Chapter 3

Geography and Development

The mistaken notion that has long held sway in Latin America is that since geography is unchangeable, there is no reason why public policies should take it into account. The relationship between development and geography has been ignored if not dismissed outright as fatalistic if not racist. While there were undoubtedly some grounds for such criticism decades ago when studies of physical and human geography were influenced by European ethnocentrism, that is no longer the case today.

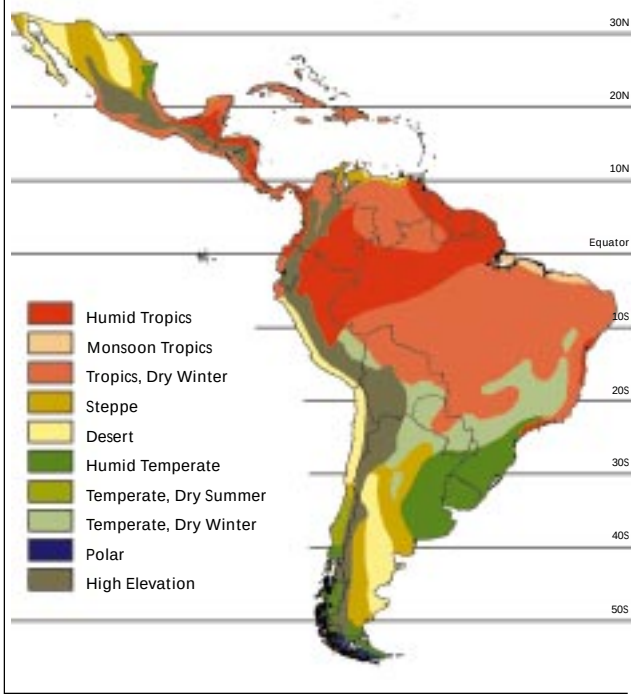
Yet geography remains largely ignored in discussions of public policy in Latin America in the face of considerable evidence and suffering that points to its ongoing relationship to development. Hurricanes and earthquakes cause enormous damage, injuries and death that are preventable; thousands of people suffer every day from endemic diseases for which there is no cure or treatment; farm families throughout the region remain mired in poverty because of the poor productivity of their lands and the lack of appropriate technologies; and countless Latin Americans pile up in cities without access to the basic infrastructure they need for services and transport. Moreover, in several regions in Latin America, there remain the problems of excluding indigenous communities, blacks and other racial minorities who for historical reasons are located in geographically disadvantaged areas. The physical, economic and social isolation of these areas tends to reinforce the development gaps between these groups and the rest of society.

All of these problems and many others that will emerge throughout this chapter are the result of geography and its relationship to the societies of Latin America over the course of history. Many of the painful effects of these problems could have been prevented or mitigated had the influence of geography been better understood. Although many geographical conditions such as climate and location cannot be changed, their influence can be controlled or channeled toward the goals of economic and social development.

Geography affects development through the interaction between physical geography—such as climate, characteristics of land or topography—and human geography, which is the settlement patterns of populations. This chapter looks at the ways these two types of geography affect economic and social development, and examines how different policies can take better advantage of geographical conditions. The objective is not to discuss influences operating in the opposite direction—that is, from development (or lack of it) to geography. Thus, the chapter does not consider the effects of erosion, pollution and overexploitation of natural resources on environmental sustainability, although admittedly they may affect the very possibilities of development over the long run. Curiously, these channels of influence have been subjects of more analysis than has the more immediate effect of geography on development.

Physical geography influences possibilities for economic and social development through three basic channels: productivity of lands, health conditions, and the frequency and intensity of natural disasters. Naturally, these channels interact with other factors such as settlement patterns and the makeup and spatial distribution of productive activities, which are largely the result of historic processes. Settlement patterns in turn influence development in terms of access to markets—especially international markets that are a broader and more dynamic source of exchange of goods, technologies and ideas than domestic mar-

Figure 3.1 Köeppen-Geiger Ecozones



Source: Derived from Strahler and Strahler (1992).

Figure 3.2 Geographical Zones

Source: Derived from Strahler and Strahler (1992).

kets—and through urbanization, which facilitates specialization of labor and makes it possible to generate economies of scale and learning, although it may also entail congestion costs.

These channels of influence can be modified through a variety of policies. Land productivity and health conditions can be changed through technological developments and the provision of certain basic services. The destructive potential of natural disasters can be offset through adequate building standards and safer location of housing. Access to markets can be improved with investments in transportation routes. Urbanized areas can function more effectively if cities have adequate service infrastructure, incentive systems, and public administration. These and other policies can be identified and designed to turn geography into an advantage, but only if, as a first step, there is recognition of the different channels through which physical and human geography influences the potential for economic and social development.

This chapter begins with an overview of the key geographical features of Latin America and their relationship to current development indicators. That is followed by an historical look at the profound and persistent influence of geography in shaping Latin American societies. The chapter then examines each of the five channels of influence of physical and human geography presented in this introduction: productivity of lands; health conditions; natural disasters; access to markets; and urbanization.

