaria, Czechoslovakia, Hungary, Poland, Romania, U.S.S.R., Yugoslavia; *Latin America* Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela; *Asia* Bangladesh, Burma, China, India, Indonesia, Japan, Pakistan, Philippines, South Korea, Taiwan, Thailand; *Africa* Côte d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Morocco, Nigeria, South Africa, Tanzania, Zaire.

b. 1987 PPP-adjusted international dollars.

Equatorial Guinea and formerly war-torn Mozambique lead the way with growth rates averaging 8.4 and 5.5 percent per year, respectively.[4] Traditionally fast-growing Mauritius and Botswana achieved per capita growth of more than 4 percent per year, while Uganda, a recent reformer, grew at a rate of 3.3 percent per year. Ghana, a reformer since the early 1980s, grew at a rate of 1.5 percent. In fact, in 1995 average African per capita growth achieved a recent high of 1.7 percent per year, apparently the result of policy reforms in preceding years combined with widespread good weather conditions. In 1996 it was about

4. From 1992 to 1995, Equatorial Guinea grew at a rate of 21 percent per annum on the basis of significant discoveries and development of offshore oil.

Table 1. Economic Growth by Region, 1820-92[a]
Percent (annual rates)

Period and size	*West Europe*	*Western offshoots*	*South Europe*	*East Europe*	*Latin America*	*Asia*	*Africa*	*World total*
1820–69	1.0	1.4	0.6	0.7	0.2	0.1	0.1	0.6
1870–1912	1.3	1.8	1.1	1.0	1.5	0.6	0.4	1.3
1913–49	0.9	1.6	0.4	1.2	1.5	0.1	1.0	0.9
1950–72	3.9	2.4	4.9	3.5	2.5	3.8	2.1	2.9
1973–92	1.8	1.4	1.7	−1.1	0.5	3.2	−0.1	1.2
1820–92	1.5	1.7	1.4	1.1	1.1	1.0	0.6	1.2
Number of countries	12	4	5	7	7	11	10	56

Source: Maddison (1995, table 3-1).
a. Growth is measured in GDP per capita. For definition of regions, see appendix G in Maddison.

the same, at 1.6 percent per year, but it then declined to 0.8 percent per year in 1997. A recent forecast by the International Monetary Fund (IMF) puts growth for 1998 at 1.1 percent.[5] And despite the recent growth, per capita income in 1997 was approximately 2.9 percent below its 1991 level.

The World Bank places Africa's 1996 per capita GDP at $1,259 in 1987 PPP-adjusted prices (5.9 percent of the U.S. level). Fifteen of the world's poorest twenty countries are in Africa. Moreover, our estimates indicate that in 1990, 47 percent of Africa's population lived in abject poverty, that is, with income of less than $1 per day. Finally, in terms of the United Nations Development Programme's human development index, which takes into account life expectancy and literacy as well as per capita GDP, thirty-two of the forty countries that rank lowest, and nineteen of the bottom twenty, are in sub-Saharan Africa.[6]

In recent debate, six sets of factors have frequently been invoked to account for Africa's poor economic performance:

—external conditions: the legacy of centuries of slave trading and colonial rule, as well as the manipulation of African politics during the cold war;

—heavy dependence on a small number of primary exports, with declines and volatility in terms of trade;

5. Evangelos A. Calamitsis, "Africa's Recent Economic Performance and Challenges and the Role of the IMF," 1998, p. 2; available on the worldwide web page of the IMF.

6. United Nations Development Programme (1997).

—internal politics: characterized by authoritarianism, corruption, and political instability;

—economic policies: protectionism, statism, and fiscal profligacy;

—demographic change: in particular, rapid population growth; and

—social conditions: deep ethnic divisions, indicated by high levels of ethnolinguistic and religious diversity and low levels of "social capital."

Although there is some evidence in support of each of these explanations, we believe that they miss an even bigger truth. At the root of Africa's poverty lies its extraordinarily disadvantageous geography, which has helped to shape its societies and its interactions with the rest of the world. Sub-Saharan Africa is by far the most tropical—in the simple sense of the highest proportions of land and population in the tropics—of the world's major regions, and tropical regions in general lag far behind temperate regions in economic development. Moreover, in several dimensions its environment is without parallel in raising obstacles to growth. As consequences of its climate, soils, topography, and disease ecology, Africa suffers from chronically low agricultural productivity (especially food production), high disease burdens, and very low levels of international trade, which is concentrated in a few primary commodities.

The region's economic performance is further impeded by its demographic circumstances, which are themselves most likely related to Africa's poor geographic and economic conditions. Africa has the world's highest youth dependency ratios, a consequence of the combination of the world's highest fertility rates and falling levels of infant and child mortality. High youth dependency ratios impose a substantial drag on African economies by reducing their productive capacity per capita. Low life expectancies and extremely youth-heavy age distributions also tend to be associated with lower rates of saving and investment (as conventionally measured), and therefore slower economic growth. The youthful structure of Africa's population pyramid and the sluggishness of its transition to lower fertility rates indicate that African economies will be burdened by rapid population growth for several decades.

A few countries in the tropics have made significant breakthroughs in economic growth in the past twenty-five years, in almost all cases through the promotion of manufacturing or service sector exports. Their experiences suggest that technologies in manufactures and services can

diffuse across climatic zones much more readily than technologies in agriculture. It is probably no coincidence that the greatest tropical success stories—Hong Kong and Singapore—are small island economies with negligible agricultural sectors and rapid growth in manufacturing and service sector exports.[7] With the sole exception of Mauritius, no African country has made a similar transition to export-led growth in manufactures or services. This is partly the result of Africa's greater inherent difficulties, but also due to the fact that neither African governments nor the IMF or the World Bank have promoted the kinds of institution needed for such a transition; the ultimate irony of the "structural adjustment programs" of the Bretton Woods institutions is that they promoted virtually no structural change. After twenty years of reform, Africa remains the exporter of a narrow range of primary commodities (for example, oil, diamonds, copper, gold, coffee, tea, cocoa, palm oil, and rubber), most of which are suffering long-term declines in international terms of trade.

Much too little is known about the effects of climate, topography, and natural ecology on public health, nutrition, demographics, technological diffusion, international trade, and other determinants of economic development to make definitive claims. Therefore at many points below we present informed speculation. One goal of the paper is to stress the need for intensified research on the complex issues at the intersection of ecology and human society.

Our paper could well be misunderstood. Some will regard it as a new case of "geographic determinism" arguing that Africa is fated to be poor because of its geography. Some will regard it as a distraction from the important truth that, geographic difficulties or no, African governments have seriously mismanaged economic policy in the past generation. Let us therefore be clear at the outset. We believe emphatically that economic policy matters, and our formal econometric results show that to be true.[8] We nonetheless focus on geography for three reasons. First, there is little to be gained from yet another recitation of the damage caused by statism, protectionism, and corruption to African

7. We point out below that these economies are also blessed by the fact that as islands, they are better able to control vector-borne tropical diseases such as malaria, which has been eradicated in both.

8. We also make this point in recent related studies; see, in particular, Sachs and Warner (1997).

economic performance. Second, most economists are woefully neglectful of the role of forces of nature in shaping economic performance in general, and in Africa in particular. They treat economies as blank slates onto which another region's technologies and economic history may be grafted. A healthy counterexample is the recent study of world economic history by David Landes, which in its very first chapter assigns geography an extremely prominent role as a determinant of long-term performance.[9]

Third, and perhaps most important, good policies must be tailored to geographical realities. If agricultural productivity is very low in Africa for climatological reasons, perhaps the real lesson is that growth should be led much more by outward-oriented industry and services, rather than blindly making yet another attempt to transplant "integrated rural development" strategies from other parts of the world without customizing them to Africa's unique conditions. At the very least, the intensification of scientific research on tropical agriculture in Africa—along the lines of that underpinning the "green revolution" in South and East Asia—is warranted, since current technologies are insufficient for dramatic improvements in agriculture.

The paper is organized as follows. In the next section we discuss the general problems of tropical development and put Africa's problems in worldwide tropical perspective. We then discuss demographic trends in Africa, emphasizing the low levels of population density and urbanization and the delayed demographic transition compared with other developing regions. In the following section we use standard cross-country growth equations, augmented with demographic and geographic variables, to account for the relative roles of geography, demography, and policy in Africa's recent growth experience. We then consider future growth strategies, and especially the urgent need for urban-based export growth in manufacturing and services. Finally, we summarize our conclusions and discuss an agenda for future research.

Geography and Economic Development in Africa

Sub-Saharan Africa is the tropical region *par excellence*, with 93 percent of its land area lying between the Tropic of Cancer and the

9. Landes (1998).

Tropic of Capricorn. At the root of Africa's long-term growth crisis is Africa's extraordinary geography. As Fernand Braudel writes: "In understanding Black Africa, geography is more important than history. The geographical context is not all that matters, but it is the most significant."[10] Thomas Sowell also emphasizes geography, especially its role in making cultural interaction more difficult both between Africa and the rest of the world and within Africa.[11]

An Overview of Tropical versus Temperate Development

In all parts of the world, economic development in tropical zones lags far behind that in temperate zones. In 1995 tropical economies averaged $3,326 in GDP per capita (PPP-adjusted), while the nontropical countries averaged $9,027.[12] In a world ranking of countries by GDP per capita, only two of the top thirty lie in the tropics: Hong Kong and Singapore.[13] These are also the only two tropical economies that the World Bank currently classifies as high-income economies. And what is true across countries is also true within countries that straddle the tropics and temperate zones, such as Australia and Brazil: the temperate regions within these countries are much more highly developed than tropical regions.[14]

10. Braudel (1995, p. 120).

11. Sowell (1998) quotes Braudel approvingly in his excellent chapter on Africa. For extremely comprehensive and illuminating treatments of long-term linkages among geography, health, and economic development, see Diamond (1997); Landes (1998); Reader (1998). In addition, see Hall and Jones (1997) for recent empirical evidence that a country's distance from the equator is strongly positively associated with income per capita.

12. Since many countries straddle the tropics, for purposes of discussion we define a tropical country as one in which half or more of the land area lies between the Tropics of Cancer and Capricorn. The GDP per capita calculations are based on the universe of countries with populations of 1 million or more, a total of 150 countries covering approximately 99 percent of the world's population. There are seventy-two such tropical countries, of which forty-one are in Africa—including all sub-Saharan African countries except South Africa and Lesotho. The tropical countries have a combined 1995 population of 2.3 billion, or 41 percent of the total in our universe of countries. Their combined land area is 45 million km^2, out of a total of 129 million km^2 in our universe, or 35 percent.

13. World Bank (1998). These data are PPP-adjusted, expressed in current international dollars.

14. On Brazil, see Gallup, Llussa, and Sachs (1998).

Within the African continent, the small temperate zones at the north and south have significantly higher incomes than the tropical core. The five North African countries have an average 1995 income of $4,371 (PPP-adjusted), compared with tropical sub-Saharan Africa's average of $1,732, and nontropical South Africa's $7,348. The average of four southern countries—South Africa and Lesotho in the temperate zone and Botswana and Namibia, which straddle the tropics—is $5,438. According to the World Bank, the three fastest growing countries in sub-Saharan Africa during 1985–95 were Botswana, Mozambique, and Namibia, all of which straddle the tropical and temperate zones at the southern end of the continent.[15]

Productivity growth in the tropics has lagged far behind productivity growth in the midlatitudes since the middle of the nineteenth century, and all evidence suggests that the temperate zone continues to be the dynamic center of innovation in the world economy. Well over 90 percent of global R&D expenditure and at least that percentage of patents worldwide originate in the northern midlatitude economies. Such differences in productivity growth and innovation probably reflect the interplay of four related factors. First, many kinds of technologies—for example, in agriculture and construction—do not transfer well across ecological zones. Second, the temperate zones have long had much higher rates of endogenous technical change than the tropics. One reason for this might be the simple fact that the northern hemisphere midlatitudes have had much larger populations than the tropics throughout history (at least since 1500), and so have offered much larger markets for innovation. Since innovation has crucial increasing returns to scale properties, this advantage would tend to cumulate over time. Third, the tropics seem to pose several inherent difficulties, especially in agriculture and public health. Fourth, the tropics are disadvantaged simply because they are far from the large midlatitude markets; many firms choose to locate near larger markets in order to lower transport costs from suppliers and to final customers. Problems of transport costs are especially acute for African countries, both within the continent and between it and the rest of the world. Distance alone is *not* the main explanation of the shortfall in tropical development, however. The

15. World Bank (1997b, table 1, p. 214).

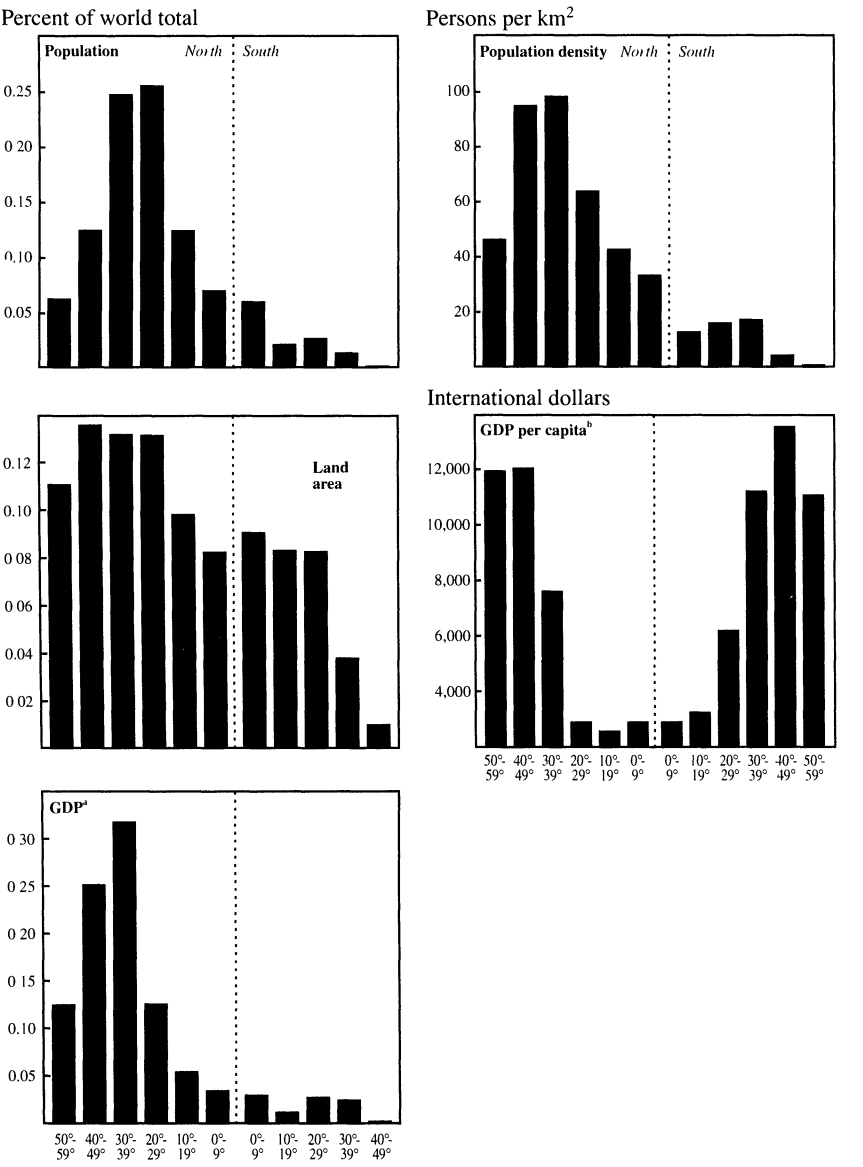
southern hemisphere temperate zone economies are even farther from the main world markets than are the tropics, but are considerably richer in per capita terms. The problem seems to lie with the tropics itself.

Figure 2 shows the world allocation of population, land area, population density, aggregate GDP, and GDP per capita, by 10° latitude bands (thus the tropical region is closely but not exactly captured by the bands from latitudes 20° N to 20° S).[16] To make the allocations of GDP by latitude band, we maintain the counterfactual simplification that per capita incomes are uniform within countries, so that the geographic allocation of GDP within a country that extends across one latitude band is allocated solely according to the distribution of its population across bands. This procedure no doubt overstates the share of income in the tropics, since, as noted above, the per capita income gradient within countries favors temperate zone regions compared with tropical regions.

The first important point from figure 2 is that the bulk of human population (62 percent) and almost half of the land mass (45 percent) are between latitudes 20° N and 50° N. Indeed, almost three-fourths of the human population (73 percent) resides in the great Eurasian land mass and closely associated islands, of which only a very small part (8 percent of the land and 14 percent of the population) lies in the geographical tropics. The northern hemisphere midlatitudes are not only the most populated region but also the most densely populated. Population densities fall off in the high latitudes (above 50° N), as well as in the tropics and the southern hemisphere nontropics. We believe that this differential population density reflects, at a deep level, three forces. First, as a basic biological condition, the photosynthetic potential for food production is probably highest in the midlatitudes. This would give advantage in achieving high population densities to both northern and southern hemisphere midlatitudes relative to the tropics and the high latitudes. Second, long-term endogenous technical change, which has been inherently favored by the large populations in the temperate regions (interacting with scale effects in innovation), has further

16. Between the tropical latitudes 23.45° N and 23.45° S, the population stands at 1.2 billion, or 21 percent of the world population of 5.7 billion. The tropical land area is 45 million km^2, or 35 percent of a world habitable land area of 129 million km^2. The average tropical population density is 39.1 persons per km^2, compared with the nontropical population density of 45.2 persons per km^2.

Figure 2. World Allocation of Geographic, Demographic, and Economic Variables by Latitude, 1995



Source. Environmental Systems Research Institute (1992), Tobler and others (1995), World Bank (1998)
a PPP-adjusted real GDP
b PPP-adjusted

boosted the population-carrying capacities of the midlatitudes. Third, the southern hemisphere mid- and high latitudes have very little land, and therefore offer a very small local market compared with the northern hemisphere. Even if technologies in the temperate northern and southern hemispheres are fully transferable, enterprises will choose to locate in the northern hemisphere rather than the southern hemisphere in order to benefit from the proximity to markets.

Figure 2 also shows the remarkable U-shaped distribution of per capita GDP by latitude band. The northern and southern mid- and high latitudes are rich compared with the tropical zone. This panel strongly suggests that technologies readily diffuse between the northern and southern temperate regions, so that Argentina, Australia, Chile, New Zealand, and South Africa benefit from the technological advances of the northern temperate zone, as well as sharing some intrinsic advantages relative to the tropics. The small southern markets do not support large populations or large population densities, because of their great distance from the main world markets, but they do support high per capita living standards. In figure 3 we show GDP per capita by ten-degree latitude bands for three sub-regions: the Americas, Africa, and Eurasia and Oceania. In each case, the U-shaped pattern is plainly evident.