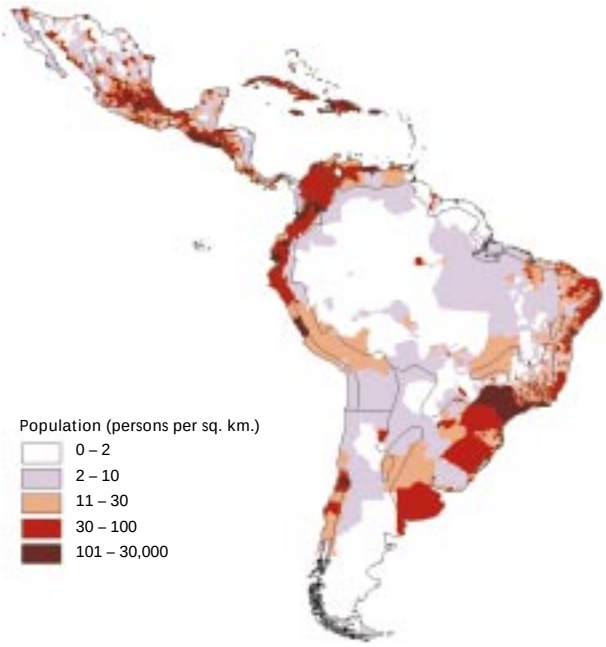
The final sections quantify the impact of these factors on the development potential of Latin America, and then examine the policy implications of areas ranging from technological research to decentralization—making it clear that geographical variables have to be explicitly interjected into the discussion of many if not all public policies in the region.

The Diverse Geographical Regions of Latin America

Latin America is largely located within tropical zones, but its geographical features span a large variety of climates and ecozones, not all of them characteristic of tropical regions.

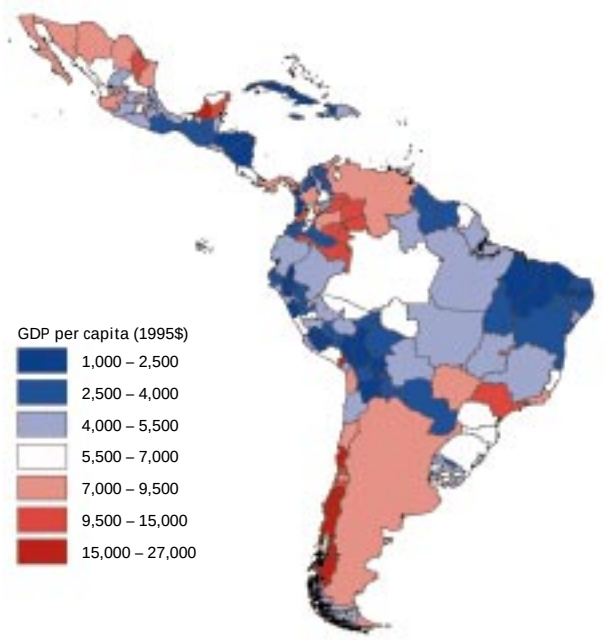
One of the first climatic classification systems was that of Köppen, developed a century ago but still

Figure 3.3 **Population Density**



Source: Calculations based on Tobler et al. (1995).

Figure 3.4 **Regional GDP Per Capita**



Source: Summers and Heston (1994); Azzoni et al. (1995); Escobal and Torero (1999); Esquivel et al. (1999); Morales et al. (1999); Sánchez and Núñez (1999); and Urquiola (1999).

the most useful and widely used today. Köppen's ecozones, shown in Figure 3.1, are based on temperature and precipitation data, as well as elevation (as modified by Geiger).[1] The main ecozones in Latin America are tropical (A), dry (B), temperate (C), and high elevation (H). The ecozones allow us to identify the region's major geographical differences: temperate versus tropical, highlands versus tropical lowlands, and dry versus temperate outside of the tropics.

Several other geographical factors besides climate have had a strong impact on economic activity and population distribution in the region. Coastal areas are distinct from the inland; northern Mexico is unique because it borders the huge U.S. market; and direct access by sea to Europe historically has differentiated the Caribbean and Atlantic coast from the Pacific coast. The Köppen ecozones and these simple patterns form the basis of seven broad geographical zones for the region: border, tropical highlands, lowland Pacific coast, lowland Atlantic coast, Amazon, highland and dry Southern Cone, and the temperate Southern Cone (Figure 3.2).

Different Geographical Zones, Different Economic Outcomes

The border zone comprises the arid or temperate climate in the north of Mexico. This zone is sparsely populated, has higher-than-average per capita GDP than the rest of Mexico and Latin America, and contains most of the Mexican *maquiladora* manufacturing assembly industry due to its proximity to the U.S. market (see Figures 3.3 and 3.4).

The tropical highlands cover the highland regions of Central America and the Andean countries north of the tropic of Capricorn. This zone has very high population densities despite its difficult access to the coast, and is home to most of the indigenous people of Latin America. Overall, it has the lowest per capita GDP on the continent, despite including Mexico City and Bogota, which have high-income levels relative to the rest of Latin America. The problems of this zone highlight what happens when populations continue over time to live in areas with geo-

[1] See Strahler and Strahler (1992, pp. 155-60).

Table 3.1 **Characteristics of Latin American Geographical Zones**

Geographical zone	GDP per capita (1995$)	Population density (persons/sq km)	GDP density ($1,000/sq km)	Area (millions of sq km)	Population within 100 km of coast (%)
Tropical highlands	4,343	52	226	1.9	11
Lowland Pacific coast	4,950	61	302	0.8	95
Lowland Atlantic coast	5,216	46	240	2.2	83
Amazon	5,246	6	31	9	1
Temperate Southern Cone	7,552	35	264	3.2	31
Mexican-U.S. border	7,861	17	134	1.1	30
Highland and dry Southern Cone	9,712	7	68	2.2	16

Source: Authors' calculations from data in Figures 3.2, 3.3 and 3.4.

graphical disadvantages. Poverty persists when the geographical barriers people face cannot be overcome, and when they do not move to more geographically favored regions.

The lowland Pacific and Atlantic coastal zones are tropical with some small areas of dry ecozone. The Pacific coast has the highest population density of the seven geographical zones. The Atlantic coast also has dense population, though less so than the Pacific. The two coastal zones have per capita GDP about 20 percent higher than the highland zone they abut, with similarly high population concentrations. The coastal zones have excellent access to the sea and international trade, of course, but must face the burden of disease and agricultural challenges of a tropical environment.

The Amazon zone is still largely uninhabited in comparison with the other geographical zones, despite migration and the accompanying environmental consequences that have occurred over recent decades. Perhaps surprisingly, per capita GDP in the Amazon is higher than adjacent coastal and highland zones. This is due to migration equilibrium and resource rents. Settlers will move to the difficult environment of the Amazon if they expect income opportunities to be better than those in areas from which they migrated. The migrants are also more likely to be working age males with no dependents, resulting in higher average per capita income. However, much of the GDP of the region comes from natural resource rents of mining and large plantations that are often owned by investors who do not reside in the jungle. Thus, GDP per capita is probably higher than average household incomes per capita.

The two Southern Cone zones are both high-income areas, like the northernmost border zone. The temperate Southern Cone has a substantial population density, while the highland and dry Southern Cone has a population density barely higher than that of the Amazon. Average GDP per capita and the population density of the temperate Southern Cone are somewhat less than they would otherwise be because of the inclusion of temperate ecozones in Paraguay and Bolivia.

Looking at the average income levels and population densities of the geographical zones in Table 3.1, the four tropical zones have the lowest GDP per capita, clustered around $5,000 (in 1995 dollars), except for the highlands at $4,343. The three temperate regions in the Southern Cone and northern Mexico have much higher income, averaging from $7,500 to $10,000. Population densities follow a very different pattern, with very low densities in the arid Southern Cone and Mexican border zones, intermediate in the temperate Southern Cone, and higher in the tropical coastal and highland zones.

The result of GDP per capita and population density is the density of economic production by land area. The zones with the highest economic production are the three densely populated tropical zones and the temperate Southern Cone. The Mexican border region is intermediate and the arid Southern Cone and the Amazon very low. Although the GDP densities are similar across these groups of tropical and tem-

perate zones, the temperate regions achieve higher GDP per capita with a lower population density, while the tropical regions struggle with the opposite combination.

The diversity of geographical conditions within Latin America is also apparent in some of its countries. While Uruguay and the Bahamas are homogeneous—that is, most of their territory belongs to only one main ecozone—countries like Bolivia, Brazil, Ecuador, Colombia and Peru show an astonishing geographical diversity. Few other countries in the world offer so many climate zones and landscapes. Peru contains 84 of the 104 ecological regions in the world (according to one classification) and 28 different climates. The geographical diversity of some of the Latin American countries has led to severe geographical fragmentation, as reflected in patterns of population settlement, at times with dire political consequences (see Chapter 4).

History

The geographical remoteness and isolation of the Americas played a central role in the devastation of the indigenous people at the point of first contact with Europeans. Relative to the historical timeline, humans did not settle permanently in the Americas until quite recently, probably about 11,000 BC.[2] The first settlers were most likely small nomadic groups crossing the cold Bering Straits, so they carried few Old World diseases with them from Northern Asia, in particular, no "crowd" diseases such as smallpox, measles and typhus, and no tropical diseases. When Christopher Columbus arrived, followed by other conquistadors and explorers, the toll of Old World disease was catastrophic to the indigenous peoples of the New World, in some cases wiping out whole tribes before a shot was fired.[3] The implausibly lopsided victories of Cortés over the Aztecs and Pizarro over the Incas are as much attributable to smallpox as to Spanish firearms and horses. The emperors of both the Incas and the Aztecs, along with large proportions of their populations, were killed by smallpox before the decisive battles with the Spaniards even began. By 1618, Mexico's initial population of about 20 million had collapsed to about 1.6 million.[4] According to McNeill, "ratios of 20:1 or even 25:1 between the pre-Columbian populations and the bottoming-out point in Amerindian population curves seem more or less correct, despite wide local variation."[5]