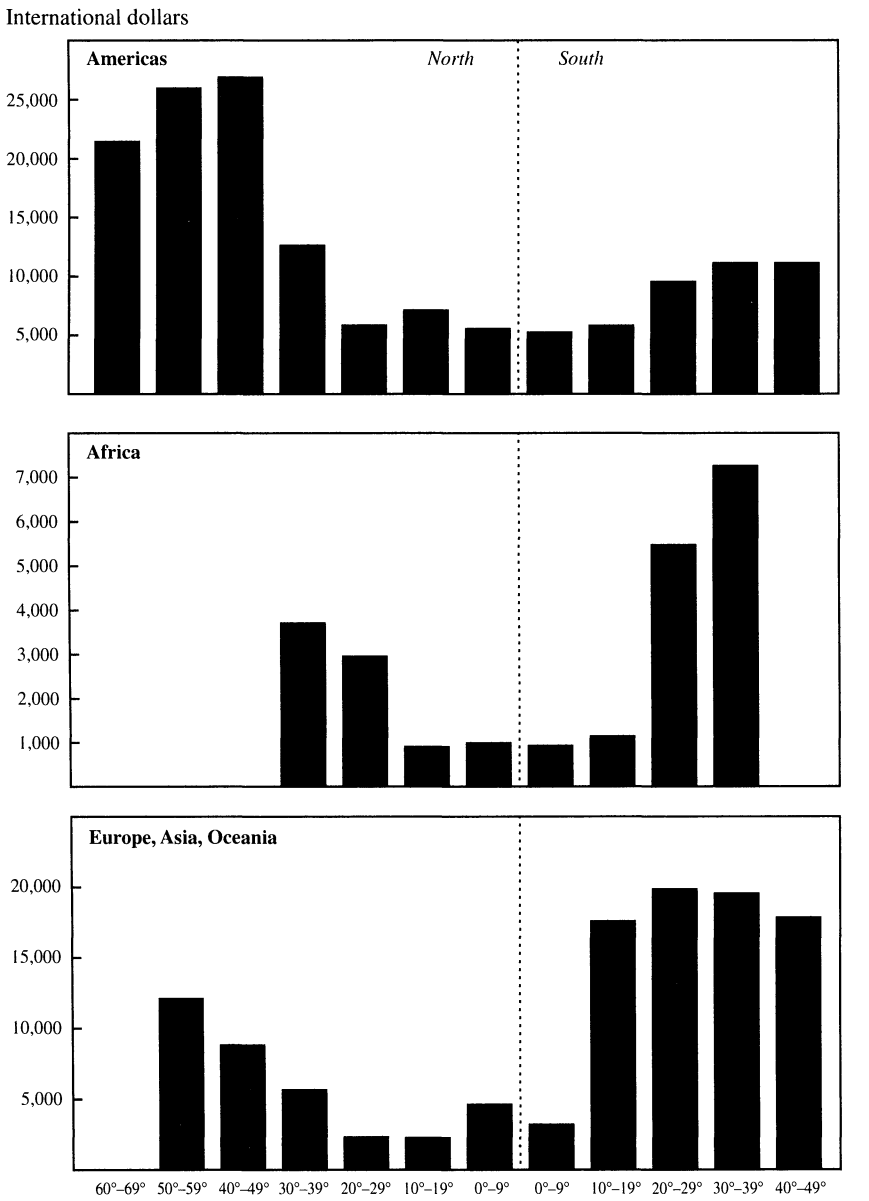
The combination of large land area, high population density, and high per capita income leads to a remarkable concentration of overall world GDP in the northern mid- and high latitudes. No less than 69 percent of world GDP, on a PPP basis, falls within latitudes 20° N and 60° N. Only 12 percent of world GDP lies within latitudes 20° N and 20° S.[17]

The Tropical Environment and Agricultural Productivity

As stated above, the income lag in the tropics reflects three forces: endogenous technical change biased toward the large temperate zone markets, inherent difficulties of the diffusion of technology across ecological zones, and inherent liabilities of the tropics in agriculture and

17. The figure of 69 percent is based on an equal allocation of GDP per capita within countries. If in fact per capita income is higher in temperate than in tropical zones in countries that straddle both regions, the share of GDP in the northern temperate band would be even higher.

Figure 3. GDP Per Capita by Latitude, Selected Regions, 1995[a]



Source: Environmental Systems Research Institute (1992), Tobler and others (1995); World Bank (1998)
a PPP-adjusted

health. In this section we discuss the problems of agriculture: why agricultural technologies do not easily diffuse from temperate zones to the tropics and why the tropics are inherently disadvantaged in food production. And we examine the special case of Africa in this regard. In the following section, we present a comparable discussion of health issues.

Although the tropics include a wide array of climatic and ecological zones, there are several important common features. First, temperatures at sea level are uniformly high throughout the year; the major temperature gradients are related to altitude—a decline of approximately 0.4°C to 0.5°C for each 100 m of height—and land mass—higher temperatures in the interior of continents, lower temperatures where moderated by the sea or monsoon rainfall. Second, insolation is generally high year round, except where it is limited by cloud cover, as it tends to be over the equator. Third, there is no freezing except at very high altitudes, such as in the tropical Andes region, or the highest mountains of East Africa. Fourth, day and night are approximately equal in length throughout the year. At the equator, all days are twelve hours in length, not including diffuse sunlight at dusk and dawn. At the tropical boundaries, the shortest day (on the winter solstice) is approximately eleven hours, and the longest day (on the summer solstice) is approximately thirteen hours.

Within these common parameters, tropical climates vary greatly due to latitude, altitude, ocean currents, the size and configuration of land masses, location within continents (east coast climates, for example, are markedly different from west coast climates), relation to mountain ranges, and so forth. Our analysis of the effect of climatic variation within tropical Africa is based heavily on the Köppen-Geiger classification system, as reported by Tom McKnight.[18] Around the equator in Africa, as in most of the tropics around the world, lies a zone of intense year-round rainfall and high temperature, which produces the great equatorial rain forests of West Africa, the Amazon Basin, and Southeast Asia. In Africa, this band is concentrated within latitudes 5° S to 5° N, but in West Africa (Liberia and Sierra Leone) it also exists around 10° N. In the latitude bands of approximately 5° to 20° both north and south

18. McKnight (1995).

of the equator, the climate is generally characterized by a wet summer season and dry winter season. Such alternating seasons with high temperatures around the year produce the vast savannas (grasslands) that cover roughly 60 percent of the African continent. Within these bands, the farther from the equator, the longer is the dry season. Closer to the equator, the climate supports grassy woodlands; the far edges of the bands are extremely dry and support only open grassland, as in the Sahel region just south of the Sahara desert. Beyond 20° latitude, the arid zone tends toward desert. In the northern hemisphere in Africa, such deserts include the Sahara and parts of the Horn of Africa. In the southern hemisphere, they include the Namib and the Kalihari.

Much of East and southern Africa rests on a high plateau at least 1,000 m above sea level, with a range of much higher mountains. The high plateau mitigates the intense heat of the tropics and generally receives more precipitation than land at sea level. In part this is an orographic effect, in which the mountains cause moist tropical air brought from the Indian Ocean by easterly trade winds to rise, resulting in condensation. Thus while coastal East Africa is extremely hot and generally arid, the eastern highlands are cooler and much wetter. The results are profound: most of the populations of East Africa live up in the highlands and therefore far from the sea. What is gained in agriculture is sorely lost in transport costs!

The climate in tropical Africa differs from other parts of the tropical world for several key reasons. First, because Africa is a large land mass, vast interior parts of the continent become extremely hot, as the temperature is not moderated by proximity to the sea. By contrast, in the island economies of Southeast Asia, temperatures at similar latitudes and altitude are tempered. Second, Africa does not receive the great monsoon rainfalls that provide vital seasonal precipitation to South and East Asia. A lesser monsoon phenomenon occurs in part of West Africa, centered on Nigeria, but there is no equivalent in East Africa. Thus in general in Africa, either it rains all year round, as near the equator, or seasonal rainfalls are much less than in South and East Asia. Higher precipitation occurs in the East African highlands, due to orographic effects.

As a result of lower rainfall and higher mean temperatures, much of Africa's soil-water balance (measured as precipitation minus potential

evapotranspiration) is highly unfavorable—much less favorable than in many other tropical regions.[19] Much of Africa suffers from serious aridity and a constant risk of drought. Further increasing the risk of drought, rainfall variability (measured as absolute average percentage departure from the mean) is much higher in Africa than in tropical America or Asia.[20] World Bank drought indicators show that twenty-nine African countries experienced at least one year of drought during 1983–95. These countries include 50.9 percent of the African population. Twenty-four countries (with 46.7 percent of the population) experienced at least two years of drought, and fourteen countries (with 28 percent of the population) experienced three or more years.[21]

Tropical climates pose serious difficulties for agricultural productivity, especially for many food staples. As Jen-Hu Chang argues, "the rational choices are fewer and less appealing in the humid tropics than in most other climatic regions of the world."[22] In addition to obvious factors such as temperature and rainfall, Chang cites several biological phenomena that distinguish plant growth in the tropics and temperate zones. First, plants often use the length of sunlight as a stimulus to flower (photoperiodism). Since there is little variation in the length of the day in the tropics, many temperate zone plant species would not be induced to flower, whereas several tropical species have adapted to the twelve-hour sunlight in the growing season, as "short-day" plants. Second, many plants require a period of cold temperatures in order to flower and develop (vernalization). Third, many plants require variation in insolation (or radiation variation) to develop properly. A fourth problem, specific to the humid tropics, is the lack of a dry season, since many plants can only bloom during the dry period of the growing season. The key economic plant species endemic to the tropics—for

19. The soil-water balance compares the rate of precipitation, which makes water available for photosynthesis, with the losses of water due to evaporation and transpiration (which are combined in the term evapotranspiration). Potential evapotranspiration measures the rates of evaporation and transpiration that would take place if there were an abundant supply of water and a complete cover of vegetation. Thus in a barren desert, for example, actual evapotranspiration may be essentially zero (since there is neither precipitation nor transpiration), but potential evapotranspiration could be very high, since the high temperatures would promote rapid evaporation and transpiration in the presence of ample precipitation and vegetation cover.

20. Strahler and Strahler (1991, fig. 10.24, p. 187).

21. World Bank (1997a, p. 241).

22. Chang (1968, p. 361).

example, sweet potato, yam, taro, coconut, oil palm, cocoa, coffee, tea, groundnut, cassava, nutmeg, banana, mango, papaya—are specifically adapted to these conditions. But these four factors deeply constrain the variety of plant crops that can grow in the tropics.

In addition to factors that limit the variety of plant crops, there are also basic biological factors that limit agricultural yields in warm tropical zones. Crop yields depend on net photosynthesis, that is, the generation of energy net of the energy that the plant uses to stay alive and to develop. Plant consumption of energy, or respiration, is dependent on temperature, with higher respiration in warmer conditions. In areas where temperatures remain very high at night, losses of net photosynthetic potential are particularly high: what is gained by sunlight during the day is lost at a rapid rate at night, so that net photosynthetic potential in the warm tropics is reduced. Chang notes that "other factors being equal, an increase of 2° to 3° C of mean annual temperature, particularly night temperature, can spell the difference between profit and loss in the operation of tropical plantations."[23]

As temperature (especially night time temperature) is such an important regulator of net photosynthetic potential, many of the most fertile areas of the tropics are at relatively high altitudes, for example, the highlands of East Africa and the Andes, the mountainous spine of Central America, and the Himalayan foothills. These environments generally enjoy not only lower night time temperatures, but also greater precipitation (due to orographic rainfall), and often volcanic soils rich in nutrients. But in these cases, the increased productivity comes at a high price: the economic isolation of populous communities from regional and international trade due to heavy transport costs from the mountain regions. It is the irony of tropical highlands that the most densely populated countries in Africa are Rwanda and Burundi—with 244 persons per km^2 and 259 persons per km^2, respectively—which lie in the interlacustrine highlands of the Great Lakes region. Although they are blessed with plentiful rainfall and subtropical temperatures, they suffer profound economic isolation, which contributes to their ranking among the world's ten poorest countries.

The tropics face another problem in addition to high temperature. It is usually supposed that usable sunlight during the growing season is

23. Chang (1968, p. 347).

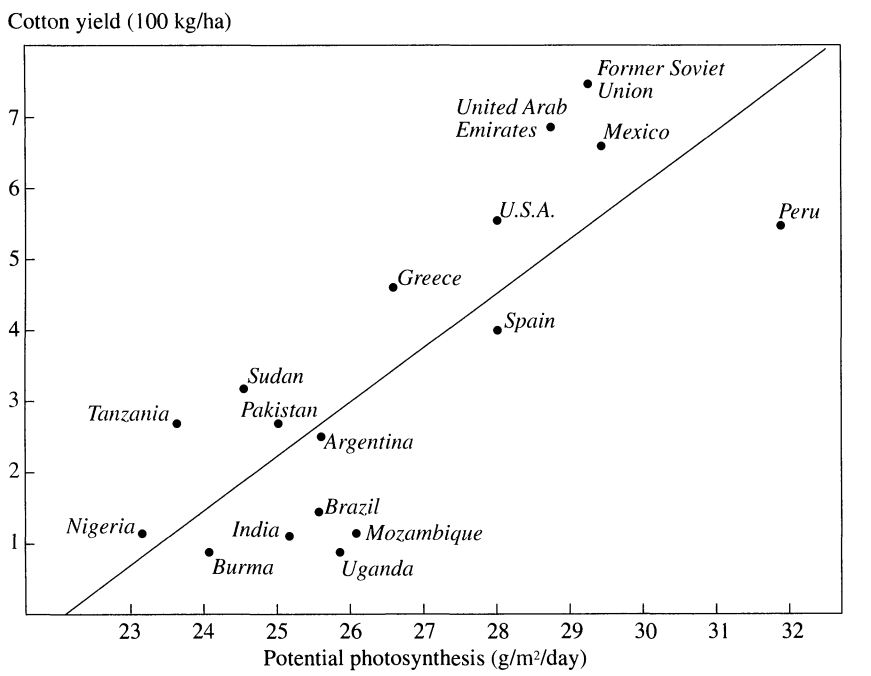
much greater in the tropics than in the midlatitudes and that photosynthetic potential is therefore greater. However, while in the tropics there are around twelve hours of sunlight per day throughout the year, in the midlatitudes during the interval between the vernal and autumnal equinoxes there are considerably more than twelve hours of sunlight per day (and there are much fewer than twelve hours in the interval between the autumnal and vernal equinoxes). At 40° latitude, for example, the summer solstice has fifteen hours of sunlight. Thus for crops that are grown once or twice a year, in a four to eight month period, the amount of available sunlight in the annual crop cycle will actually be much higher in the midlatitudes than in the tropics. This conclusion holds even after accounting for variation in the angle at which sunlight strikes the earth at different latitudes and times of year. By contrast, the extent of tropical sunlight is greater for crops that can grow year round (such as bananas and oil palm) and in regions such as eastern Java, where precipitation patterns and water control allow for multiple crops throughout the year, rather than tying crops to the rainy season.

If one combines the effects of sunlight and night time respiration, it appears that the intrinsic advantages of the temperate zones in photosynthetic potential for crops with a four- to eight-month growing season can be very large. Phillip Porter concludes: "The net effect of these latitudinal differences is that crops that can be grown in a four- to six-month period (e.g., maize, wheat, sorghum, soybeans, and cotton) will have higher yields [in the mid-latitudes] than their counterparts grown in the tropics."[24] For both cereals and root crops, yields in the tropics are much lower than in the temperate zones and are especially low in Africa.

Cotton provides an instructive example, since it is grown in both temperate and tropical climates, and the European colonial powers attempted to develop profitable cotton production in tropical Africa. In almost all cases, the African plantations produced disappointingly low yields. Figure 4 suggests that such low yields are an intrinsic feature of the lower photosynthetic potential of the low-altitude tropics relative to the temperate zones and the highland tropics of Peru, where night time respiration is considerably reduced by cooler temperatures. The issue of intrinsic geographical differences in agricultural productivity remains

24. Porter (1995, p. 46).

Figure 4. Effect of Potential Photosynthesis on Cotton Yields, Selected Countries[a]



Source Porter (1995, p 42)
a. $R = 0.67$

poorly studied and a matter of continuing debate, but it is surely one that agricultural economists should turn to with more focus and effort.

Agricultural productivity is affected by more than temperature and sunlight, however. Water, soil, and pests also have profound importance. The question of water is complicated, since what counts is the soil-water balance, that is, precipitation net of potential evapotranspiration. Because of the very high temperatures in the tropics, evapotranspiration is very high, and usable water is often scarce, even in areas of relatively high rainfall. Much of tropical Africa is therefore vulnerable to arid or semi-arid conditions; the exceptions are those parts of West and Central Africa that receive equatorial rainfall, those parts of West Africa that receive monsoon rainfall, and parts of the East African highlands. Moreover, since rainfall outside of the narrow equatorial

rain forest band is highly variable, much of Africa is vulnerable to drought. There is also evidence of a long-term decline in rainfall in the Sahel, which may be linked to anthropogenic climate change, both local, possibly resulting from deforestation and overgrazing, and global, resulting from greenhouse gas emissions.

Moreover, only 4.0 percent of crop lands in Africa are irrigated, compared with 11.1 percent in Latin America, 35.1 percent in South Asia, and 51.8 percent in China.[25] This is arguably due to problematic soils, topography, and lack of suitable water supplies. It is one of the most interesting and important practical questions for Africa's agricultural future whether significantly more land could be brought under cost-effective irrigation. If the current lack of irrigation is a matter of social custom, land-use patterns, public goods provision, and appropriate technologies, then much more land could perhaps be irrigated, with important effects on productivity. If, instead, the limited agriculture reflects intrinsic weaknesses due to the manifold factors mentioned above, any improvements in productivity are likely to be seriously hindered by the continued dependence on rain-fed agriculture.

Soil quality is multidimensional—related to texture, capacity to hold water, nutrient content, and other factors—and also crop specific. Moreover, the qualities of soil can be highly variable within a narrow geographical range. In some parts of the tropics, volcanic soils provide a rich nutrient base, so that high population densities are often found in well-watered volcanic zones, such as Java, the islands of the Philippines, parts of the central Mexican Valley, and parts of the highlands of East Africa. In much of Africa, however, soils are very poor. Much of the land is heavily weathered, with a large concentration of oxisols in Central Africa.[26]

Soil problems are greatly compounded in rain forest environments, since torrential rains leach the soils of nutrients. As a result, the great bulk of nutrients in rain forest ecosystems are actually found above ground, in the plant growth, rather than in the soils. The soils maintain

25. World Bank (1998, table 3.2).

26. Oxisols are "very old, highly weathered soils of low latitudes, with an oxic horizon and low CEC [cation-exchange capacity]. . . . The level of plant nutrients under natural conditions are so low that the yields obtainable under hand tillage are very low, especially after a garden patch has been used for a year or two. Substantial use of lime, fertilizers, and other industrial inputs is necessary for high yields and sustained production." (Strahler and Strahler, 1991, pp. 460, 472.)

their fertility only by the rapid decomposition of dead plant material, which is then quickly recycled into new plant growth. When rain forests are cleared for agriculture, the nutrient cycle is broken and the soils are quickly depleted, which is why shifting (swidden) cultivation has characterized traditional agricultural systems in rain forest ecozones.

The disease environment is another complicating factor of tropical agriculture. As we discuss with regard to human disease, many veterinary disease vectors are concentrated in the tropics, since cold weather, and especially freezing temperatures, are barriers to the reproduction and survival of both vectors and microbes. Thus much of African woodlands, the zone between the equatorial rain forest and the arid savanna both north and south of the equator, was effectively off limits to cattle raising until very recently because of trypanosomiasis (cattle sleeping sickness), transmitted by the tropical tsetse fly. Likewise, plant pests are prolific. Insect pests, such as locusts, are far more destructive in the tropical environment than in the midlatitudes, and massive rodent populations cause widespread crop damage.