Geography most likely played a hand in the pre-Columbian settlement patterns in the Americas. The main empires—the Aztec and the Inca—were in the tropical highlands, probably due to better climate for agriculture and a more benign disease environment. With no use of seaborne trade, or even wheeled transport, access to the sea was not an economic disadvantage for these civilizations. The major exception to the highland New World civilizations was the Mayans in the tropical lowlands, but the dense population in the Yucatan peninsula mysteriously collapsed before contact with Europeans.[6] The current concentration of indigenous peoples of Mexico, Central America and the Andean countries in the highlands is also a function of where indigenous people survived the introduction of Old World diseases. Highland populations were protected from the lowland tropical diseases of malaria, yellow fever and hookworm, which contributed to the extinction of substantial Amerindian populations from most of the Caribbean islands.

Geography and Colonization

Colonization played a complicated but important role in shaping current patterns of economic development, but it is of little help in explaining the dramatic geographical variation in present-day Latin America. Most of the countries in the region share the same colonial heritage, despite very different economic outcomes. Among the countries with British, French or Dutch rather than Iberian heritage, one can find some of the richest and also some of the poorest countries of the region.

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[2] Diamond (1997, p. 49). However, human arrival in the Americas may have been as early as 25,000 BC, although much debate surrounds these estimates.

[3] Many chilling examples are documented by Crosby (1972, 1986).

[4] Diamond (1997, p. 210).

[5] McNeill (1976, p. 190).

[6] Substantial evidence points to sustained drought brought on by the El Niño climatic oscillation as the cause of the Mayan collapse, due to high population density agriculture on fragile tropical soils. See Fagan (1999, Chapter 8).

Box 3.1

How the Climate of Haiti Destroyed Two Large Armies[1]

In the general chaos brought on by the French Revolution, the richest of France's colonies, Saint Domingue, later to become Haiti, began to slip from her grasp. With the promulgation of the Rights of Man in a colony based on a brutal system of slavery, armed resistance to the white planters progressed from the mixed-race, pro-slavery, *mulâtres* to a general revolt by the African slaves by 1791.

Britain and Spain, both at war with Republican France in the 1790s, agreed to divide the prize of St. Domingue between them. Spain fought by proxy through the rebel slave bands in the north, but Britain invaded with its own troops in the south in 1793. Realizing that neither Spain nor Britain would brook an end to slavery, the rebels cast off the Spanish and turned to attack the British. Though rarely directly engaged by the rebels until near the end, the British succumbed to the geography of St. Domingue. The British commander had assured London that he could take the territory with 877 troops, but reinforcements could not keep up with the ever increasing toll of yellow fever and malaria. In a typical case, Lieutenant Thomas Howard's regiment of 700 hussars lost 500 men in one month with only seven battle deaths. In the end, disease and the rebels forced the British to evacuate with over 14,000 dead. Edmund Burke summed up the debacle: "The hostile sword is merciful: the country itself is the dreadful enemy."

When Napoleon consolidated his power in France after 1799, he turned to reconquering the prized colony of St. Domingue to use it as a springboard to reassert French control of the Louisiana Territory. His downfall was the same as Britain's. French troops could not survive in Haiti's disease-ridden environment. Leclerc, Napoleon's brother-in-law, quickly occupied almost the whole colony with 20,000 troops in 1802. Then yellow fever and malaria took hold. Mortality from yellow fever exceeded 80 percent, and to hide the losses, the dead were carted away at night and military funerals suspended. With all but two of his corps commanders dead, Leclerc himself would succumb to yellow fever before the year was out.

The French struggled on with massive reinforcements until 1803 before pulling out the surviving remnants of the army. Only 10,000 men made it back to France, with 55,000 dead in the colony. The hemisphere's second independent republic, Haiti, was born. It was to provide refuge and support to Simón Bolívar in his darkest hour in 1815. Napoleon was forced to give up his designs on the Louisiana Territory, which he sold to the United States. The tenacity of the Haitian rebels was essential to the only successful slave revolt in history, but victory depended on Haiti's crushing burden of tropical disease.

[1] Based on Heinl and Heinl (1978).

Moreover, as shown by Diamond (1997), geography had a profound role in determining which countries were colonizers and which countries were colonized. Eurasia was highly favored relative to the other continents in terms of domesticable crops and livestock both by chance and because of its large area of contiguous ecological zones.[7] The constant proximity of settlements to their livestock and their own waste in Eurasia caused new diseases such as smallpox, measles, chickenpox, and a range of intestinal parasites. The concentration of sedentary populations in cities made possible by agricultural advances provided a constant pool of new infectives to sustain "crowd diseases" such as tuberculosis and influenza. This heady brew of infectious disease proved to be devastating to unexposed populations, and largely explains the easy conquest of the Americas and Australasia. The technological advances made possible by the agricultural advantages of Eurasia also explains the eventual European domination of Africa.