To summarize, tropical agriculture, especially food production, is faced with chronic problems of low yields and fragility due to low photosynthetic potential, high evapotranspiration, low and variable rainfall, highly weathered soils, veterinary diseases, and plant and animal pests. In Africa, these problems are particularly severe. Large parts of equatorial West Africa are rain forest zones, with very high temperatures, fragile soils, extreme precipitation, and therefore extreme limits in food potential. These regions specialize in cash crops adapted to the humid tropical environment and tend to be net importers of foodstuffs. Outside of the equatorial zone, a large part of the continent lies in semi-arid or arid zones, which are problematic for food production because of insufficient water and the ever-present risk of drought. The moderately watered woodland areas also suffer from serious pests, poor soils, and high temperatures. Much of the relatively successful agriculture takes place in the East African highlands, but as a result, local populations are isolated from internal and international trade.

Infectious Disease and Economic Development in Africa

Tropical populations have lower life expectancies at birth than those in temperate zones, and the effect seems to hold even after controlling

for per capita income levels. In our cross-country growth equations reported below, we show that low life expectancy at birth is highly predictive of slow economic growth, after controlling for initial income levels, economic policy, and a set of demographic and geographic variables. The unweighted average life expectancy at birth of all non-African tropical countries in 1992 was 66.3 years, compared with 49.8 years in tropical Africa. In nontropical countries, the corresponding figure was 70.4 years.

In a simple regression (not reported here) of life expectancy on per capita income and mean ambient temperature, as a measure of tropical conditions, we find that hotter climates display systematically lower life expectancies. The point estimate suggests a loss of 2.3 years of life expectancy at birth for each 10°C increase in average annual temperature. We do not attribute this to the direct effects of heat on body stress, since the best evidence shows that populations can become well acclimatized to a very wide range of ambient temperatures and that even hard physical work effort is not generally impeded by high temperatures, except under extreme conditions.[27] Rather, we believe that high temperatures mainly affect nutrition and disease ecology, which indirectly affect human morbidity and mortality. One key linkage is through endemic vector-borne infectious diseases. The evidence suggests that the burden of infectious disease is vastly higher in the tropics than in the temperate zones, both as a percentage of total disease burden, as measured by total disability-adjusted life years (DALYs), and in absolute DALYs per capita.[28]

Health conditions in Africa are very poor in comparison with the rest of the tropics.[29] With a life expectancy of 53.8 years in 1995, Africa

27. Heat is debilitating when the body's heat load cannot be relieved by sweating, that is, when ambient temperatures are around or above body temperature and when humidity is very high. In these circumstances, heat stress can occur rapidly in association with heavy physical labor.

28. The burden of disease refers to DALYs lost due to disease or injury. It aims to combine morbidity and mortality into a single summary measure of disease burden. See Murray and Lopez (1996).

29. For example, using 1965 data for a sample of 107 countries, the regression of log life expectancy at birth (*LEB*) on log income per capita (*LY*), percent of the country's land area located within the tropics (*TR*), and an Africa dummy (*AF*), yields the following result: $LEB = 3.2 + 0.12\,LY - 0.06\,TR - 0.18\,AF$ ($R^2 = 0.75$), in which all coefficients have p values of less than 0.1. These results, which are closely comparable

has the poorest regional health status in the world. The nature of its disease burden is significantly different from that faced by other regions: 42.5 percent of lost DALYs in sub-Saharan Africa are caused by infectious and parasitic diseases, as compared with 28.9 percent in India (the next highest percentage), and 2.8 percent in the market economies of Europe.[30]

It is not fully known why Africa has been extraordinarily vulnerable to so many infectious diseases. To understand the linkages between geography and disease, epidemiologists need to unravel an enormous number of channels of potential interaction. Climate may affect health through nutrition, disease vectors, human behavior, prevalence of parasites, exposure to natural disasters, and so on. There are also significant feedback mechanisms between factors, for example, nutrition and vulnerability to a specific infectious disease. Since so little is known about many of these interactions in the tropical setting, and the quality of data on causes of death and morbidity are very poor for most of Africa, we are not in a position to describe the disease ecology of the African tropics in any detail. We illustrate the core issues by looking at two infectious diseases of profound consequence for Africa, the traditional killer malaria, and the new epidemic killer HIV/AIDS. Lessons from vector-borne diseases such as malaria no doubt shed light on other endemic infectious diseases such as yellow fever (transmitted by the mosquito *Aedes aegypti*), leishmanaisis (transmitted by the sand fly), trypanosomiasis (transmitted by the tsetse fly), schistosomiasis (transmitted by snails), and various helminth (worm) infestations, such as onchocerciasis (river blindness), roundworm, and hookworm.[31]

MALARIA. Malaria is widely recognized as one of the most serious health problems faced by the region. It is estimated that between

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to those based on 1995 data, indicate that income-adjusted life expectancy is relatively low in Africa, even by tropical standards.

30. The African percentage is from Murray and Lopez (1996, p. 261).

31. On the mathematical biology of vector-borne infectious disease in general, see Anderson and May (1991), especially chapter 14. On the public health perspective on tropical disease, see various essays in Jamison and others (1993). On the biology of hookworm, see Peter J. Hotez and David I. Pritchard, "Hookworm Infection," *Scientific American*, vol. 272, no. 6, pp. 68–74 (1995). They estimate that one in five of the world population suffers from hookworm, with a heavy concentration in the tropics, since the worm larvae need a warm and moist environment to survive and grow before infecting a human host.

1 million and 2 million Africans die from malaria each year, out of a continentwide total of roughly 9 million deaths per year. Malaria is caused by a protozoan parasite, which is transmitted among humans by means of a mosquito host, or vector. Of the four species of *Plasmodium* parasite that cause malaria—*P.falciparum*, *P.malariae*, *P.ovale*, and *P.vivax*—the first is by far the most deadly. The vectors of malaria include about a hundred different species of the genus *Anopheles*. When an infected vector bites a susceptible human, it may transmit the parasite. If an uninfected vector bites an infected person, it may imbibe the parasite. In the latter case, it may then transmit the disease to a new human host. The most important vector species in Africa are *An. gambiae* in the rainy season and *An.funestus* in the dry season. Where they coexist, this pair of vector mosquitoes may sustain transmission perennially.

Individuals who contract and survive repeated episodes of malaria gradually acquire partial immunity. In highly endemic communities, therefore, children tend to experience far more morbidity and mortality than do adults. Acquired immunity is relatively short-lived, however, if an individual leaves the malarial environment.[32] There is no vaccine or effective long-term medical prophylaxis. Treatments exist, but fail to reach a large proportion of affected individuals because of problems of cost, availability, and education. Besides, the rapid spread of drug resistance is reducing the effectiveness of many medications, including chloroquine, mefloquine, and fansidar. Certain preventative methods, such as the use of insecticides and bed nets treated with insecticide, have had some success, but insecticide resistance tends to grow over time.

The epidemiology of malaria is extremely complex, since it involves interaction among human, mosquito, and parasite. The disease ecology of malaria depends not only on the density of *Anopheles* mosquitoes relative to the human population, but also on mosquito longevity relative to the life cycle of the parasite within the mosquito. Once ingested by a vector mosquito, the parasites transform over a period of eight to twelve days into the sporozoite stage, which can subsequently infect other humans. If the mosquito dies before this incubation period is

32. Oaks and others (1991).

completed, it never becomes infective, even though it carries the parasite. For our purposes, the crucial biological fact is that this extrinsic incubation period is regulated by temperature. In the case of falciparum malaria, the transformation is likely to occur only if the ambient temperature is above 22°C; for vivax malaria, above 18°C.[33] Thus the transmission of malaria tends to be stable in hot climates, unstable in warm but not hot climates, and absent in cool climates, such as in most temperate zones and above the 2,000m level in most of the tropics. In Africa, malaria tends to be stably transmitted both because *An.gambiae* and *An.funestus* are long-lived and human-specific and because the climate favors the development of falciparum malaria. A stably transmitted pathogen perpetuates readily, even in the face of energetic public health interventions.

This ecological point is consistent with evidence on reductions in the prevalence of malaria since World War II. In 1946, the range of the disease extended to many subtropical regions, including southern Spain and Italy, the Levant, and Central Asia. During the 1950s and 1960s, the U.S. government and the World Health Organization spearheaded a global eradication campaign, which relied solely on indoor application of the insecticide DDT to control mosquito populations. The campaign was a failure relative to its initial bold goal of total eradication, but it did succeed in eliminating malaria in a limited geographic range, mainly the areas of southern Europe from which the disease was already beginning to recede by the early 1950s, and the islands of Jamaica and Taiwan. Other notable successes during this period included Hong

33. Mathematical modeling employs the concept of the basic reproduction number (BRN) of a disease, defined for microparasites such as malaria as the number of secondary infections deriving from each primary infection in a totally susceptible population (May and Anderson, 1990). Restated as a rate per day based on entomological parameters, the BRN is termed vectorial capacity (VC) and is expressed as

$$VC = \frac{ma^2p^n}{-\ln p},$$

where m is mosquito density (relative to human population); a is the number of bites per mosquito per person per day; n is the length of the extrinsic incubation period; p is the duration of mosquito life; and e is the natural logarithm base, that is, about 2.718 (Garret-Jones and Shidrawi, 1969). This equation demonstrates that the transmission of malaria is sustained when the vector population is long-lived and primarily bites human hosts.

Kong, Mauritius, and Singapore, all of which were greatly advantaged by their island geography, and Malaysia, where the prevalence of mosquitoes was easier to control for other reasons.

In sum, the failure of Africa to control the disease is not mainly the result of poor public health measures, unresponsive governments, or poverty, but rather is due to the natural environment, in which mosquito longevity exceeds the latency period of mosquito infectivity. Moreover, *Anopheles gambiae,* the most effective vector of falciparum malaria, is exclusive to sub-Saharan Africa.

Although the development implications of malaria and other vector-borne diseases are hard to ascertain with precision, they are likely to be very serious. Numerous studies have estimated the microeconomic costs of the disease, including both direct and indirect costs. Personal medical care costs, including expenditures on medicines, treatment fees, transportation to health facilities, and prevention measures such as bed nets and insecticides, have been estimated to range between $5 and $75 per household per year in Africa.[34] Furthermore, there are public health expenditures on prevention and treatment of the disease. These differ greatly across the region and are not easy to estimate, as the symptoms of malaria often make it difficult to identify. Estimates of the loss of productivity associated with malaria vary widely. In a recent review of studies that estimate time lost due both to the illness itself and to the care of sick family members, Reginald Chima and Anne Mills report a range of one to five days of productivity loss per person due to adult illness, and one to four days loss per sick child. Malaria also reduces the returns to investment in schooling, as it causes children to miss school days and is believed to diminish long-term cognitive performance. Incorporating both direct medical costs and costs of lost productivity, Donald Shepard and others estimated that the annual economic burden of malaria in Africa was $0.8 billion in 1987, representing 0.6 percent of GDP, and projected a rise to 1 percent of GDP in 1995 due to increasing severity and drug resistance.[35]

We hypothesize that the indirect costs of falciparum malaria are much higher than the direct costs, though this is merely a conjecture based on macroeconomic evidence. Sachs and John Gallup have found

34. See Chima and Mills (1998).
35. Shephard and others (1991).

in cross-country growth equations that falciparum malaria is associated with reduced annual GDP growth of more than 1 percentage point, after controlling for other standard policy and structural variables.[36] We surmise that these high costs come not only through microeconomic effects, but also from barriers to technical diffusion and foreign investment in endemic malarial regions. Historical accounts of interactions between Africa and the rest of the world in the past 500 years repeatedly stress that malaria has been a major barrier—perhaps the major barrier—to Africa's normal integration into the world economy. Until the advent of quinine in the second half of the nineteenth century, Europeans could barely survive in coastal settlements, much less venture into the interior. As of 1790, there were only around 25,000 Europeans living in continental Africa, of which an estimated 21,000 (84 percent) lived in the temperate-zone Cape Colony.[37]

Richard Hall describes the period of Portuguese exploration and colonization on the African coastline as follows: "Eastern Africa and western India were the obvious places where a good harbor and some surrounding land might be seized then declared a Portuguese possession. Africa, however, had already proved to be infested with deadly fevers: the Kilwa fort . . . had to be abandoned after only seven years. On the mainland further south, small trading stations set up at Sofala and Mozambique were intended to give succour to ships which had just rounded the Cape, but these ships often discovered more dead and dying on shore than they were themselves carrying."[38] Similarly, historian C. L. R. Boxer points to malaria as one of the main reasons why Portugal did not found a colony in Luanda (Angola) in the sixteenth century.[39] And nineteenth century explorer David Livingstone cited quinine, together with the breech-loading rifle, as vital tools in his mission to "civilize" Africa.

Malaria continues to present serious obstacles to foreign investment and tourism in many parts of Africa. Foreign businessmen lack the immunity acquired by African adults who have experienced repeated bouts of malaria since early childhood. Prophylaxis with existing medicines is imperfect and often not feasible for periods longer than a few

36. Gallup and Sachs (1998b).
37. Hugon (1993, p. 18).
38. Hall (1996, pp. 214–15).
39. Cited in Thomas (1997).

weeks. Conversely, malaria is a problem for Africans who travel abroad for prolonged stays, since their acquired immunity will diminish within months if not boosted by repeated infection.

HIV/AIDS. This is perhaps the most daunting health problem currently hanging over Africa's economic future—even more daunting than malaria. From 1985 to 1995, over 4 million Africans died of AIDS, and nearly 10 million more deaths are expected by 2005. Of the more than 30 million people in the world living with the HIV infection, 21 million are in sub-Saharan Africa. Among HIV-infected people in the world, six out of ten men, eight out of ten women, and nine out of ten children live in Africa. In 1998 an estimated 600,000 babies in Africa will be born with HIV; many more will be infected as infants through breast feeding, which is currently chosen as a better option than costly infant formula mixed with unsafe water. And AIDS has greatly jeopardized the economic and social futures of 8 million African children who have been orphaned by the disease. Nearly half of the world's 16,000 new HIV infections per day occur in Africa, which, given the lengthy time lag (about eight to ten years for adults) between infection and the onset of clinical symptoms, suggests that the AIDS epidemic will continue well into the future. As over 80 percent of AIDS deaths have occurred among twenty to forty-nine year olds, the epidemic is offsetting decades of normal improvement in life expectancy in several African countries.[40]

HIV infection rates vary considerably across countries in Africa. Surveillance data collected among representative samples of pregnant women suggest that one in four adults in Botswana, Zambia, and Zimbabwe is infected, with rates approaching one in three in a number of urban areas. By contrast, HIV prevalence is considerably lower in Angola (2.1 percent), Equatorial Guinea (1.2 percent), and Senegal (1.8 percent). Complicating the problem is the fact that several types and subtypes of the virus are spreading at different rates in different parts of the continent. At least one subtype, HIV-I-C, is rapidly spreading throughout southern Africa and is replacing other subtypes currently common in East Africa.

In contrast to malaria, it is difficult to link geography definitively to the virulence of the current AIDS epidemic, but because of its eco-

40. Bloom and others (1996); UNAIDS (1998).

nomic, social, and cultural conditions, Africa is extremely vulnerable to the spread of HIV. Specific factors that underlie Africa's extreme vulnerability include high rates of multiple sexual partnering and of sexually transmitted diseases; widespread use of untested and contaminated blood and blood products and nonsterile medical practices; reliance on breast feeding, which carries a 10 to 14 percent risk of HIV transmission from an infected mother to her child; low rates of condom use; low levels of education; and very high proportions of the population in the sexually active years (see below).[41] In addition, large numbers of intracontinental migrants and refugees and high rates of urbanization, especially among young men seeking seasonal work, contribute to the spread of HIV via social patterns and practices arising from increased anonymity and separation from family.

HIV/AIDS imposes a heavy economic burden on many African economies. Notwithstanding the inaccessibility of the expensive ($16,000 per year) "drug cocktails" currently used to treat those infected with HIV in wealthy industrial countries, the costs of detecting the infection and treating its clinical manifestations—for example, pneumonia, tuberculosis, diarrhea, and fever—are significant and well in excess of per capita public expenditures on health care in Africa, which range between $10 and $15 per year. Access to health care centers is extremely limited in many rural areas of Africa, and the transportation costs can represent a nontrivial share of household income. There are currently no vaccines, cures, or inexpensive treatments available for HIV infection, and due to the scientific complexity of the virus and its ability to mutate, there are none in sight.

HIV infection is also exacerbating the burden of other major diseases. As the greatest risk factor for the progression of tuberculosis infection from the primary-latent phase to the active phase, HIV is contributing to the resurgence of tuberculosis in Africa. An estimated 12 million Africans are infected with both HIV and *Mycobacterium*

41. Recent trials have demonstrated that mother to infant transmission can be reduced by up to 50 percent through the use of oral ziduvidine (AZT) by mothers in resource-poor settings. Although the cost of this drug protocol is roughly $70 per treatment, UNAIDS has succeeded in persuading its producer, Glaxo-Wellcome, to negotiate agreements with different countries in the hope of reducing that cost. However, most African countries have yet to negotiate such agreements. Also, the ancillary costs associated with HIV testing and counseling may make this treament prohibitively expensive for many people in Africa, given their severe poverty.

tuberculosis. In 1990 there were over 7 million cases of tuberculosis in Africa, and over 500,000 deaths. Like malaria and HIV, tuberculosis has a great proclivity for mutating into drug-resistant strains, making treatment (if any exists) extremely costly.

Perhaps even more important than the direct medical costs of AIDS, however, are the indirect costs embodied in loss of income and output. Because heterosexual sex is the dominant transmission category for HIV in Africa, AIDS tends disproportionately to afflict working-age adults, greatly exacerbating the economic burden imposed by the medical care costs associated with the disease. John Cuddington and John Hancock estimate the impact of AIDS on economic growth in Tanzania and Malawi, using macrosimulation models, and find an average reduction of GDP per capita growth of 0.25 percentage point per year. Using similar models, Mead Over estimates a reduction of 0.15 percentage point in sub-Saharan Africa. By contrast, using cross-country data from 1980 to 1992, Bloom and Ajay Mahal find no evidence of a statistically significant effect of AIDS on the growth rate of income per capita; however, their point estimates are negative and comparable in magnitude to those reported by Over.[42]

Africa's HIV/AIDS epidemic may also have important consequences for poverty and income inequality. The early data from Africa suggested a positive association between HIV infection and affluence, presumably because the number of partners and the demand for commercial sex increase with income. However, more recent data reveal a growing linkage between HIV infection and poverty, mainly because the uneducated have the least access to knowledge about which behaviors put them at high risk for contracting or transmitting HIV. The virus thus has considerable potential to further impoverish Africa's poor.

Transport Barriers and Economic Development in Africa

Poor agricultural and health conditions would be barriers enough to African growth, as they have been in other parts of the tropics. Yet the situation is made much worse by the continent's remarkable disadvantages in transport costs. The factors underlying these disadvantages include the great distance from major world markets in the northern

42. Cuddington (1993): Cuddington and Hancock (1994); Over (1992); Bloom and Mahal (1997).

midlatitudes—a common plight of the tropics—in particular, separation from Europe by the vast Sahara desert, larger than the continental United States; a very small coastline relative to land area; very few natural coastal ports; populations generally far from the coast; the highest proportion of landlocked states, and the highest proportion of the population within landlocked states, of any continent; and the absence of rivers leading into the interior of the continent that are navigable by ocean-going vessels, as are the Rhine, the Mississippi, the Amazon, and the Yangtze on other continents.[43] Sachs has demonstrated elsewhere that differences in transport costs, appropriately defined, can help to explain differences in overall growth performance.[44]

Adam Smith noted Africa's disadvantages for trade 222 years ago in the *Wealth of Nations*. He first stressed the importance of sea-based trade to an extensive division of labor and then drew implications for Africa and Central Asia:

> As by means of water-carriage a more extensive market is opened to every sort of industry than what land-carriage alone can afford it, so it is upon the sea-coast, and along the banks of navigable rivers, that industry of every kind naturally begins to subdivide and improve itself, and it is frequently not till a long time after that those improvements extend themselves to the inland parts of the country. . . .
>
> All the inland parts of Africa, and all that part of Asia which lies any considerable way north of the Euxine [Black] and Caspian seas, the antient Scythia, the modern Tartary and Siberia, seem in all ages of the world to have been in the same barbarous and uncivilized state in which we find them at present. . . . There are in Africa none of those great inlets, such as the Baltic and Adriatic seas in Europe, the Mediterranean and Euxine seas in both Europe and Asia, and the gulphs of Arabia, Persia, India, Bengal, and Siam, in Asia, to carry maritime commerce into the interior parts of that great continent.[45]

Table 2 shows that Smith's concerns about "inland" Africa continue to be important today. Only a small proportion of Africa's population,

43. In regard to length of coastline relative to land area, note that while western Europe has about one-eighth the land area of Africa (3.5 million km^2 compared with 29 million km^2), its coastline is about 50 percent longer (54,000 km compared with 35,000 km). In regard to water-borne access to the interior, all of Africa's major rivers, including the Nile, the Niger, the Congo, and the Zambezi, have sharp cataracts.

44. Radelet and Sachs (1998).

45. Smith (1776, pp. 27, 30).

Table 2. Indicators of Accessibility for Trade, by Region

Units as indicated

Region	Number of countries	Land area (million km²)	Population (millions)	Proportion of land area in tropics	Proportion of population			Distance to core market[c] (km)	Ratio of coast to land area[d]	Shipping costs[e] (ratio)	GDP per capita[f]
					Coastal[a]	Coastal or by river[a]	Landlocked[b]				
Sub-Saharan Africa	41	24	580	0.91	0.19	0.21	0.28	6,237	1.15	1.20	1,488
Western Europe	16	3	383	0.00	0.53	0.89	0.04	922	15.74	1.05	19,367
East and Southeast Asia	12	14	1,819	0.30	0.43	0.61	0.00	3,396	11.54	1.10	4,996
South Asia	5	4	1,219	0.40	0.23	0.41	0.02	5,744	2.45	1.10	1.469
Transition economies[g]	25	24	400	0.00	0.09	0.37	0.28	2,439	0.86	1.08	4,108
Latin America	22	20	472	0.73	0.42	0.46	0.03	4,651	2.54	1.11	6,332
All others	29	40	780	0.16	0.40	0.57	0.04	3,514	2.34	1.09	12,853

Source: Tobler and others (1995), Microsoft, Inc (1998), Radelet and Sachs (1998); World Bank (1997b, 1998); U.S. Central Intelligence Agency, *CIA World Factbook 1997* (available on the worldwide web)

a Within 100 km of coast or coast and river, as applicable

b Further than 100 km from coast or river.

c Unweighted average linear distance from capital city to the closest of the following ports: New York, Rotterdam, Tokyo

d 1,000 km of coastline per km² of land area.

e. Ratio of cost of insurance and freight (CIF) to free on board (FOB) cost for 1995, see Radelet and Sachs (1998)

f PPP-adjusted GDP per capita for 1995, in international dollars; regional averages, weighted by population

g Transition economies include Armenia, Azerbaijan, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Moldova, Mongolia, Poland, Romania, Russian Federation, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan These countries both have a common recent economic history and comprise a geographic region

around 19 percent, lives within 100 km of the coast. If one also includes populations close to rivers navigable by ocean-going vessels, this figure only rises to 21 percent, as compared with 67 percent in the United States and 89 percent in western Europe. Much of the population lives in the interior highlands, presumably attracted there by agricultural considerations of cooler temperatures and better precipitation. The problems of population distribution are compounded by political boundaries: there are no fewer than fourteen landlocked African countries with populations in excess of 1 million, and fully 28 percent of the sub-Saharan population lives in landlocked economies.

Table 2 also reports population densities near the coast (within 100 km) and inland (beyond 100 km). Based on earlier research by Gallup and Sachs, we expect a high coastal population density to support economic growth by facilitating a richer division of labor.[46] By contrast, high *inland* population densities appear to be neutral or detract from economic growth. Isolated populations are not able to enjoy a high division of labor because many of the inputs needed for modern production must come from international trade. High transport costs frustrate the needed trade linkages and keep the inland market too small to support a refined division of labor. Table 2 shows that Africa's coastal population density is the lowest of any region in the world, for reasons already noted: an unusually high proportion of the population is settled in the interior, where agriculture prospects are better. Inland population densities are also fairly low compared with other regions, but they are high relative to coastal population densities in Africa.

In addition, table 2 reports one convenient summary measure of transport costs on imports: the ratio of import prices including cost of insurance and freight (CIF) to free on board (FOB) import prices. The CIF-to-FOB ratio is much higher in Africa than for any other region. In 1995 the unweighted CIF-to-FOB ratio for African countries was 1.195 (that is, CIF prices were 19.5 percent higher than FOB prices), compared with 1.098 for East Asia, and 1.106 for Latin America.

The bottom line is extraordinarily high transport costs, especially over land within the continent, but also from low-volume sea ports to major markets in Europe, the United States, and Asia. According to World Bank estimates, for example, in 1995 the cost of shipping a

46. Gallup and Sachs (1998a).

twenty-foot-equivalent container from the West African port of Dakar to landlocked Bamako, Mali, a distance of around 1,000 km, was equal to $770, which is approximately 45 percent of the cost of shipping the container from Dakar to Rotterdam ($1,610), a shipping distance of around 5,000 km. Moreover, a container shipment from Dakar to Rotterdam cost around the same amount as a shipment from Singapore to Rotterdam, despite the fact that the latter distance (via the Suez Canal) is roughly 17,000 km. This high cost of sea transport per shipping kilometer probably reflects the relatively low volumes of trade and lack of competitiveness of Africa's ports.

Demography in Africa

Between 1950 and 1995, Africa's population grew at an average annual rate of 2.6 percent and more than trebled, reaching 561 million. This rate of increase is historically unprecedented among major regions of the world over comparable lengths of time. Asia and Latin America, the other main developing regions, have also experienced rapid population growth during the past half century, but at the lower rates of 2.0 percent and 2.3 percent, respectively.[47] Figure 5 shows Africa's shares of world income and population from 1820 to 1992. Africa's share of world population was fairly constant and below 5 percent from 1820 until around 1915 but has increased steadily since, reaching over 8 percent in the early 1990s.[48] A rising share of world population coupled with a relatively constant share of world income is one of the most important stylized facts of Africa's postindependence experience.

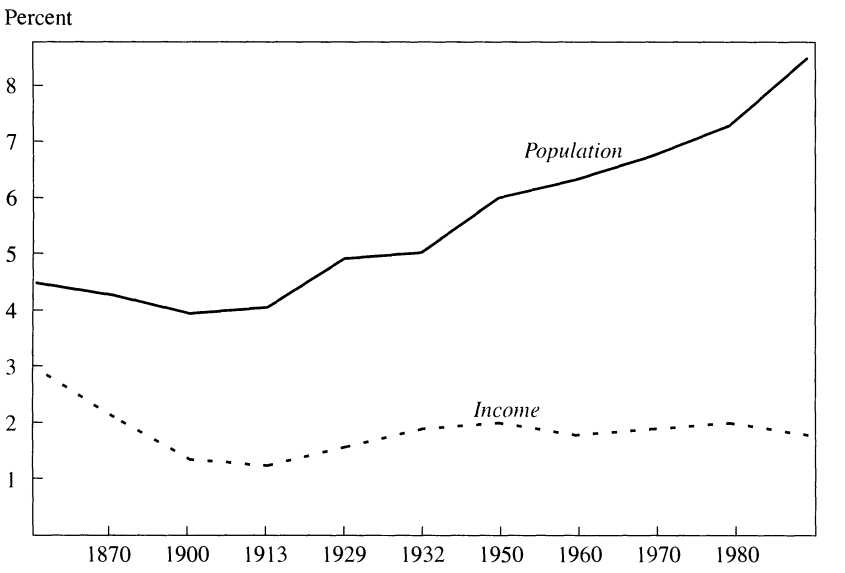
Population Density, Urbanization, and Ethnic Fractionalization

Most of Africa is sparsely populated, with an average population density of twenty-five persons per square kilometer, as compared with 148 persons in Asia. This low average population density reflects the weighted combination of vast expanses of almost empty desert (Chad

47. United Nations (1996); available on diskette.

48. Maddison (1995). By contrast, from 1700 to 1900 Africa's share of world population was declining or fairly constant, as the slave trade resulted in an absolute depopulation of the continent from 100 million in 1700 to a low of 90 million in 1850, and population growth accelerated in Europe (see Tarver, 1996; Austen, 1987).

Figure 5. Africa's Share of World Income and Population, 1820–1992[a]



Source Maddison (1995)
a. Note. periods between plotted points are uneven

has five people per square kilometer), large areas of sparsely populated savannas with weak agricultural potential, and few areas of relatively dense population. Regions of relatively high population density are mainly in the East African highlands near the Great Lakes—in particular, Burundi and Rwanda—as well as the section of coast running from southern Côte d'Ivoire to Nigeria, and the Indian Ocean island economies, for example, Reunion and Mauritius.

The low levels of population density are reflected in low levels of urbanization. Only 31 percent of Africa's population lives in urban centers.[49] This contrasts sharply with the high level of urbanization in Latin America (74 percent), but is comparable with that in Asia (30 percent). Furthermore, African urban centers are small by world standards. The largest sub-Saharan city, Lagos, ranks nineteenth in the world. Some capital cities, such as Gaborone in Botswana, are little more than trading posts. Despite lower fertility rates in Africa's urban

49. World Bank (1998).

centers as compared with its rural areas, urban population growth is proceeding more rapidly than in any other region of the world—about 5 percent per year since 1965—as a result of large-scale migration from rural areas.[50]

Two main factors would seem to explain the very low rates of urbanization in Africa. First, agricultural productivity is very low. Local food production cannot support large urban areas. Many of Africa's urban areas must be fed, at least in part, from international imports. Second, much of the population is in the highlands, or at least far from the coast or navigable rivers. However, urban centers are strongly favored by coastal (or riverine) locations, because low transport costs facilitate trade. In Africa, urbanization has tended to be associated either with administrative and political capitals, economically dependent on government spending rather than on their own international exports earnings; or with service centers for mining economies, living on the foreign exchange earned in the mining region rather than exporting to world markets. Thus as of 1994, the highest rates of urbanization in Africa were found in Congo (58 percent), an oil exporter; Mauritania (52 percent), an iron ore exporter; South Africa (50 percent), a gold and diamond exporter; Gabon (49 percent), an oil exporter; Cameroon (44 percent), an oil exporter; and Zambia (43 percent), a copper exporter.

Low population densities and low rates of urbanization tend to raise the costs of providing infrastructure services such as road networks, telephone systems, container port services, and urban sewerage. They are therefore important factors, in addition to low income, in the very poor state of African infrastructure, which (other than in South Africa and Mauritius) is among the worst in the world. As one example, the total length of paved roads in all of sub-Saharan Africa except South Africa was estimated to be 171,000 km as of 1992, about 16 percent less than the total of paved roads in Poland, about 206,000 km. Yet Poland has a mere 1.4 percent of the corresponding land area and just 8 percent of the corresponding population, and is also not a high-income country. Moreover, the World Bank estimates that just 39 percent of the sparse network of paved roads in Africa are in good condition. As another example, Africa had approximately 2.4 million main telephone

50. Cohen (1993).

lines in 1995, or 0.47 lines per one hundred households, about the same number of phone lines as in Norway, which has less than 1 percent of Africa's population.

Africa's demography, together with its geography, no doubt also account for a factor much discussed in recent writings on African growth: the extent of linguistic diversity. Linguistic diversity has been taken as a measure of strong ethnic cleavages in African societies and as a barrier to trade, and thereby as a potential explanation of Africa's growth shortfall. But we are skeptical of using it as an explanatory variable in this way, since linguistic diversity is itself a function of demographic and geographical variables that have a large and direct effect on economic performance. We find that African countries do not in fact have an especially high rate of linguistic diversity compared with other regions of the world, once one accounts for tropical environment (which, by restricting mobility, may plausibly promote linguistic diversity), the low proportion of the population near the coastline, the low population density, and a dummy variable for Latin America and the Caribbean (reflecting the extinction of many ethnic and linguistic groups following the Spanish colonization and the accompanying demographic collapse).

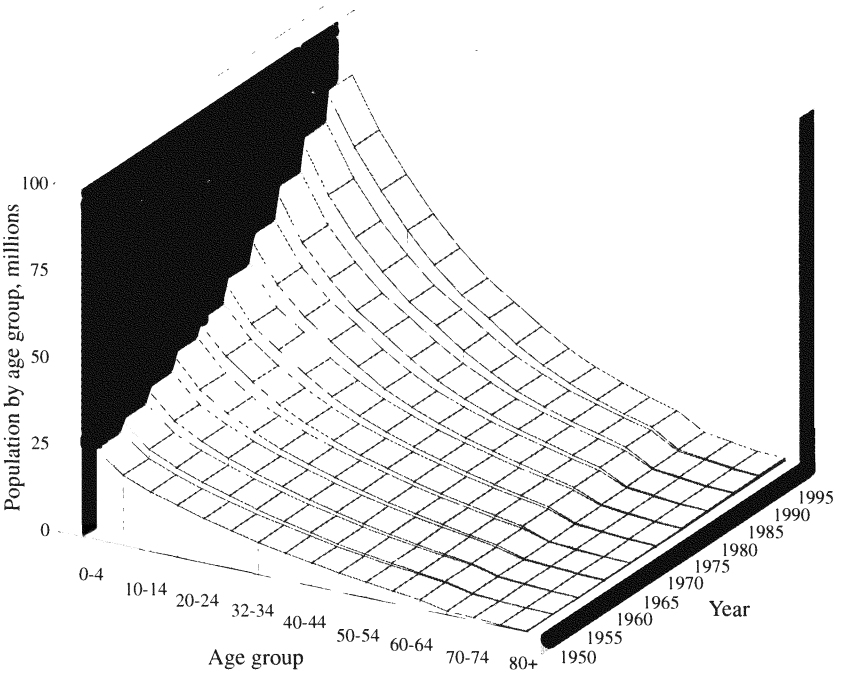
Delayed Demographic Transition

While most of the developing world has undergone a demographic transition from high fertility and high mortality to low fertility and low mortality, this process has stalled or progressed exceedingly slowly in Africa. As in most of the developing world, mortality declined sharply in Africa with the introduction of modern public health practices and health technologies after World War II.[51] The impact on child survival was particularly large, because antimicrobials are often powerful treatments for infectious diseases such as acute respiratory infections and diarrheal disorders.[52] Yet in contrast to other developing regions, Africa has not experienced corresponding declines in fertility to any appreciable degree (until, perhaps, very recently).

51. These health technologies include chloroquine, sulfa drugs, and powerful antibiotics such as penicillin and streptomycin, as well as DDT, which became available in 1943.

52. While life expectancy increased by roughly 20 percent from 1960 to 1995, infant mortality fell by 40 percent, from 159 to 96 deaths per thousand births.

Figure 6. Age Distribution in Sub-Saharan Africa, 1950–95.

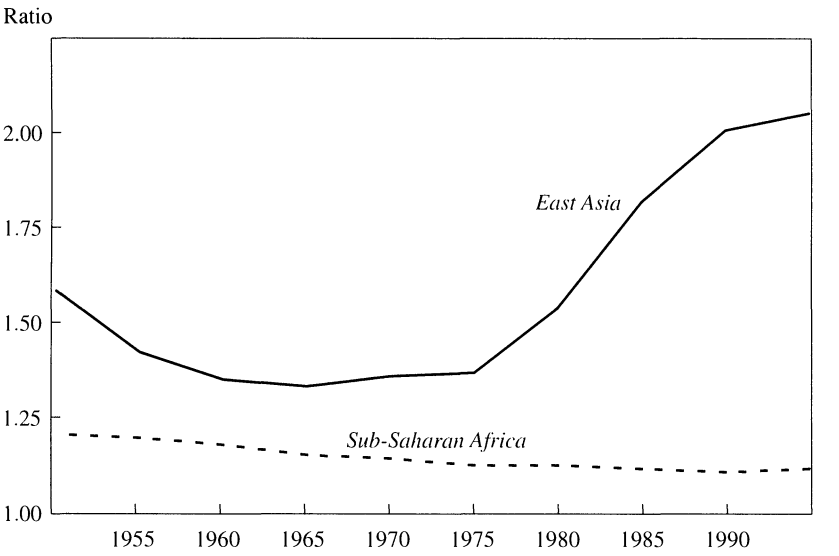


Source: United Nations (1996)

The combination of falling death rates, concentrated in the youth cohort, and stable birth rates have had two principal demographic consequences: rapid population growth and a skewing of the age structure toward the young ages. These trends are illustrated in figure 6. Population growth averaged 2.3 percent in the 1950s, 2.4 percent in the 1960s, 2.7 percent in the 1970s, and 2.9 percent from 1980 to present. By contrast, in Asia and Latin America population growth has fallen, from rates of 2.4 percent and 2.7 percent, respectively, in the 1960s to rates of 1.5 percent and 1.7 percent, respectively, over 1990–95. Africa's current population growth rate, which implies a doubling of the population in less than twenty-five years, is huge by historical and comparative standards and is certainly not sustainable over the long run.

Figures 6 and 7 show that accelerating population growth has swelled

Figure 7. Ratio of Working-Age to Dependent Populations, Africa and East Asia, 1950–95[a]



Source: United Nations (1992).
a. Working-age population is between the ages of fifteen and sixty-four; dependent population includes all others.

the youth cohort, and consequently decreased the ratio of the working-age to dependent populations. The working-age population (between the ages of fifteen and sixty-four) is roughly half of the total population of Africa, and this share has actually fallen slightly since 1950. This contrasts with the higher (60 to 70 percent) and generally rising share found in other regions. Cross-country data indicate that the working-age population in Africa grew at an almost identical rate to the total population from 1965 to 1990. In the rest of the world, by contrast, the working-age population grew, on average, 0.35 percent per year faster than the total population over the same period. This difference between African and world trends accounts for Africa's relatively high youth dependency ratio. Africa's youth dependency burden poses a significant impediment to the growth of income per capita, since labor force participation, productivity, and saving are low among the dependent population, relative both to the working-age population and to their own consumption and investment requirements.