When Europeans brought Africans to the New World as slaves, they also imported a panoply of African diseases new to the Americas. Malaria, yellow fever, hookworm, schistosomiasis and other diseases further devastated the indigenous population and have had a persistent impact on the burden of disease since then. Most of these diseases remain major public health and economic problems in the American tropics to the present day.

The imported African diseases also plagued the European colonizers in the tropical regions of the New

[7] The lack of domesticable livestock in the Americas for use in agriculture as well as war was probably due to the impact of the first human settlers of the Americas 13,000 years ago on large mammals, ironically similar to the deadly impact of European settlers on the descendants of the original American settlers. American mammals had no experience of coevolution with humans until the Asian migrants' sudden appearance, and thus no natural wariness and defenses against human attack. In the Americas, as in Australia, the first human settlers brought about the extinction of most of the large mammals. See Crosby (1986, pp. 273-81).

World, especially the Caribbean. Haiti was the graveyard for two large colonial armies (see Box 3.1). Yellow fever and malaria devastated successive invasions by the British and the French, whose losses in Haiti were greater than the losses of either side at Waterloo.[8]

Slavery implied not only a new pool of diseases but profound changes in the composition of populations, the ability to exploit certain lands, and the patterns of institutional development of those countries that absorbed slaves in large numbers. Slavery was not a uniform phenomenon, but one clearly influenced by a combination of geographical, technological and institutional factors (see Box 3.2).

Ever since Eric Williams' insightful analysis nearly a half century ago, it has been generally accepted that the origin of slavery "was economic, not racial; it had to do not with the color of the laborer, but the cheapness of the labor." Nevertheless, "racial differences made it easier to justify and rationalize black slavery." Thus, "slavery was not born of racism: racism was the consequence of slavery." Racism was its longer lasting effect, since racial prejudice did not end with slavery. It continues to affect the lives of the descendants of slaves, thereby limiting their economic and social opportunities (Williams, 1964).

The Harsh but Not Indomitable Tropics

The difficulties of operating in a tropical environment were abundantly clear during the building of the Panama Canal. The effect of the humid tropics on everything from tools to clothing wrought havoc: "Anything made of iron or steel turned bright orange with rust. Books, shoes, belts, knapsacks, instrument cases, machete scabbards, grew mold overnight. Glued furniture fell apart. Clothes seldom ever dried."[9]

Above all, abandonment of the project by the French (1881-89) and the early failures by the Americans (1904-05) showed that intensive disease control, particularly for malaria and yellow fever, was a necessary condition for its completion.

Although the French made major investments in medical care, in the 1880s they did not yet understand the means of transmission of these two major mosquito-borne diseases. Besides the fearsome mortality of workers and the recurrent debilitation of those who survived, many of the most dynamic project leaders and engineers perished from tropical disease. On top of unrealistic technical goals and organizational difficulties, the loss from disease was more than the project could sustain. At least 20,000 lives were lost to disease during the nine years of the French effort.[10]

U.S. President Theodore Roosevelt, the prime mover behind the American attempt to build the canal, immediately recognized the importance of disease control from his own experiences in the tropics: "I feel that the sanitary and hygienic problems…on the Isthmus are those which are literally of the first importance, coming even before the engineering."[11] When the Americans revived construction of the canal in 1904, a crucial element of their success was William Gorgas. He demonstrated in Havana in 1901 what few believed possible: endemic yellow fever could be eliminated by intensive mosquito control. Once Gorgas was given substantial resources and support in 1905, he carried out a similar feat in Panama. In one of the most intensive vector control efforts before or since, Gorgas largely eliminated the threat of both yellow fever and malaria by denying mosquitoes the pools of stagnant water they need to breed. An army of health inspectors was used to go house to house. The provision of clean water and other public health measures reduced the incidence of other diseases. Contrary to popular impression, malaria was a greater threat to health than yellow fever in Panama, as Gorgas recognized, with higher mortality under both the French and American canal projects.[12]

Yellow fever is no longer a major public health problem due to a successful worldwide control effort in the 1930s and the development of an effective vaccine. The story of malaria is completely different. The worldwide eradication effort that started in the 1920s and intensified in the 1950s and 1960s was largely a failure in the tropics, and no vaccine strategies have yet proven viable. Currently, all the inexpensive drugs for treatment of and protection from malaria are losing their effectiveness in the face of resistant strains.

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8 Heinl and Heinl (1978, p. 81).