Table 3, which reports total fertility rates and infant mortality rates

Table 3. Fertility and Infant Mortality by Region

Units as indicated

Region	1950–55		1990–95		Percent change in	
	Total fertility rate[a]	*Infant mortality rate*[b]	*Total fertility rate*[a]	*Infant mortality rate*[b]	*Fertility*	*Infant mortality*
Africa	6.6	185	5.7	94	−14	−49
Asia	5.9	180	2.8	62	−52	−66
East Asia	5.7	181	1.9	41	−67	−77
Oceania	3.8	69	2.5	26	−35	−62
Latin America and Caribbean	5.9	126	2.9	40	−50	−68
Europe	2.6	72	1.6	13	−39	−82
North America	3.5	29	2.0	9	−42	−69

Source: United Nations (1996).

a. Births per woman.

b. Deaths per 1,000 births.

across major world regions, demonstrates Africa's divergence from demographic trends elsewhere. It is striking that African fertility is so closely comparable to that observed in Asia and Latin America in the 1950s. Africa's demographic uniqueness, therefore, is not in the level of fertility but in the persistence of such a high level in the face of declining mortality rates. High fertility is the most salient feature of the continent's stalled demographic transition and the cause of its accelerating population growth and remarkably young age structure.

Contraceptive use increased modestly from a prevalence rate of 5 percent in 1960 to 17 percent in 1990. In East Asia contraceptive prevalence increased from 13 to 75 percent over the same period, and even in poorer South Asia, usage increased from 7 to 41 percent.[53] Table 4 summarizes fertility and contraceptive prevalence data collected in household surveys in seventeen African countries in the late 1980s and early 1990s. The most striking feature of the table is that in most countries not only total fertility rates but also "wanted" fertility rates, are above 5.0. Thus the provision of contraceptives is by itself unlikely to reduce fertility significantly. Africa's population problem is one of high desired fertility, rather than a need for contraceptive services. In contrast to other developing regions, eliminating unwanted fertility would have negligible to small effects on the achievement of replacement fertility levels (2.1 children per woman). Indeed, Africa's low levels of unwanted fertility are consistent with the pattern of extremely low rates of contraceptive prevalence among married women.

High fertility in Africa probably reflects a combination of low socioeconomic development (for example, in terms of education and gender inequality) and sociocultural practices that reinforce a preference for large families. There is an extensive literature on the determinants of fertility in Africa.[54] This literature notes that even after accounting for differences in infant mortality, income, education, and urbanization, Africa typically remains a positive outlier.[55] Explaining why this is so is an important research question.

53. Bongaarts (1994).

54. See, for example, Boserup (1985); Caldwell and Caldwell (1987); Caldwell (1991, 1994); Bledsoe (1994); Ainsworth, Beegle, and Nyamete (1995); Pitt (1995).

55. Chesnais (1992); Cohen (1993). Chesnais also provides a discussion of variance of socioeconomic "thresholds" and the onset of fertility decline in a not exclusively African context.

Table 4. Fertility and Contraception, Selected Sub-Saharan African Countries

Units as indicated

Country and year	Fertility rate[a]			Proportion of progress toward replacement level via wanted fertility rate[c]	Percentage of married women using contraception
	Total	Wanted[b]	Unwanted[b]		
Burkina Faso, 1993	6.9	6.0	0.9	0.19	7.9
Côte d'Ivoire, 1994	5.7	4.7	1.0	0.28	11.4
Ghana, 1988	6.4	5.5	0.9	0.21	12.9
Liberia, 1986	6.5	6.0	0.5	0.11	6.4
Madagascar, 1992	6.1	5.2	0.9	0.23	16.7
Malawi, 1992	6.7	5.7	1.0	0.22	13.0
Mali, 1987	6.7	6.9	. . .	. . .	4.7
Niger, 1992	7.4	7.1	0.3	0.06	4.4
Nigeria, 1990	6.0	5.8	0.2	0.05	6.0
Rwanda, 1992	6.2	4.4	1.8	0.44	21.2
Senegal, 1992–93	6.0	5.1	0.9	0.23	7.4
Sudan, 1989–90	5.0	5.9	. . .	. . .	8.7
Tanzania, 1991–92	6.3	6.4	. . .	. . .	10.4
1994	5.6	5.5	0.1	0.03	17.8
Togo, 1988	4.1	5.3	. . .	. . .	33.9
Uganda, 1988–89	7.3	6.8	0.5	0.10	4.9
Zambia, 1992	6.5	5.4	1.1	0.25	15.2
Zimbabwe, 1994	4.3	3.5	0.8	0.36	48.1

Source: Macro International (various years).

a. Births per woman.

b. A birth is "wanted" if the number of living children is less than or equal to the current ideal. Wanted fertility rates express the level of fertility that would prevail if all unwanted births were prevented. Unwanted fertility is total less wanted fertility. Note that in some cases, wanted fertility exceeds total fertility, possibly in part because some statistics refer to all women, while others refer only to currently married women.

c. That is, progress toward fertility rate of 2.1 children per woman that would be achieved by reducing the total fertility rate to the wanted rate.

We can identify two sets of factors that appear to be related to high fertility in Africa. First, in rural areas of Africa market activity is limited and corresponding financial institutions are poorly, if at all, developed, so that the scope for saving for old age is limited. Therefore children continue to be viewed as the current generation's main source of old age insurance. Similarly, formal labor market activity is limited, which tends to reduce the perceived costs to fertility. Children are also an important source of labor in rural settings, assisting both in smallholder cash crop agriculture, such as coffee, and in household work.[56] Second, sociocultural institutions and practices encourage large family sizes. The long history of low population densities and the ever-present struggle for survival in an environment of drought, low crop yields, slave trade, and infectious disease no doubt led to powerful norms of high fertility and large families, and these have changed only slowly in the face of rapidly declining infant mortality rates and rising population densities that limit the availability of farm land to divide among children.

Social structures that promote high fertility include fostering children, communal land tenure, and polygyny. The common practice of children being raised in households headed by someone other than their parents reduces the costs of raising children. John Caldwell and Pat Caldwell report that in West Africa as many as one-third of all children live in this way.[57] In addition, communal land tenure places a premium on family size, as village leaders distribute land according to family "need." In a system where there is no private title to land but land remains the primary factor of production, having a large family is the best way to acquire access to increased resources. Finally, polygyny continues to be widely practiced in Africa, especially West Africa, and dilutes family and paternal bonds. Each wife comprises a discrete economic unit within the family, responsible for the care of her children. Husbands, while they have access to the fruits of their children's labor, have little responsibility for their welfare.

To test some of these hypotheses, we assembled an unbalanced panel data set for 103 countries at six points in time between 1960 and 1990. We regressed the log of the total fertility rate on income and income

56. Caldwell (1982, 1991).
57. Caldwell and Caldwell (1987); see also Bledsoe (1994).

squared, infant mortality, schooling, gender gaps in schooling, geography, time, and financial market depth (measured by the ratio of liquid liabilities to GDP). The results reveal that fertility tends to increase with infant mortality and tropical location. They also reveal that fertility has tended to decline over time, and that it decreases with income, education, the degree of gender equality in schooling, and financial market depth. In addition, there is considerable fertility variation across geoclimatic regions, for example, tropical and subtropical wet and dry climates. Finally, an Africa dummy has a small but significant positive coefficient, consistent with other literature on the subject. These results imply that high fertility rates in Africa will decline as economic and social development proceeds.

Implications of Demographic Change in Africa

The dominance of youth in Africa's population creates enormous momentum for continued population growth. Even if the total fertility rate were immediately reduced to the replacement level of 2.1 children per woman, Africa's population would still increase to more than 1 billion (that is, by over 50 percent) during the next century, as today's children progress through their prime childbearing years.[58] Correspondingly, dependency ratios would remain high for decades, depressing the growth of income per capita, as discussed below. Much of the most rapid population growth in Africa is occurring in the regions least suitable for rapid economic growth: rural, landlocked, and arid areas that are already under tremendous demographic stress.[59] Rising population densities in these low-productivity interior regions not only threaten economic growth but also intensify environmental degradation through deforestation, soil erosion, and the depletion of aquifers.

Rapid population growth imposes a great burden on African governments in the provision of basic education. Indeed, Africa is the only region of the world in which school enrollment rates fell during recent decades (though the quality of the data is uncertain). According to the World Bank, between 1980 and 1993 primary school enrollment rates in sub-Saharan Africa fell from 68 percent to 65 percent of the primary school age cohort for females and from 90 percent to

58. Bongaarts (1999).
59. Gallup and Sachs (1998a).

78 percent of the cohort for males.[60] Nonetheless, increased numbers of primary school graduates (due to overall population growth) has led to increased demand for secondary education, which has also strained education budgets. In addition, it is extremely difficult to improve the low quality of education in Africa when the school-age population is growing so fast. For example, for the 106 developing countries with data for 1990, the correlation between the number of students per primary school teacher and the ratio of the dependent to total population is 0.52. Spending per primary school student in Africa, at an average of $126 per year (1985 PPP-adjusted), represents only 45 percent and 30 percent of that in Latin America and Asia, respectively. The number of students per teacher (forty-three) is much higher than in Latin America (twenty-eight) and Asia (thirty-two).[61]

Evidence on African Growth from Cross-Country Growth Regressions

Empirical cross-country growth equations are now well established as a tool among development economists and have been employed by Sachs and Andrew Warner in the case of Africa.[62] In this paper we extend those earlier results, for example, by including new demographic and geographic data, but the basic results are very similar. Such models are typically based on the Solow-Swan or Ramsey models of output per worker.[63] Equations 1 and 2 capture their essence:

$$(1) \qquad g_y = \alpha(y^* - y_t),$$

where g_y is the growth rate of output per worker, α is the rate of convergence to the steady state, y^* represents the steady-state level of income per worker in logarithms, and y_t represents current income per worker. Equation 1 implies that a country's rate of growth at a given time is proportional to the difference between its current log income and its steady-state income. The poorer a country is with respect to its steady state, the faster it can be expected to grow: the conditional

60. World Bank (1997a).
61. Barro and Lee (1997).
62. Sachs and Warner (1997).
63. See Barro and Sala-i-Martin (1995) for a detailed description.

convergence hypothesis. The higher a country's steady-state level of income, the faster its expected rate of growth for a given level of initial income.

Empirically, the steady state is assumed to be determined by a set of factors

$$y^* = \mathbf{X}\beta, \tag{2}$$

where $\mathbf{X}$ is a matrix of variables that typically includes measures of human capital, health status, natural resource abundance, and economic policy. Substituting equation 2 into equation 1 and adding an error term ϵ yields the estimable equation

$$g_y = \alpha y_t + \alpha\beta\mathbf{X} + \epsilon. \tag{3}$$

Although the foregoing model refers to output per worker, economic growth is usually operationalized in terms of output per capita, which is preferable as a measure of welfare. Following Bloom and Jeffrey Williamson, we account for this difference by noting the following identity:[64]

$$\frac{Y}{P^T} = \left(\frac{Y}{P^W}\right)\left(\frac{P^W}{P^T}\right), \tag{4}$$

where P^T is total population; P^W is the working-age population (ages fifteen to sixty-four), for which more accurate data are available for more countries than is true of labor force data; and Y is aggregate output. Taking differentials gives

$$g_{\bar{y}} = g_y + g_{workers} - g_{population}, \tag{5}$$

where $g_{\bar{y}}$ is the growth rate of GDP per capita and g_y is the growth rate of GDP per working-age person. Incorporating this into the standard neoclassical model gives the following estimable equation (with $\gamma_1 = \gamma_2 = 1$):

$$g_{\bar{y}} = \alpha\, y_T + \alpha\, \beta\, \mathbf{X} + \gamma_1 g_{workers} - \gamma_2 g_{population} + \epsilon. \tag{6}$$

The introduction of these two growth rates on the right-hand side of equation 6 is unnecessary in demographically stable populations, that is, those in which the growth rates of all ages groups are identical.

64. Bloom and Williamson (1999).

However, most populations are highly destabilized. By including the population growth rate and the growth rate of the economically active population, we account for the fact that a rising dependency ratio implies a lower per capita growth rate, as the dependent population's contribution to output is close to zero. In addition, there is some evidence of a negative association between dependency ratios and saving rates.[65] In populations with high rates of fertility, there are large numbers of young dependents who need to be fed, clothed, housed, educated, and provided with medical care, but who contribute relatively little to aggregate output. As the size of the working-age population increases relative to the total population, the per capita productive capacity of the economy expands. This expansion, which may result from either increased employment per capita or increased saving per capita, creates the potential for more rapid growth of per capita income.

If there are no direct effects of population growth on steady-state income, the coefficients on $g_{workers}$ and $g_{population}$ should be 1 and -1, respectively. However there is an extensive literature on the possibility of such effects, both positive and negative.[66] Therefore we do not constrain the coefficients either to be unity or to equal each other in absolute terms.

In addition to the demographic variables, one must specify the **X** vector of explanatory variables. Our specification follows the large cross-country growth literature, which in general includes policy variables (for example, trade policy and fiscal policy), indicators of the quality of public institutions, and proxies for human capital (for example, years of schooling) and public health (for example, life expectancy at birth).

Our strategy is to add two kinds of geographic variables, one related to the tropics and the other, which is also demographic in nature, related to transport conditions. In particular, we introduce the share of a country's land area in the geographic tropics as an explanatory variable, expecting that tropical land area will be associated with lower steady-state per capita income, y^*, and therefore with lower growth. We also introduce population density near the coast (within 100 km) and population density away from the coast (further than 100 km) as additional

65. Higgins and Williamson (1997); Kelley and Schmidt (1996).

66. For positive effects, see Boserup (1981) and Kuznets (1973); for negative effects, see Coale and Hoover (1958) and Ehrlich (1968).

explanatory variables. We expect that high population density near the coast benefits growth and steady-state income, by expanding the size of the market and the division of labor; whereas high population density away from the coast is either neutral or negative, since remote regions are less likely to urbanize and industrialize and thereby take advantage of an increased division of labor, while decreasing returns to scale associated with traditional agriculture are likely to reduce steady-state income.[67] In earlier papers, we have used the ratio of the length of coastline to land area as an additional indicator of a country's access to international trade, as well as a dummy variable for whether the country is landlocked. While the regression estimates suggest a clear positive role for coastal populations in growth, they cannot distinguish precisely between these alternative measures of proximity to the coast. Therefore, in this paper we choose to report only the specifications using coastal and interior population densities.

We are especially interested in the coefficient on life expectancy at birth (our proxy for health status), which has a strong connection with both geography and demography in Africa. Although it is not an ideal measure of health, it is widely available and often used in this context. We interpret it as capturing possible effects of health on economic growth that may operate through lower morbidity, that is, a more productive labor force; higher returns to investments in human capital, directly due to increased longevity; and increased saving at all ages for a longer period of retirement.[68]

Econometric Results

We report results from a standard cross-country specification based on data for seventy-seven African and non-African countries over the period 1965–90. These data are described in table 5. Regression results are reported in table 6.

The first column of table 6 reports results for a parsimonious cross-country regression that excludes the geographic and demographic var-

67. See Gallup and Sachs (1998a).

68. The theoretical models and empirical results discussed here do not address some rather thorny issues related to reverse causality. See Bloom, Canning, and Malaney (1998) for a detailed treatment of these issues and for evidence that our basic findings are upheld when some of the potentially endogenous variables analyzed below are appropriately instrumented.

Table 5. Data Characteristics for African and Non-African Countries[a]

	African countries		*Non-African countries*	
Variable	*Mean*	*Standard deviation*	*Mean*	*Standard deviation*
GDP per capita growth, 1965–90	0.55	1.35	2.32	1.75
ln GDP per capita, 1965	−0.13	0.55	1.04	0.83
ln GDP per worker, 1965	0.51	0.53	1.62	0.75
ln Years secondary schooling, 1965[b]	−1.95	1.25	−0.36	0.82
Trade openness[c]	0.04	0.08	0.53	0.45
Quality of institutions[d]	4.72	1.17	6.42	2.42
Central government deficit[e]	3.00	4.87	1.29	3.34
Percent tropical land area	0.94	0.23	0.41	0.47
ln Coastal population density[f]	2.22	1.79	4.02	1.55
ln Inland population densityl[g]	2.65	0.84	2.77	1.71
Working-age population growth rate, 1965–90[h]	0.027	0.005	0.021	0.011
Total population growth rate, 1965–90	0.028	0.005	0.017	0.010

Source: Authors' calculations.

a Sample comprises seventy-seven countries; eighteen African and fifty-nine non-African (including Egypt, Morocco, and Tunisia).

b. Average for working-age population, ages fifteen to sixty-four. Data on secondary education are available only for sixty-nine countries, twelve African and fifty-seven non-African.

c. Percentage of years during 1965–90 that a country was open to foreign trade

d. Unweighted average of five subindexes developed by Political Risk Services: *rule of law* "reflects the degree to which the citizens of a country are willing to accept the established institutions to make and implement laws and adjudicate disputes"; *bureaucratic quality* measures "autonomy from political pressure" and "strength and expertise to govern without drastic changes in policy or interruptions in government services"; *corruption in government* measures whether "illegal payments are generally expected throughout" government, in the form of "bribes connected with import and export licenses, exchange controls, tax assessments, police protection, or loans"; *risk of expropriation* refers to "outright confiscation" or "forced nationalization", *government repudiation of contracts* measures "risk of modification in a contract taking the form of a repudiation, postponement, or scaling down"; see Sachs and Warner (1997).

e. Average over 1970–90, as a share of GDP.

f. Within 100 km of coast

g. Further than 100 km from coast.

h. Ages fifteen to sixty-four.

iables. We include five variables: initial income, openness, quality of institutions, and public savings as a percent of GDP, and an Africa dummy. Despite this parsimonious specification, the regression explains 65 percent of the cross-country variation in growth rates. In keeping with most other studies, the coefficients on openness, institutional quality, and public savings are positive and significant, suggesting the importance of economic policy and institutions as factors in economic growth.[69] Initial income has a negative and significant coefficient, suggesting conditional convergence. In the second regression

69. See, for example, Barro (1997); Sachs and Warner (1995).

Table 6. Basic Cross-Country Growth Regressions, 1965–90[a]

Independent variable	*Parsimonious specification (1)*	*Parsimonious specification with schooling (2)*	*Basic specification (3)*	*Basic specification with schooling (4)*	*Basic specification*		
					Constraining demography (5)	*Africa (6)*	*Non-Africa (7)*
ln GDP per worker, 1965	−1.655	−1.957	−1.838	−1.868	−1.794	−2.577	−1.706
	(5.89)**	(6.50)**	(6.64)**	(5.29)**	(6.57)**	(3.12)**	(4.95)**
ln Years secondary schooling, 1965		0.370		0.087			
		(1.79)		(0.59)			
Trade openness	2.079	1.825	2.043	1.950	1.967	−4.656	2.009
	(3.83)**	(3.39)**	(5.98)**	(5.00)**	(5.67)**	(2.09)	(5.51)**
Quality of institutions	0.358	0.391	0.161	0.204	0.122	0.179	0.111
	(2.92)**	(2.76)**	(1.73)	(2.20)*	(1.40)	(0.68)	(1.14)
Central government deficit	0.134	0.112	0.144	0.107	0.141	0.186	0.091
	(3.34)**	(2.28)*	(4.17)**	(2.91)**	(4.03)**	(4.02)**	(2.21)*
Percent land area in tropics	. . .	. . .	−1.180	−1.158	−1.131	−.241	−1.124
			(4.38)**	(3.79)**	(4.17)**	(0.22)	(3.66)**
ln Coastal population density	. . .	. . .	0.196	0.207	0.183	0.267	0.212
			(3.21)**	(3.35)**	(3.08)**	(1.96)	(3.25)**

ln Inland population density	. . .	. . .	−0.056	−0.045	−0.060	−0.533	−0.050
			(0.84)	(0.69)	(0.87)	(1.19)	(0.71)
Population growth rate, 1965–90							
Total population	. . .	. . .	−101.099	−105.694	. . .	. . .	. . .
			(1.51)	(1.56)	. . .	. . .	. . .
Working-age population	. . .	. . .	125.486	−136.722	. . .	. . .	.
			(2.30)*	(2.47)**			
Difference	. . .	. . .	. . .	. . .	148.811	349.294	173.872
					(3.14)**	(2.27)*	(3.52)**
Life expectancy at birth, 1965			4.140	3.712	3.601	4.346	3.064
			(3.64)**	(3.50)**	(3.67)**	(1.75)	(2.62)*
Africa dummy	−2.219	−2.074	0.038	−0.063	0.113		
	(4.91)**	(3.78)**	(0.09)	(0.14)	(0.26)		
Constant	1.437	2.014	−15.081	−13.657	−12.253	−14.208	−10.315
	(3.89)**	(3.29)**	(3.28)**	(3.14)**	(3.34)**	(1.40)	(2.36)*
Summary statistic							
N	77	69	77	69	77	18	59
R^2	0.65	0.70	0.82	0.86	0.81	0.71	0.83

Source: Authors' regressions.

a. Data are described in notes to table 5. Absolute values of *t* statistics are in parentheses. Significance at the 5 percent level is denoted by *; at the 1 percent level, by **.

we repeat the exercise but add a measure of secondary schooling. The schooling coefficient is positive but not very well determined. The other coefficients remain significant and of about the same order of magnitude as in the first column. However, the schooling variable reduces the sample size by eight countries, because of limited data availability. In view of its marginal significance, therefore, and its even lesser statistical significance in other specifications not reported here, we hereafter drop the schooling variable in order to maintain our sample size at seventy-seven countries.[70]

Despite the considerable explanatory power of the policy variables, the Africa dummy variable is negative and highly significant in the first and second columns. In the latter, the coefficient suggests that, other things equal, income per capita grew 2.1 percentage points more slowly in African economies than in non-African economies over the period 1965–90.[71] This result is consistent with other studies and suggests that some influences on growth not captured in the specification are operative in Africa.[72] Accordingly, some researchers argue that special social characteristics, such as ethnolinguistic heterogeneity and stocks of social capital, may be key "missing factors" in Africa's poor growth performance.[73]

In the third column, we augment the parsimonious regression with geography and demography (including health) variables. We control for changing age structure as described in the previous section. We also enter three geographic variables: the percentage of a country's land area in the tropics; the logarithm of the density of population within 100 km of the coast; and the logarithm of population density in the interior, further than 100 km from the coast. If the entire population lives further than 100 km from the coast, the coastal density variable is given a value

70. Pritchett (1996) also finds evidence that the direct effect of schooling on economic growth is insignificant. By contrast, Benhabib and Spiegel (1994) find a significant positive association.

71. We have also conducted an F test to examine whether the coefficient estimates for African economies are equal to those for non-African economies except for the intercept. The resulting statistic, based on the regression reported in the second column of table 6, accepts the hypothesis of common parameters—a result echoed by Easterly and Levine (1997). This finding suggests that Africa's slow growth is due to differences in fixed effects and the level of model variables, not to differences between parameters for Africa and for the rest of the world.

72. Barro (1991); Easterly and Levine (1997); Temple (1998).

73. See Easterly and Levine (1997); Temple (1998); Collier and Gunning (1999).

of zero. Similarly, if the whole population lives within 100km of the coast, the interior density variable is assigned a value of zero.[74] Based on the discussion above, we expect that proximity of the population to the coast will be positively related to economic growth, while high population densities away from the coast will not be strongly related to growth, and may even have a negative effect.

Including these variables in the empirical specification eliminates the negative sign on the Africa dummy and also its statistical significance. This result suggests that the augmented specification better captures the fundamental processes underlying economic growth, both in Africa and elsewhere. Note also that the coefficients on life expectancy, the age structure variables, and the coastal population density all have the expected signs and are statistically significant. The interior population density is negative but statistically insignificant. The coefficient on tropical coverage is negative and highly significant. In the fourth column we add the schooling variable to this augmented specification, to confirm that it is statistically insignificant and does not play any decisive role in Africa's growth shortfall.

In the fifth column we run the basic specification once more, this time constraining the coefficients on the two population growth variables, total population and working-age population, to be of equal and opposite sign. This constraint is not rejected in a formal F test for the equality of the two coefficients. The regression estimates show that the policy variables (openness, budget deficit, and quality of institutions), geography variables (tropical land area and coastal population density), and demographic variables (life expectancy and population growth) are all statistically significant.

The sixth and seventh columns of table 6 estimate growth equations for the eighteen African and the fifty-five non-African countries in our sample, respectively. The specifcation is the same as in the fifth column. Notwithstanding some differences between the two equations that presumably reflect the small size of the Africa sample and the low extent of variation in some of the key variables such as tropical land area and openness of the economy, F tests do not permit rejection of the null hypothesis of common regression coefficients between the African and

74. Note that to account for these special cases, we in fact measure ln (1 + density), so that the value equals zero when density equals zero.

non-African countries. The implication of this result is that economic growth is slow in Africa because the continent lacks favorable values for the factors that determine steady-state growth in all countries, rather than because those characteristics are rewarded less generously in Africa than elsewhere.[75]

Based on these estimates, table 7 decomposes the sources of Africa's growth gap with East and Southeast Asia, Latin America and the Caribbean, and the non-African world generally over the period 1965–90, using the fifth regression from table 6. After controlling for differential rates of growth due to differences in initial income, Africa's rate of growth is 4.9 percentage points slower than that of East and Southeast Asia, 2.3 percentage points slower than that of Latin America, and 3.7 percentage points slower than that of the rest of the world generally. The table highlights the direct contributions of age structure, geography, and health as proximate factors explaining Africa's relatively poor growth performance. The combined effects of these three factors account for 73 percent of the gap with East and Southeast Asia, 103 percent of the gap with Latin America, and 78 percent of the gap with the non-African world.

These estimates do not account for influences of demography and geography that may operate indirectly through other included variables. For example, rapid population growth and disadvantageous geography may create enormous barriers to good governance. Although a full decomposition of these and other possible channels awaits further research, these initial results are highly suggestive.[76] By far the biggest

75. The eighteen countries in the Africa sample comprise those for which all of the requisite data are available. However, this group represents only about two-fifths of all fifty-five countries in sub-Saharan Africa (including Eritrea, Madagascar, Mauritius, and the Seychelles) and just less than one-half of the forty-one sub-Saharan African countries for which we have any data. Comparison of the African countries in our dataset with the omitted countries on selected variables for which we do have information reveals that our sample is representative of sub-Saharan Africa in terms of growth rates of total and working-age populations, growth rates of income per capita, openness to trade, liquidity, quality of institutions, and tropical coverage. By contrast, the countries in our sample tend to have higher initial income, higher coastal and inland population densities, and lower ratios of coastline to land area.

76. Bloom and Williamson (1999) find that youth dependency has a greater negative effect on economic growth than elderly dependency. Since youth dependency dominates the overall dependency burden in Africa much more than in other regions, an analysis that took into account the growth rates of different segments of the age distribution

Table 7. Sources of Growth Gaps between Africa and Selected Regions[a]

Units as indicated

	Impact on growth gap between Africa and					
	East and Southeast Asia		*Latin America*		*Non-Africa*	
Variable	*Percent*	*Percentage point*	*Percent*	*Percentage point*	*Percent*	*Percentage point*
Geography, demography, and health	73	−3.23	103	−2.24	78	−2.82
Percent land area in tropics	7	−0.30	7	−0.16	16	−0.57
ln Coastal population density	14	−0.61	9	−0.19	8	−0.31
ln Inland population density	0	0.01	3	−0.06	0	0.00
Difference in population growth rate	26	−1.14	33	−0.72	19	−0.68
ln Life expectancy at birth, 1965	27	−1.19	52	−1.12	35	−1.26
Economic policy and governance	37	−1.65	2	−0.05	23	−0.84
Trade openness	32	−1.40	13	−0.27	24	−0.89
Quality of institutions	5	−0.22	−1	0.02	5	−0.20
Central government deficit	1	−0.03	−9	0.20	−7	0.25
Total gap explained	110	−4.88	105	−2.29	101	−3.66

Source: Authors' calculations.

a Growth is measured in GDP per worker Results are based on specification 3 in table 6 over the period 1965–90. The observed gaps between Africa and the regions specified are as follows: East and Southeast Asia, −3.6 percentage points; Latin America, −0.4 percentage point; non-African countries, −1.7 percentage points. The effective gaps reported in the table are obtained by controlling for differential rates of growth due to differences in initial income Components may not sum to totals, due to rounding. Data are described in notes to table 5.

effects are from demography and life expectancy. The tropics effect is especially small in the comparisons with Asia and Latin America, mainly because the comparison groups are also heavily tropical. Relative to a temperate zone economy, the absolute size of the tropics effect is actually quite large: a point estimate of 1.13 percentage points per year in slower economic growth.

Among the policy variables, much the most important is Africa's lack of openness to international trade.[77] Almost all postindependence African governments adopted autarkic trade policies, with the goal of achieving industrialization through import substitution. As elsewhere in the world, that strategy failed decisively, both because local markets were far too small to support efficient and competitive industry and because export growth was needed to support imports of capital goods and intermediate products. The result was a serious negative impact on economic growth, estimated at 1.2 percent per year (or 32 percent of the total gap) in comparison with East Asia, where more open trade policies were pursued.[78]

A number of recent studies evaluate the sources of slow growth in Africa using panel data.[79] With respect to Africa, some argue that cross-country studies do not account for the dramatic slowdown in growth since 1973.[80] We have constructed a panel dataset and conducted some basic analyses, following a core specification similar to that of William Easterly and Ross Levine with the addition of variables measuring changes in age structure and geo-climatic conditions.[81] Our conclusions are similar to those based on the cross-sectional analyses. We do find, however, that the magnitude—but not the statistical significance—of the contribution of demography, health, and geo-climatic conditions is sensitive to the inclusion of infrastructure variables (that is, the natural

would likely indicate an even more important role for demography. See the appendix to Bloom and Malaney (1998) for a discussion of the relevant models.

77. The comparisons with Latin America are between closed economies.

78. More generally, the failure of import substitution policies also left these countries vulnerable to macroeconomic upheaval; see Sachs and Warner (1995, 1997).

79. See, for example, Easterly and Levine (1997); Temple (1998); Islam (1996).

80. Collier and Gunning (1999). Growth apparently declined at an accelerating rate; population-weighted per capita growth averaged 1.5 percent in the 1960s, 0.8 percent in the 1970s, −1.2 percent in the 1980s, and (using data from World Bank, 1998) −0.9 percent over 1990–96.

81. Easterly and Levine (1997).

logarithm of telephones per working-age person). This is not surprising, given the discussion above of the links between geography and the provision of infrastructure. Africa's poor infrastructure may in large measure reflect geographic realities: low population densities and populations living far from coastal regions, where infrastructure investments are presumably cheaper and more efficient.

The cross-country and panel data estimates highlight the importance of a similar set of factors to economic growth. Policy, education, and the role of initial income have received significant attention in the growth literature; age structure, health conditions and their ecological determinants, and geography have received much less. Yet these factors reflect significant aspects of Africa's fundamental conditions and are estimated to account for a sizable share—70 to 100 percent, depending on the point of comparison (see table 7)—of Africa's extremely slow growth.

Overcoming Africa's Structural Barriers to Growth

African economies remain characterized by very low levels of income, high proportions of the population engaged in agriculture, urban areas that function as political and administrative centers rather than as exporting regions, and very limited international trade, concentrated in a narrow range of primary commodities. Given these realities, and the geographic and demographic factors that underlie them, what kinds of growth strategies might be effective?

Just as we started our analysis by placing Africa within the general development context of tropical economies, one can also examine the success stories of growth among tropical economies for lessons they may hold for Africa. To be sure, there have been precious few successes. Within tropical Africa, there are only two unambiguous long-term candidates: Botswana and Mauritius. Botswana's case is not generally replicable, since its success has depended on a very small desert population enjoying the benefits of large and well-managed discoveries of diamonds—although one should note that Botswana has used its resources effectively: trade policy has remained open, democracy has been vigorous and stable, and fiscal policy has been prudently managed. Mauritius is more apposite, as a typical tropical agricultural exporter (mainly of sugar cane) that has succeeded in export-led growth in man-

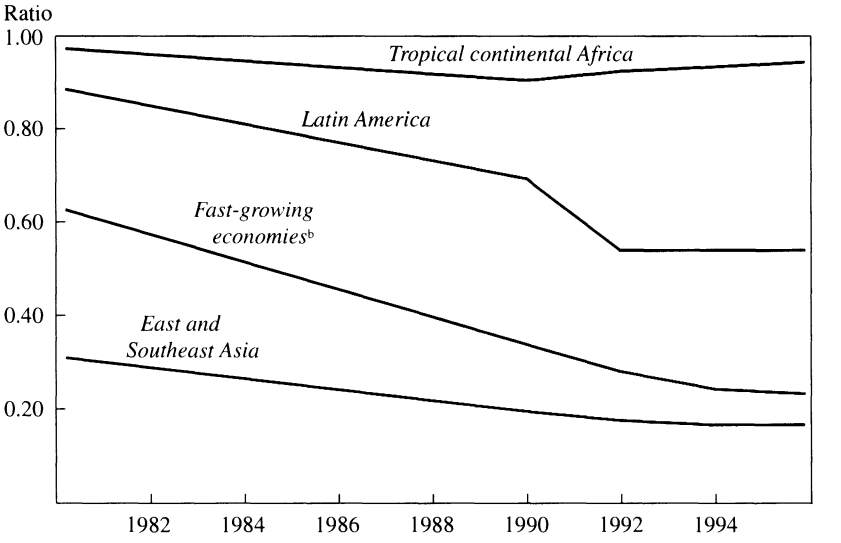
ufactures and services. Outside the African region, the only tropical developing countries that averaged more than 3.0 percent per year in per capita GDP growth during 1965–96 are in Asia: Hong Kong (5.6 percent), Indonesia (4.6 percent), Malaysia (4.1 percent), Sri Lanka (3.1 percent), Singapore (6.3 percent), and Thailand (5.0 percent).[82] Much has been written about these economies—especially since they are also currently embroiled in financial upheaval; it is therefore possible to identify some of the key factors of their success that might be relevant to a strategy for renewed African growth strategy.

Most important, the core of the Asian countries' growth strategy was an industrial policy that aimed to promote manufacturing, and increasingly service sector, exports.[83] These countries not only aimed to increase export growth, but to diversify away from their traditional dependence on tropical commodities in order to benefit from the much more rapid growth in world trade in manufactures and services. They recognized that agricultural exports would lack dynamism, not only because of limits to the growth of world demand but also due to technological limits to the expansion of production. As many observers have noted, success in manufacturing export-led growth was not just a function of market forces. It also required the introduction of key institutions, designed to link domestic labor-intensive manufacturing production with world markets. Thus Southeast Asian countries made novel institutional arrangements with multinational firms to facilitate the outsourcing of labor-intensive operations to the local economies. Such arrangements included export processing zones, in which infrastructure and customs administration were set up to reduce transactions costs for multinational enterprises and industrial parks were established for export-oriented production; duty drawbacks on tariffs on raw materials and capital goods imported for export production; generous tax holidays for export-oriented foreign investors; and flexibility in labor markets. The strategy was essentially passed on from one location to the next. Hong Kong was first to adopt the approach, in the 1950s, and was emulated by Korea and Taiwan in the early to mid-1960s. Singapore adopted the export-led manufacturing model around 1967. In 1971 Malaysia established Penang Island as an export processing zone in

82. Asian growth rates are based on World Bank (1998).

83. See Radelet, Sachs, and Lee (1997) for a more complete discussion.

Figure 8. Ratio of Values of Primary Commodity Exports to Total Exports by Region, 1980–96[a]



Source. Statistics Canada (1997)
a. Total exports include primary commodities and manufacturing exports
b. Hong Kong, Indonesia, Malaysia, Mauritius, Singapore, Sri Lanka, and Thailand

emulation of Singapore. In the 1980s Thailand and Indonesia began to promote similar manufacturing export schemes. And in the early 1990s the Philippines adopted the approach, focusing in particular on export-oriented consumer electronics.

The pattern of export growth in the rapidly growing export-oriented Asian countries stands in sharp contrast to the performance of Africa, which remained overwhelmingly tied to primary commodities, except for Mauritius and, to a small extent, South Africa. In fact, Mauritius adopted the export processing zone model in 1971, in emulation of Taiwan.[84] Figure 8 presents primary commodity exports as a proportion of total exports by region, over the period 1980–96. It shows that tropical Africa (excluding Mauritius and Madagascar) has had close to 100 percent concentration of exports in primary commodities and has

84. In Mauritius, export firms were not required to establish operations within special industrial parks in order to qualify for export processing zone-type privileges on taxes and customs and other export incentives.

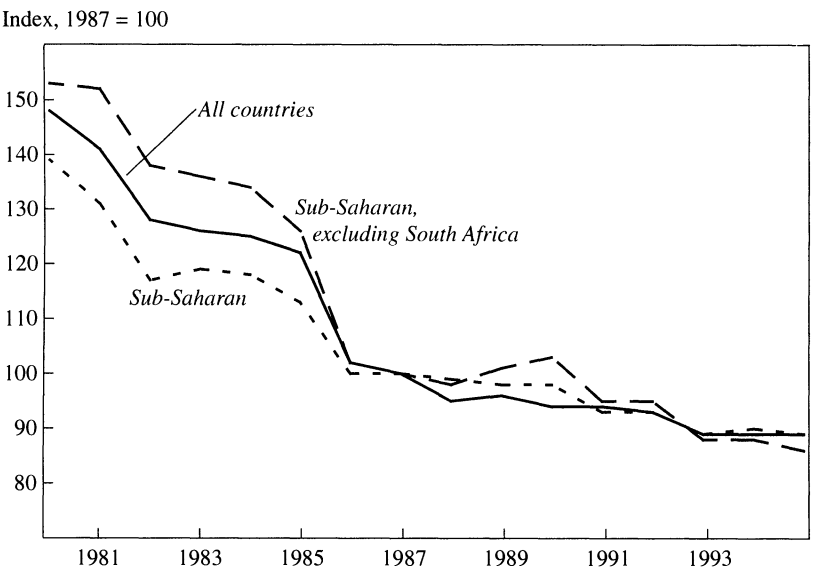
experienced little change in commodity dependence between 1980 and 1996. Latin America is the second most commodity-dependent region, but it experienced a rather sizable shift toward manufactures. Although the developing countries of East Asia were already largely in manufacturing by 1980, they did experience an increased proportion of manufactures in total exports between 1980 and 1996. The six fast-growing Asian countries (Hong Kong, Indonesia, Malaysia, Singapore, Sri Lanka, and Thailand) and Mauritius, as a group, also had a steep decline in the share of commodities in total exports.