9 McCullough (1977, p. 135).

10 Ibid., p. 235.

11 Ibid., p. 406.

12 Ibid., p. 139.

Box 3.2

Box 3.2 Why Slavery Only Developed in Certain Regions

The relationship between geography and slavery has been the subject of extensive debate, motivated by the racist culture that evolved from colonists of European origin in order to justify the exploitation of blacks. The issue is to explain the concentration of slavery in tropical areas, since the large majority of slaves went to the Caribbean islands or Brazil, and in the United States they were concentrated in the subtropical south. The deep-seated justification given by the racist culture is that blacks were better able than whites to endure the unhealthy tropical environment.

Some of the most recent studies, which have their antecedents in the innovative findings of Thompson (1941), Williams (1964) and other authors, base their arguments on the conditions of production on plantations and the scarcity of other types of manual labor. Following this view, Engerman and Sokoloff (1997) have shown that slavery predominated in the tropics not because of its hostile disease environment, but because the institution of slavery was more economically productive on tropical plantations (though disastrous for those who actually did the work), while free labor was more productive in the temperate New World. The tropical climate was suitable for certain crops (sugar, tobacco, cacao, coffee, cotton and rice) that were conducive to production on large-scale plantations, while temperate zones were conducive to grain-based agriculture with efficient smallholder production. Furthermore, the tropical plantation crops could be cultivated by gang labor forced to work rapidly without significant risk of damage to the crops. Hence, Engerman and Sokoloff argue that economies based on slave labor in Latin America and the Caribbean resulted in high levels of inequality with far-reaching consequences for institutions and economic development in these countries. The Spanish colonies had relatively little slavery, but the Amerindians, with a slave or serf-like status, comprised a large percentage of the population in all these colonies until the end of the 19th century. This disparity resulted in high inequality and restrictive economic institutions similar to those in the slave states. According to Engerman and Sokoloff, the institutional environment (due to the historical but not persistent impact of geography) is what explains the divergence between Latin American economic performance and that of the United States and Canada.

Some authors, however, believe that health conditions in tropical areas could have been a factor in the predominance of black slavery over other races. Coelho and McGuire (1997) have argued that as a result of the exposure of many generations to tropical diseases, Africans had both greater genetic and acquired immunity to them, especially malaria, yellow fever and hookworm. Most sub-Saharan African ethnic groups have two blood characteristics: the Duffy factor and the sickle cell trait. The Duffy factor confers immunity to the milder vivax form of malaria, while the sickle cell trait provides partial protection from the more deadly falciparum malaria. Most Africans were immune to yellow fever due to exposure as children (when the disease is milder), and even nonimmune Africans have lower death rates from the disease for poorly understood reasons. Similarly, West Africans, from whom most New World slaves descended, have a clear but poorly understood tolerance to hookworm.

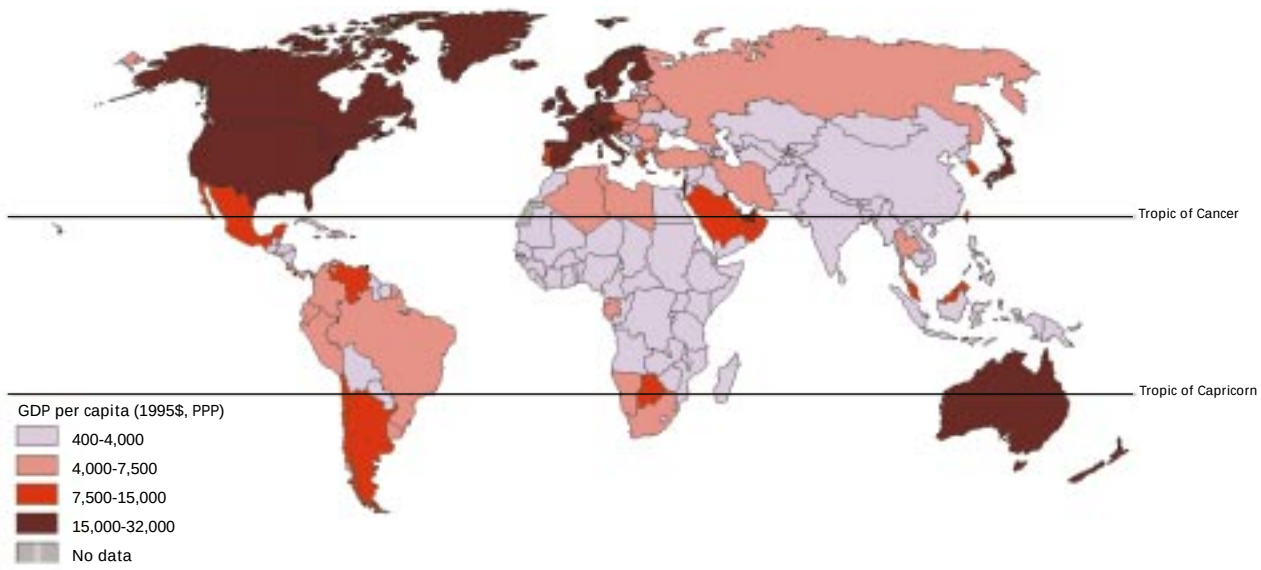
In any event, the ultimate explanation for the spatial concentration of black slavery is the scarcity of other types of manual labor in large-scale production units. Europeans engaged in or forced to work on plantations were allowed the opportunity to purchase lands and have the recourse to institutions whose protection did not extend to blacks. American Indian natives constituted a limited supply of manual labor that in many areas was decimated by diseases. A better resistance of blacks to certain tropical diseases possibly eased the process, although it neither explains nor justifies it.