Perhaps the most striking example of Africa's absence from manufactures trade is the textiles and apparel sector, which has produced labor-intensive exports in virtually all parts of the developing world. Other than Mauritius and (very recently) Madagascar in the Indian Ocean, and the North African countries of Egypt, Morocco, and Tunisia, African countries play virtually no role in textile and apparel trade; only Kenya and Zimbabwe have even minuscule apparel exports, adding up to a mere 0.05 percent of global trade.[85]

Was there really an advantage to manufacturing export-led growth over commodity export-led growth in this period? It seems clear that the answer is yes. World demand for manufactures rose far faster than demand for primary commodities: a cumulative increase in the dollar value of manufactures trade of 2.7 percent per year, compared with an average annual increase of 0.65 percent in world commodity trade. The terms of trade for commodities producers declined significantly during the period, as shown by the terms of trade of African economies in figure 9. Moreover, table 8 shows that Africa suffered an *absolute decline* in the dollar value of per capita export earnings, in contrast to the significant increases in total earning per capita in other regions of the world. If it is true that the manufacturing sector enjoys faster productivity growth than primary commodities, why does the rising supply of manufactures relative to primary commodities not lead to a decline in the relative price of manufactures? A large part of the answer is that manufacturing growth involves not only growth in volumes, but also growth in varieties, which is much faster than the growth in varieties of primary commodities. Thus manufacturers can find niches in new

85. Estimates by the Harvard Institute for International Development, based on data from the U.S. Trade Commission; see HIID and World Economic Forum (1998, table 4, p. 40).

Figure 9. Terms of Trade of African Economies, 1980–95



Source World Bank (1997a).

product lines in which the terms of trade remain strong, even as overall manufacturing supply rises much faster than primary commodity supply. And there are other possible answers as well.[86]

Can Africa Diversify Its Exports?

Our main conjecture is that manufacturing and service sector export-led growth would benefit Africa not only as an outlet for new exports, but as a way to address some (though not all) of its geographical liabilities. In essence, we are surmising that at a general level, Africa and many other tropical environments have a true comparative advantage

86. Part of the story may simply lie in price measurement. Quality improvements in manufacturing goods are probably understated in price indexes, so that price rises over time are probably overstated. This would tend to exaggerate measured increases in the terms of trade of manufactures vis-à-vis commodities. Two other frequently argued propositions are that the income elasticity of demand is less for primary commodities than for manufactures, and that technical change saves on primary resources, such as when fiber optic cables replace copper wires, or synthetic rubbers substitute for natural rubber.

Table 8. Nominal Value of Exports Per Capita by Region, 1980 and 1996
U.S. dollars

Region	*1980*	*1996*	*Ratio, 1996/1980*
Tropical continental Africa	130	70	0.5
East and Southeast Asia	144	472	3.3
Latin America	260	509	2.0
Fast-growing economies[a]	361	1,611	4.5

Source: Statistics Canada (1997), World Bank (1998)
a Hong Kong, Indonesia, Malaysia, Mauritius, Singapore, Sri Lanka, and Thailand.

in manufactures and services, despite having been viewed for centuries as suppliers of primary commodities. While there will surely remain a significant niche for a range of agricultural goods endemic to the tropics (such as coffee, tea, cocoa), it may simply be a matter of comparative advantage—especially influenced by the low productivity of food production in the continent—that Africa should be a net importer of agricultural commodities (mainly foodstuffs), paid for by net exports of manufactures and services, as well as traditional resource exports.

Admittedly, the continent as a whole could not follow such a strategy. Successful export-led growth in manufactures in low-wage, low-skilled countries requires low transport costs, especially because manufacturing processes tend to involve a significant import component of final output. In the export processing zones in the Philippines, for example, the cost of imported inputs are 60 percent of the FOB value of electronics exports.[87] Even slight increases in transport costs on imported inputs can easily wipe out all domestic profits. For this reason, the success stories in manufacturing export-led growth are almost all coastal economies, well connected to international shipping routes. Thus in Africa, a manufacturing export-led growth strategy would probably be most effective in the large urban areas on the east and west coasts, such as Abidjan, Accra, Dar es Salaam, Lagos, Maputo, and Mombasa. Currently, these port cities play almost no role as export-oriented manufacturing centers. An urban-based export strategy would have other obvious advantages as well. Infrastructure provision is considerably less costly in the more densely populated urban setting, and

87. See Radelet and Sachs (1998).

the transmission of vector-borne diseases, such as malaria, is often easier to moderate in an urban environment.[88]

Inland countries inherently face high transport costs for imported intermediate items. It is therefore likely that their success in manufacturing export growth will depend on the extent to which they increase processing of locally produced commodities. For example, Uganda could sell roasted and branded coffee, rather than raw beans; while Mali, Uganda, and other cotton producers could become competitive textile exporters (as Uganda was on a very modest scale thirty years ago). In addition, all parts of Africa have at least some potential in the service sector, especially in tourism, and also in several kinds of data transmission and data processing operations, such as data transcription and back-office services, which can be outsourced to low-wage countries via telephone and internet connections.

Export success does not emerge automatically as the result of comparative advantage based on relative factor costs. Competitiveness in labor-intensive manufacturing exports requires the following:

—effective logistical operations at the port and low-cost internal transport to port facilities;

—duty-free access to imported inputs and capital goods;

—timely customs administration;

—physical security and reliability in warehousing;

—cost-effective access to international telephone and internet services;

—reliable power supply;

—flexibility in hiring and dismissing workers;

—low (or zero) taxation on multinational income, at least to be competitive with alternative production sites; and

—reasonable shipping costs to major ports in Europe, the United States, and Japan.

The list is straightforward; the achievement of competitiveness is not. As in Michael Kremer's "O-ring" theory of development, the

88. Urban centers can be inhospitable breeding grounds for *Anopheles* mosquitoes, which require clean water sites for larval development and are typically stifled in polluted urban settings. Unfortunately, the tropical urban areas at low altitude in Africa are generally malarial, but disease transmission is less stable, and therefore there may be greater potential for success in controlling it.

process can break down at its weakest link.[89] In much of urban coastal Africa, the development of export-oriented manufacturing is frustrated by poor port services, unreliable power supplies, abusive customs agents, duties on imported intermediate inputs, or lack of tax holidays.[90]

Despite more than a decade of structural adjustment lending by the IMF and World Bank throughout Africa, very little structural change is actually taking place in exports and production. Why these programs have not promoted export diversification and dynamism is an open, empirical question. Our hypothesis is that the programs are not sufficiently focused on the nitty-gritty work of overcoming the practical obstacles to international manufacturing competitiveness. Moreover, practical policy advice from these institutions—for example, their long-standing ambivalence or outright opposition to the establishment of export processing zones and their frequent opposition to tax concessions aimed at attracting export-oriented manufactures—is often in direct conflict with the diversification of exports.

The real sources of Africa's lack of competitiveness in manufacturing exports are not well understood. Researchers have as yet undertaken very little systematic comparison of African economies with other regions regarding factor costs, transport costs, tax arrangements, infrastructure availability, and the like. This basic fact finding should be made a high priority.

Conclusion

The central objective of this paper is to highlight some deep underlying factors that have hindered African economic growth, not only over the past three decades, but for the entire period of modern economic growth. Identifying these factors and the mechanisms through which they influence growth is a vital step in developing strategies for achieving higher growth rates in Africa. Perhaps our most important

89. Kremer (1993).

90. Tanzania recently attracted a Korean apparel firm that was successfully producing and exporting clothing for the U.S. market. The U.S. customer subsequently cancelled the contract, however, because of excessive shipping delays due to obstruction and hassles by port and customs authorities. (Personal communication with the economic advisor to the prime minister of Tanzania, August 1998.)

finding is that economic policy and governance, which receive the largest share of economists' attention, are perhaps not the dominant factors impeding economic growth in Africa. Rather, we find that various aspects of tropical geography, demography, and public health are vitally important, and we argue that causality runs strongly from these factors to growth, rather than vice versa (although some reverse feedbacks exist as well). Our statistical estimates, admittedly imprecise, actually give about two-thirds of the weight of Africa's growth shortfall to such "noneconomic" conditions and only one-third to economic policy and institutions. This does not mean that economic policy is unimportant. Indeed, good policies are especially important, because economic growth will otherwise be so hard to achieve.

Our findings suggest that economists ought to lift their gaze above macroeconomic policies and market liberalization, in order to deepen their understanding of the linkages between the physical environment and social outcomes. The complex interplay among geography, demography, health, and economic performance surely requires intensive and systematic examination. For the sake of development in Africa, there needs to be much greater cross-fertilization between fields such as demography, epidemiology, agronomy, ecology, geography, and economics. In short, there is a need for better tools in an area of study perhaps best termed human ecology, which places social activity and economic development more firmly in the context of the physical environment.

Given this enormous intellectual challenge, Africa surely suffers from a remarkable lack of attention from the international scientific community in regard to health, agricultural, and environmental problems. Many able scientists in Africa and elsewhere are pursuing relevant basic and applied research, but their efforts do not match the scale of the problems. Many of the issues—for example, designing an effective campaign against malaria, and developing better understandings of the virology and epidemiology of AIDS in Africa, the interaction of climate and low life expectancy, and tropical forestry and the adaptation of food production to tropical conditions—are international public goods. Scientific research on these topics will naturally be underprovided by private markets and even by the efforts of individual nations. For example, on a per fatality basis, global expenditures on malaria research are roughly one-twelfth of those on asthma research and one-fiftieth of

those on HIV/AIDS research (mainly because AIDS is such a huge problem in industrial countries).[91] The decline in financial support for the Consultative Group for International Agricultural Research—the main global network supporting agricultural research appropriate to conditions in developing countries—bodes ill for innovation in agriculture and animal husbandry in Africa. New ways also have to be found to bring in private sector research efforts for vaccine development, biotechnology research, and other areas. At least part of the financing for reinvigorating scientific effort on behalf of Africa should probably come from redirecting aid programs away from standard policy-based lending and toward the underlying scientific and technical problems.

Africa was the only major region in the world to experience an absolute decline in export earnings per person between 1980 and 1996. This is not only a vivid illustration of its marginalization in the world economy, but also a proximate cause of Africa's slow growth, since it has lacked the foreign exchange earnings needed to invest heavily in capital goods from abroad. It seems clear, therefore, that Africa's economic development will require a major commitment to policies and institutions that promote manufactured exports. Such an approach was key to the economic growth of many tropical countries in East and Southeast Asia. While general points of economic reform, such as macroeconomic stability, currency convertibility, and low inflation are important in this regard, they are not enough. International competitiveness in manufactures requires a set of effective institutions (often mediated by multinational enterprises) linking the domestic economy with world markets. These have not been fostered adequately by the World Bank and IMF programs of recent years; more direct focus on export diversification and manufacturing sector competitiveness is needed. Most of the major coastal port cities of East and West Africa are candidates for a greatly expanded role in export-led growth. In addition, creative effort is needed to promote investment in infrastructure. However, one important lesson of recent development experience in other parts of the world is that infrastructure can increasingly be financed privately and in a competitive market setting, rather than by cash-strapped state monopolies, as has traditionally been the case in

91. Anderson, MacLean, and Davies (1996, table 2.3, p. 29).

Africa. The rapid urbanization that Africa is currently experiencing will enhance this process by allowing private entrepreneurs to benefit from greater economies of scale in densely populated urban areas.

Africa is the largest and most complex development challenge facing the world today. And many of the factors that contribute to Africa's apparent growth trap continue unabated or may even be tightening their hold. On the one hand, pockets of improvement in health and education, the incipient decline of fertility in some countries, and growth of the world economy provide some hope that this challenge will be successfully confronted. On the other hand, rapid population growth, environmental stresses, and the AIDS epidemic are enormously disconcerting. Based on the results presented here, it appears that economists and donors must reorient their efforts more toward the roles played by geography, demography, and health in Africa's growth crisis, in order to devise more effective approaches to alleviating the human misery that continues to pervade the continent.

Comments and Discussion

Paul Collier: One of the quests of recent growth research has been to explain why Africa has grown so slowly.[1] In simple growth regressions there is a significant negative Africa dummy: Africa just grows unaccountably slowly. There are two new structural explanations for this lack of growth.

First, David Bloom and Jeffrey Sachs propose in this insightful paper that Africa is locationally disadvantaged. It is tropical, and so suffers from diseases such as malaria, and most of its population lives far from the coast. Both the presence of malaria and being landlocked are isolating, and isolation is the main cause of slow growth. A corollary is that Africa's deficiencies in policy and institutions have been overplayed: the authors attribute 60 to 90 percent of Africa's slow growth to geography and demography.

Bloom and Sachs are dismissive of a second prominent structural explanation, that of Easterly and Levine, who argue that Africa's problem is its high ethnic diversity.[2] The median African country has more than double the diversity of the median non-African developing country. Just as Sachs and Warner find location to be significant in a growth regression, so Easterly and Levine find ethnic diversity to be significant.[3]

Although both of these explanations allow some role for policy, they see it as endogenous. Gallup and Sachs argue that countries isolated by

1. The findings, interpretations, and conclusions expressed in this paper are entirely those of the author and do not necessarily represent the views of the World Bank, its executive directors, or the countries they represent.

2. Easterly and Levine (1997).

3. Sachs and Warner (1997).

location will have weaker lobbies in favor of trade, so that exogenous isolation will be compounded by policy-induced isolation.[4] Easterly and Levine argue that ethnic diversity makes cooperation more difficult, which leads to worse policies.

These explanations need not be alternatives: they could both be right. However, they are both seriously overplayed. I think that Sachs is correct in identifying tropical and landlocked locations as disadvantageous, but this knowledge is not central to understanding African economic performance. Bloom and Sachs, following Sachs and Warner, build a regression including locational variables, which gets rid of the significant Africa dummy.[5] However, at least in the Sachs and Warner version, this has nothing to do with the locational variables: if one runs the regressions without them, the Africa dummy is still insignificant.[6]

In addition, location is the ultimate fixed effect. Simple ordinary least squares regressions of the average growth rate over twenty-five years, as used by Sachs with Bloom and Warner, are not the best way of testing for such an effect—for that, one needs panels. Bloom and Sachs mention, but do not report, panel data results that support their findings. However, the only panel data work on Africa that I have seen is that of Anke Hoeffler, who finds the opposite.[7] Dividing thirty years into a panel of five-year averages and using system GMM (generalized moments of the mean) estimation, she tests for Africa fixed effects in the standard Solow growth model. The coefficient on the Africa dummy is small and insignificant: there are no African fixed effects to explain, and so African location cannot be very important.

I agree that Africa's high population growth rate has been costly for per capita growth, but this may well be largely endogenous to poor economic performance. If parents saw prospects of growth in wage employment, they would have an interest in investing in educational quality, and thus would find large families uneconomic.

Finally, Africa now has a large offsetting positive against the negatives of being tropical and landlocked: it is poor. One knows from conditional convergence that, for given policies, poor countries grow more quickly. Africa's growth bonus from this catch-up effect is larger

4. Gallup and Sachs (1999).
5. Sachs and Warner (1997).
6. These results come from my doctoral student Anke Hoeffler.
7. Hoeffler (1998).

than its losses from location. In the long run, as Africa narrows the gap with other regions, the catch-up effect will be spent, leaving the locational negatives: Africa will converge to a lower income level than were it better located. However, this long run is irrelevant. Africa has the scope for several decades of catch-up growth. Before that is exhausted, the economics of tropical, landlocked locations will probably have been transformed by vaccines and airplanes.

In short, I question that a large majority of Africa's growth problems come from geography rather than policy. Further econometric work is needed, but on balance, current African nonpolicy fundamentals are probably conducive to growth.

Policy as destiny. Africa has suffered a growth failure, but this has not been due to fixed effects. It has been determined by policy, which has changed considerably over the past forty years. Further, levels of growth currently vary greatly across the continent.

During the 1960s, growth was quite reasonable: output per worker grew at the same rate of around 2 percent in Africa and South Asia. Over the next two decades there was a policy collapse; as a result, growth collapsed. Whereas in South Asia the growth of output per worker accelerated to 2.6 percent, in Africa it declined to 0.6 percent.[8]

During the 1990s, Africa has become differentiated by policy. The World Bank has just completed a standardized policy rating for all its clients. Measured across twenty different aspects, policy in Africa remains, on average, worse than in any of the other five regions of the world. However, whereas a decade ago there was little policy dispersion within the continent, now there is more than in any of the other five regions: the coefficient of variation of the African policy ratings is about double that of the other regions. There are good policy environments in Africa, as well as some very bad ones. The bottom five countries on the policy scale are all African. Nevertheless, twelve low-income African countries—accounting for 26 percent of the low-income population of Africa—had achieved broadly satisfactory policy environments by 1995. The post-1995 growth rate of output per worker in this aggregate has been 4.7 percent per year—hardly cause for despondency.

Policy might matter, but Gallup and Sachs counter that it is endogenous to geography: landlocked countries have less incentive to adopt

8. Collins and Bosworth (1996).

good policies.[9] This is an attractive analytic speculation and globally there is some evidence for it, but it happens not to be true in present-day Africa. All five of the worst policy environments on the World Bank's ratings are coastal, but among the 26 percent of the low-income population living in adequate policy environments, two-thirds are landlocked.

Easterly and Levine develop an alternative explanation for why African policies are, on average, poor: high ethnic diversity makes cooperation difficult, and in the limit, may be the cause of the high incidence of conflict.[10] Here I disagree both with the argument and with the Bloom and Sachs critique. Africa's problem has not been the high level of ethnic diversity, but the low level of political rights in the context of that diversity. When the interaction of ethnic diversity and political rights is included in a growth regression, it is the most significant variable, and any remaining effects of diversity become insignificant. Ethnically diverse societies need democracy much more than do homogenous societies. Among diverse societies, democracies grow 3 percent per year more rapidly than dictatorships, whereas in homogenous societies political rights have no effect on the growth rate.[11]

Until recently, Africa had astonishingly low levels of political rights. It was Africa's misfortune that decolonization led to dictatorship in societies for which dictatorship was economically ruinous: decolonization empowered narrow interest groups that it has taken a generation to dislodge. In a recent study, I compare the median African country with the median non-African developing country.[12] I measure political rights by the Gastil index, where full democracy rates as 1 and full dictatorship rates as 7. Averaged over 1973–90, Africa scores 6, whereas other developing countries score 4. For the median country, the implied loss of growth caused by this conjunction of low rights and high ethnic diversity is around 1.5 percent per year, which is about the magnitude of Africa's underperformance.

Nor is high ethnic diversity an explanation for the high incidence of civil war in Africa. Globally, the peak danger of civil war occurs at fairly low levels of diversity: essentially, when the country consists of

9. Gallup and Sachs (1999).
10. Easterly and Levine (1997).
11. Collier (1999).
12. Collier (1998).

two groups. Highly diverse societies are in fact safer than homogenous societies. The predominant causes of civil war are poverty and lack of political rights: poor youths have little to lose from joining rebellions, and in the absence of voting rights there are no alternative channels for registering allegiance and influencing policy. Africa's high incidence of civil war is fully explained by its poverty.[13]

Which policies are destiny? From their emphasis on geography, Bloom and Sachs draw the important inference that Africa lacks a comparative advantage in agriculture and must seek its future in manufacturing. This is the antithesis of Adrian Wood and coauthors Kristi Berger and Jörg Mayer, who argue that Africa's abundance of land precludes a manufacturing future.[14] In this instance I agree with Bloom and Sachs, though for somewhat different reasons. Africa's decline has so reduced real incomes that, despite its natural resource exports, its labor costs should be competitive. Africa is currently uncompetitive in manufacturing not because of its endowments, but because of its policies.