In many regions of Latin America, present localization patterns of both black and indigenous populations still reflect elements from the past. Frequently, adverse climatic circumstances are reinforced by physical isolation and inadequate access to markets and infrastructure, as well as by various institutional and cultural mechanisms that make it difficult to obliterate the burden of history. Latin America still does not pay the attention to these problems that they deserve. Although this book does not address these issues in detail, it is motivated by the conviction that ignoring the impact of geography on development implies running the risk of ignoring ethnic minorities.

Productivity of Land

Stark evidence of the strong and pervasive effects of geography on development is the fact that most of the world's poorer countries are located in the tropics, while the highest levels of development are found in nontropical areas (Figure 3.5). The economic disadvantage of the tropics can in turn be largely attributed to lower agricultural productivity. If geography were unimportant, one would expect to see similar economic conditions throughout the world, subject to some random variation. In fact, poor countries are rarely interspersed in the richer regions, although a few rich countries can be found in the tropical areas.

Figure 3.5 **Distribution of Per Capita Income**



Source: Gallup, Sachs and Mellinger (1999).

Latin America has more middle-income countries in the tropics than do other regions with tropical areas, suggesting that it is less bound by the general rule that the tropics are poorer. The geographical gradients within Latin America are nevertheless clear and dramatic. Figure 3.6 shows that 1995 per capita GDP levels in the region follow roughly a U-shape in latitude, with much higher levels in the temperate south, and a minimum level just below the equator in the band from 20° south to 0° latitude. The geographical tropics is defined as the region from 23.45° south to 23.45° north, where the sun is directly overhead at some point during the year. Tropical Latin America has much lower income levels than temperate South America or temperate Mexico, although some spots of high development can be found in the Caribbean (Figure 3.7). The average per capita GDP of $4,580 found in the 20° south to 0° latitude band is just under half the level found at high points in temperate regions.

The problem of poverty in the tropics is nothing new. The U-shaped gradient shown in Figure 3.6 has persisted for as long as we have data. Figure 3.8 shows that per capita GDP in 1900 in the tropical countries of Brazil, Peru, Colombia and Venezuela was less than half that of temperate Chile and Argentina, and lower than Mexico and Cuba on the tropical fringe.[13] By a factor of three, the tropical Latin American countries had lower incomes than the United States or Canada, with their temperate climates.

Data for 1800 are more tenuous and sparse, but show the same pattern by latitude (Figure 3.9).[14] The tropics were poorer than the temperate countries, with the clear exception of Cuba and, apparently, Haiti,[15] whose richness was based on the brutally productive (but eventually unsustainable) slave economy.

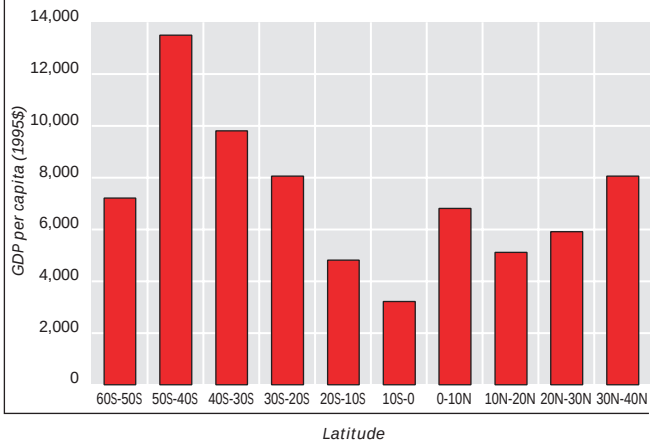
Since the Latin American countries share much of the same colonial and cultural history, current and past patterns of income by latitude within the region are striking. While differences in economic development across continents are more likely due to divergent historical experiences rather than geography, this position is less plausible within continents.

[13] GDP per capita data for 1900 are from Maddison (1995, Table C-16d), except for Cuba in 1913, which is from Coatsworth (1998, Table 1.1).

[14] GDP per capita data for 1800 are from Coatsworth (1998, Table 1.1, p. 26).