I agree with Bloom and Sachs on the centrality of openness. African governments have created barriers to openness partly through trade and exchange rate policies, and partly by neglecting transport infrastructure. Not only has the typical African country been more closed than other countries, but a given level of restrictions is more costly in Africa than elsewhere. For example, an exchange rate distortion of a given magnitude is almost twice as damaging to growth in Africa.[15] I think that this is partly because Africa's economies are so small. As a result, exposure to trade is essential both for competition and for scale economies. Further, the level of technology is so low that participation in trade is the best means of knowledge catch-up.

African firms have been handicapped by at least four other important constraints—high costs of power, high transaction costs, high costs of information, and high levels of risk—all of which have their roots in politics and policy. First, Africa is short of power. For example, even in landlocked Uganda, the constraint currently most emphasized by firms is not transport but electricity. Around a third of manufacturing investment goes to the purchase of generators. The cause of this situa-

13. Collier and Hoeffler (1998).
14. Wood (1997); Wood and Berger (1997); Wood and Mayer (1999).
15. Collier and Gunning (1999).

tion is political: vested interests preserve a highly inefficient state monopoly of large-scale generation, so that the majority of Uganda's electricity is generated on a small scale for own consumption. Electricity has become part of the subsistence sector! And this is one of the best policy environments in Africa. At the other end of the spectrum, Nigerian politics has achieved the remarkable outcome of domestic fuel scarcity in an oil exporter.

Second, transactions costs are high because contract enforcement is weak. This is, again, political: the judiciary is not, de facto, independent. A 1996 survey found that the major problem for Ugandan banks was that due to the malfunctioning of the courts, assets could not function as collateral. When courts are weak, opportunism thrives, and credit is scarce. A survey of Kenyan manufacturing found that this situation priveleged Asian-owned firms, whose dense kin networks within the sector provided an alternative means of determining the reliability of contracts.

Third, information costs are high primarily because Africa has the worst telephone system in the world and until recently has had a highly restricted press. Once again, this is political: dictators regard an open telephone system and unrestrained media as threats. Some of the costs of a bad telephone system are obvious, others are subtle. An obvious cost is that exporting is more difficult: I encountered a Zimbabwean manufacturer who had to drive for forty minutes in order to make a telephone call. A subtle cost is that by limiting social interaction it reduces trust: telephone density is highly significant in explaining international differences in trust. In the Easterly and Levine growth regression, Africa's telephone system accounts for a loss of 1 percent per year in growth.[16]

Fourth, investors regard Africa as the riskiest region in the world. Some of this risk is intrinsic to small, commodity-dependent economies. Some risk is a corollary of trade barriers and high transport costs: because the timing of international deliveries is unreliable, firms cannot operate a just-in-time delivery system. For example, in Zimbabwe the average manufacturing firm carries two months' stocks of inputs. Some risk is a corollary of unreliable power supply: production is subject to frequent interruptions. Some risk is a corollary of weak contract en-

16. Easterly and Levine (1997).

forcement: firms are unable to distinguish opportunism from *force majeur*. In response, they tend to restrict their business dealings to established relationships, making new entry more difficult. Much of the risk, however, is directly political and reflects policy uncertainty. I think that the practice of donor conditionality has been at fault here: it has increased policy uncertainty rather than sustained policy change. Aid does not induce sustained policy change, but it sometimes coerces unsustainable change. For example, the World Bank has "bought" the same price reform four times from the government of Kenya.[17]

Destiny as hysteresis. Trade barriers, transport costs, power costs, transactions costs, information costs, and high risk, all largely the result of policy, have long-lasting effects. While I share the Bloom and Sachs agenda of trying to make manufacturing work, I think one should acknowledge that hysteresis effects of a prolonged period of poor policies may have made this infeasible.

First, there has been a loss of capital that may be irrecoverable. Trade barriers, transport costs, power costs, transactions costs, information costs, and high risk reduce the risk-corrected returns on African capital. On average, the rate of return on investment in Africa since 1960 has been around one-third lower than elsewhere.[18] Not surprisingly, this has resulted in both a lack of inward investment and an exodus of African wealth. I estimate that by 1990, around 39 percent of African private wealth was outside the continent, a higher share than for any other region.[19] As a result, Africa is now chronically short of private capital: private capital stock per worker has been falling since 1980 and is now less than half that of South Asia, the next most capital-scarce region in the world.

Second, as the rest of the world has developed manufactured exports, it has developed constituencies to defend the interests of the sector. In most African countries there is not yet a political constituency for the deep changes needed to make manufactured exports competitive. The macroeconomic reforms have been implemented because they are politically easier than microeconomic reforms.

Finally, I worry more about an implication of the other new economic geography, which emphasizes economies of agglomeration. It is pos-

17. Burnside and Dollar (1997).
18. Collier and Gunning (1999).
19. Collier, Hoeffler, and Pattillo (1998).

sible that the prolonged phase of poor policies has caused Africa to miss its window of opportunity to develop manufacturing: the time when the cheap labor of Asia offset the agglomeration economies of the developed world. By the time Africa reforms its policies, the world may have enough manufacturing sites for the long-term share of manufactures in world demand, and given the advantages of an existing agglomeration, new entrants will not be able to out-compete them. I hope not. I hope that agglomeration economies are sufficiently specific to market niches that Africa could quickly reach agglomeration thresholds. But this is another unresolved empirical question.

Against these hysteresis effects, there are signs of hope. There are now comparable studies for America, China, Mexico, Morocco, and four small African countries on whether manufacturing firms get productivity increases through exporting.[20] For America, exporting has no effect. For China, Mexico, and Morocco the results are mixed: there are some effects, but they are not large. For Kenya, Zimbabwe, Cameroon, and Ghana the effects are massive: new exporters gain 13 percent relative to other firms in the year after breaking in, and thereafter continued exporting raises productivity by 9 percent per year. Once African firms get a toehold in the world market, catch-up can thus be rapid.

Christopher Udry: Bloom and Sachs have provided an interesting, provocative, and ambitious paper. Their conclusion is unambiguous: "at the root of Africa's poverty lies its extraordinarily disadvantageous geography." They support their argument with a delightful mixture of historical discussion, botanical and medical argument, and statistics. If the reader is not careful, he or she will be swept along.

The paper is convincing because much of what it says is both important and true. Conditional on current agricultural technology and existing institutions, the geography of Africa implies very low agricultural productivity, and hence terrible poverty and poor growth. Much of what is special about demographic patterns in Africa can be understood as a consequence of low agricultural productivity and poverty, and high dependency ratios and low life expectancy increase poverty and provide a further substantial drag on growth prospects. Geography

20. Bigsten and others (1998).

and demography, then, are fundamental components of any account of poverty and disappointing growth in Africa. Moreover, they are ignored in many discussions of Africa's "growth failure."

The undeniable importance of the nexus of geography, demography, technology, and institutions for economic welfare in Africa does not, however, imply that geography lies at the root of poverty in Africa. Indeed, Bloom and Sachs do not want their paper to be "misunderstood" as a new case of "geographic determinism." But the overall tone and strong statements such as that quoted above make it virtually inevitable that this is precisely how most people will read it.

Overstating geography. When thinking about the puzzle of growth in Africa, I find it useful to keep in mind the question of Robert Lucas: "Why doesn't capital flow from rich to poor countries?"[1] There are two categories of explanation: first, bad technology, so that returns to capital are low in Africa; and second, market failures that inhibit capital flows despite relatively high potential returns to capital in some parts of Africa.

Bloom and Sachs focus exclusively on the first, and in particular, on a set of geographic and demographic factors that are associated with poverty, slow growth, and low returns to capital. There is a temptation (which they resist admirably in their conclusions but to which they succumb in the introduction) to further focus their rhetoric on geography, despite their quantitative evidence that demographic factors are far more important determinants of growth. The source of this temptation is the authors' objective of uncovering "deep underlying factors that have hindered African economic growth . . . for the entire period of modern economic growth." It is impossible to identify government policy, economic institutions, or even demographic characteristics of the population as such deep underlying factors, because they are too clearly endogenous to the growth process. Geography is the ultimate exogenous determinant of the growth process—GDP plays no role in plate tectonics.

I have three main objections to the paper's emphasis on geography and demography as fundamental impediments to growth in Africa. First, while it is clear that the geography is exogenous, poor agricultural productivity is not a natural outcome of Africa's geography. It is an

1. Lucas (1990).

outcome of geographical facts in the context of a given agricultural technology in a challenging institutional environment. Therefore the effects of both geography and demography on growth are endogenous to the growth process itself. Second, there is abundant evidence that bad technology and market failures (both interpreted broadly) are essential elements of any explanation of Africa's growth performance that also answers the Lucas question regarding capital flows. Finally, the quantitative evidence on which the authors in part base their claims is extremely weak.

The endogeneity of geography, demography, and public health. Bloom and Sachs argue that causality runs from the tropics, a high youth dependency ratio, and a high disease burden to poverty and slow growth in Africa. They provide an entirely convincing case that these factors have in fact had a pernicious effect on economic growth on the continent. Any sensible analysis of economic growth in Africa must incorporate an understanding of the effects of these physical and social factors. However, their contention that geography, demography, and public health are largely exogenous to the growth process in Africa is much less persuasive. It is clear from a large literature involving economists, demographers, and public health researchers that demographic and public health patterns in Africa are themselves largely determined by poverty and poor growth prospects.[2]

My claim that geography is endogenous to the pattern of growth in Africa is less obvious. Low and slowly growing agricultural productivity in Africa is the consequence of a complex interaction between human activity and the environment, rather than the simple outcome of disadvantageous geography. The absence of a significant "green revolution" in Africa is only partly a result of the facts that (overall) the continent is hot, has low and highly variable rainfall, and has old, highly weathered, and fragile soils. This physical environment combines with systemic failures of insurance and capital markets to produce extraordinarily complex farming systems, finely designed to balance the needs to maintain land fertility, to minimize risk, and to maximize profit.[3] Individual farmers produce multiple crops (often intercropped) on many scattered plots, using managed fallows of varying lengths to maintain

2. For useful reviews of this literature, see Strauss and Thomas (1995, 1998).
3. For an overview, see Binswanger and Rosenzweig (1986).

land productivity. There is no single principle to guide agricultural research: increasing the yield of particular crops is important, but not at the costs of too large an increase in risk or adverse side effects on other crops planted on the same plot. The success of a particular innovation, therefore, is dependent on not only particular physical conditions but on the configuration of factor markets and social institutions that address problems of risk and the allocation of capital. This implies that innovations are often quite localized, and also that there is an enormous amount of indigenous agricultural research.[4] It has proven quite difficult to link this knowledge with the worldwide network of formal agricultural research in the Consultative Group for International Agricultural Research.

Despite their occasional rhetoric to the contrary, Bloom and Sachs recognize that the demographic and public health characteristics that have impeded growth in Africa are mutable. They also recognize that while the physical facts of soil, sun, and rain are given, their effects on prospects for agricultural productivity and technological change are contingent on institutions and investment in agricultural research. This is the import of their well-written and insightful conclusion: there is a "complex interplay among geography, demography, health and economic performance." Bloom and Sachs err by setting some of these factors fundamentally prior to the others.

This is an important theoretical point, but it also has strong implications for policy. An easy misreading of this paper would lead one to the mistaken conclusion that agriculture in Africa is doomed by geography to be unproductive, and that it would be best to direct development resources away from that sector. In fact, there are numerous examples of very successful, if small-scale, technological change in African agriculture. The common characteristic of these success stories is that they are the product of research that was sensitive to both the physical features of the existing farming system and the economic and institutional environment.[5] Bloom and Sachs recognize this potential, and it is vital not to overlook their conclusion that "the intensification of scientific research on tropical agriculture in Africa . . . is warranted."

4. Richards (1985); Amanor (1994).

5. For a discussion of improved maize in semi-arid West Africa, see Sanders, Shapiro, and Ramaswamy (1996). On the explosive growth of cocoa production in Ghana, see Hill (1963).

Bad technology and market failure. Bloom and Sachs focus exclusively on bad technology as an explanation of poverty and slow growth in Africa. The corollary of this is that investment does not flow from capital-rich nations to capital-poor Africa, because the returns to capital are low in Africa. In fact, real rates of return to investment are exceedingly high in parts of Africa. However, capital markets are fragmented as a consequence of information asymmetries and imperfect enforcement mechanisms; hence both international and local capital flows are inhibited.

Evidence on the returns to capital in Africa is fragmentary and often difficult to interpret. Moreover, what is of interest is the return available in that part of the economy for which standard statistical measures are least likely to be available: enterprises in the informal sector. Nevertheless, some evidence is available. Arne Bigsten and others analyze panel data on manufacturing firms in a number of African countries and find extremely high returns to investment in certain sectors.[6]

Idiosyncratic but telling evidence is available from equilibrium prices for used versus new goods, or small versus large quantities of goods. Consider the market for automobile parts in an urban setting. In Accra, Ghana, for example, there are active markets for both new (high price but long lasting) and used (cheap but short-lived) replacement parts. At one point in 1997, a used tire cost approximately 40,000 cedis and could be expected to last for about a year on a taxi in constant use. A similar new tire cost 90,000 cedis but would last three to four years. With this pair of equilibrium market prices, the real interest rate at which it is worthwhile to buy a sequence of used tires rather than a single new tire is almost 40 percent per year.[7] For the marginal purchaser of tires in Accra, the opportunity cost of capital is extremely high. The reason why capital is not flowing from my American bank to borrowers in Accra is not that there are no profitable investments available in Accra; it is that the informational and enforcement problems associated with any such loan are so daunting.

It is not only international capital markets that are fragmented. At the same time that extremely high returns are available for investment

6. Bigsten and others (1998).

7. This calculation ignores both the expected cost of more frequent punctures with a series of used tires and the effects of risk associated with the uncertain life expectancies of both used and new tires.

in some sectors, on the order of 90 percent of the nonhuman assets owned by rural African households are held in the form of physical assets, such as grain stocks, animals, and consumer durables. These savers are prevented from capturing the high potential returns to investment by the same types of problem of information and contract enforcement as interfere with international capital flows. As a consequence of these market failures, profitable investments are not made and growth remains slow.

The technological causes of poverty and slow growth in Africa described by Bloom and Sachs are real. However, the exclusive focus on these factors is misleading. In many sectors the return to capital is extremely high; institutional and market failures make it impossible for these returns to be realized.

Evidence. The authors' simple cross-sectional regressions provide a weak quantitative limb on which to base their conclusions. My worries are familiar. First, Levine and David Renelt provide a valuable cautionary tale of the sensitivity of the results of such regressions to the fine details of model specification.[8] Second, the inclusion of a lagged dependent variable as an explanatory variable is a misspecification, because it is known that there are persistent unobserved characteristics that influence growth over time (hence the error term in the regression is correlated with ln GDP per worker in 1965). The coefficient of the lagged dependent variable is biased as a consequence of this error, and so are the coefficients of other correlated explanatory variables. Finally, the geographic and demographic variables—with the exception of the proportion of land area in the tropics and the coastline variable—are themselves endogenous and sure to be correlated with the error term in the regression. The main demographic variables are life expectancy in 1965 and a measure of the relative growth rates of the working-age and total populations over 1965–90. As noted above, these features of the population are chosen, not randomly allocated by nature. The population density near the coast is also endogenous, as this must largely reflect patterns of urbanization and regional migration that are strongly correlated with the growth process. Consequently, readers should use these statistical results with a great deal of caution; sweeping conclusions based on this evidence are not warranted.

8. Levine and Renelt (1992).

General discussion: James Stock found the arguments in the paper plausible, but the regression analysis less than convincing because of possible simultaneity problems. He questioned inferring causality from regressions of high inland population density—which is correlated with a large agricultural sector—on low GDP growth or of bad health on low GDP growth, as there are clear influences in both directions. He also cautioned against using lagged dependent variables as a way around simultaneity, since the persistent nature of Africa's problems would produce high serial correlation in error terms. David Laibson suggested important cultural variables that could be used in a growth regression. He noted that hierarchical religions were negatively correlated with public good provision and economic growth, so that Catholicism and Islam, brought by colonizers, may have affected Africa negatively. Legal systems inherited from former colonial powers also help to predict economic outcomes, with the British system and its commercial code historically having been the best at protecting minority rights. He concluded that the legacy of colonialism may be important for understanding Africa today, and statistical analysis could distinguish the impacts of the various colonial powers.

William Dickens suggested a way to reconcile the paper's emphasis on geography with the complaints by Collier and Udry that it pays inadequate attention to governmental and economic institutions. He reasoned that the factors stressed by Bloom and Sachs were more basic than institutions. Important institutions such as capital markets developed in the areas where trade began to flourish. So if geography affects trade, institutions would follow geography. Similarly, the rent-collecting aristocracy that had hobbled all western economies vanished only after the dynamism of the capitalist system gave it the political strength to replace that aristocracy. He suggested that if international organizations could promote desirable change in the political and economic institutions of Africa, they could accelerate the process by which growth and institutional change interact.

Carol Graham proposed investigating directly whether geographical disadvantages are associated with slower institutional development. She agreed with the authors' idea of moving away from policy-based lending, but was more cautious about giving priority to the funding of, say, malaria research rather than to building institutions that would address problems for which there are already remedies. She would give priority

to the prevention of infectious disease and dealing with high rates of fertility and female illiteracy. Graham added that AIDS has contributed not only to the demographic problems in Africa but also to the weakness of its institutions, because it has decimated the population of talented civil servants.

Robert Gordon argued that the overriding importance that the authors attached to geography was not convincing and was at odds with broader evidence. He recalled David Landes's analysis that the best agricultural conditions in the world are on the west coast of Ireland, yet Ireland has lagged behind much of Europe economically. He also noted that both geography and the initial conditions of colonization in Africa were similar to those in parts of Asia and Latin America. A cross-country comparison among nations in these areas would help separate the distinctive role of unchanging geography from the role of things that do change, such as policies and institutions in different countries. Gordon also suggested that the return to capital is low, or even negative, in Africa because of a high risk of theft and expropriation, both of which clearly depend on the political system.

Susan Collins welcomed the paper's attention to geography, demography, and health, which are often neglected in studies of growth. But she felt that some standard macroeconomic variables would sharpen the explanation of Africa's growth and better inform the debate about what steps might help. Because the particular measure of openness used in the paper is highly correlated with other macroeconomic policy variables, she suspected that the openness variable may capture macroeconomic policies in general rather than trade restrictions, and that its interpretation was unclear. In particular, Collins suggested that the negative coefficient on openness in the regression presented in the paper should not be interpreted to mean that standard measures of macroeconomic and trade policy did not matter in these countries.

Steven Radelet thought that the contribution of the paper was to introduce geography into the analysis of growth, as Robert Hall and Chad Jones had done in a preliminary way in a previous papaer, rather than to argue for a clear distinction between policy and geography or that one matters more than the other. He agreed with Collier that one should not analyze Africa as if it were a single entity, and suggested distinguishing among at least three groups of countries. The first group is coastal countries, which would not have the transport problems of

the landlocked countries and could presumably be successful in manufacturing exports. The second is the desert-type economies that are not going to develop successful agriculture, and probably not successful manufacturing either; their prospects are a serious concern for which there seem to be no obvious policy solutions. The third group is the landlocked economies that suffer from both geographic and policy problems and which may find it inherently difficult to compete in manufacturing products, even if their labor costs are very low.

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