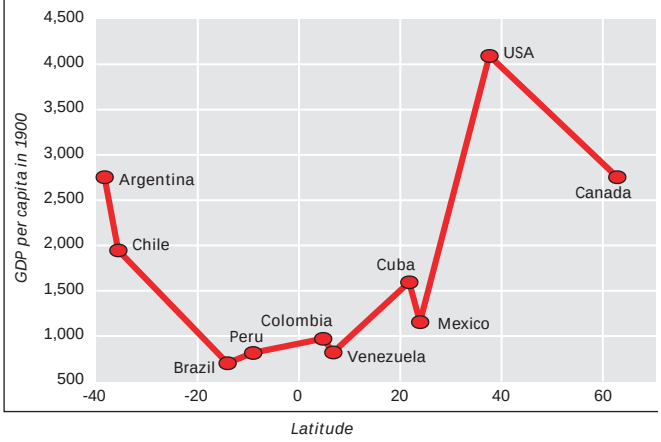
[15] Although not included in Figure 3.9, historical evidence shows that Haiti was France's richest colony and most likely had income levels similar to Cuba before the slave rebellion destroyed the plantations. See Heinl and Heinl (1978, p. 2).

Figure 3.6 Mean GDP Per Capita by Latitude Band in Latin America



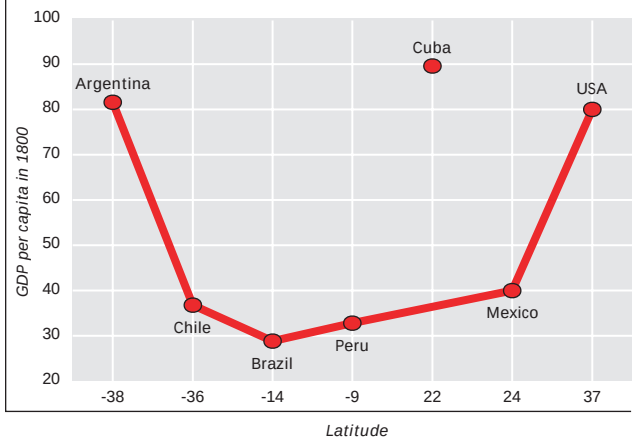
Source: World Bank (1998) and ESRI (1992).

Figure 3.8 Income by Latitude in 1900
(In current US$)



Source: Madisson (1995) and Coatsworth (1998).

Figure 3.9 Income by Latitude in 1800
(In current US$)



Source: Coatsworth (1998).

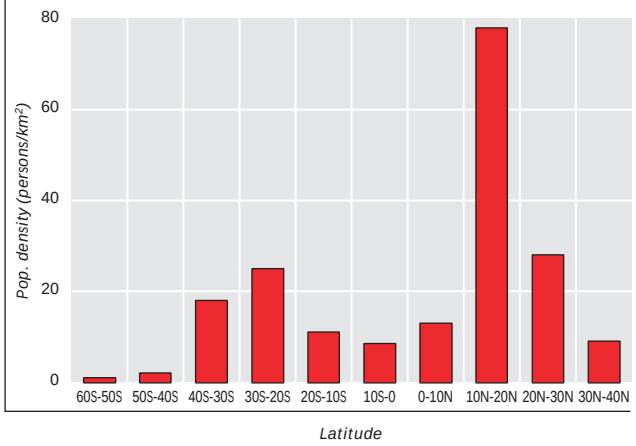
Figure 3.7 Latin America by Latitude

The pattern of development within Latin America is consistent with the pattern within Africa and Eurasia. The nontropical northern and southern extremes of Africa are the wealthiest regions of the continent. In East Asia, the tropical and subtropical regions are poorer, in general, than the temperate north.

Population density is a rough indicator of how hospitable the land is to an agrarian society, but there is no evidence of overpopulation as an explanation for why the tropics are poorer. In fact, tropical areas have fewer people on the land as well as lower per capita income levels.

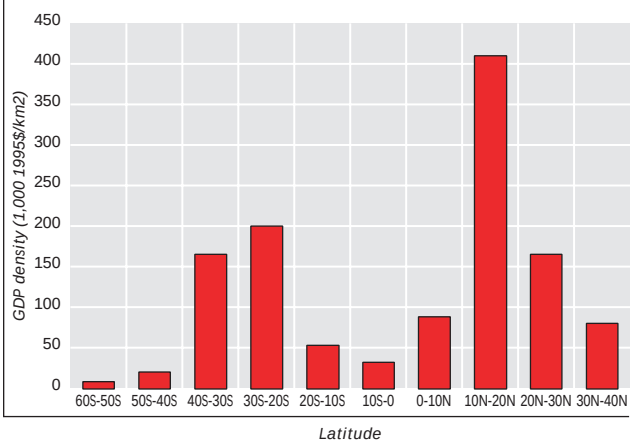
Current population distribution in Latin America largely conforms to the original European settlement patterns (including the slaves they brought), plus indigenous highland populations that survived the Columbian exchange. As with other regions of the world, population shows a bimodal pattern with respect to latitude (Figure 3.10), with peaks in the temperate middle latitudes, and lower densities in the far south and the tropics. The highest population densities in the tropical 10° to 20° north latitude band of central Mexico and Central America are something of an exception, but consistent with a relationship between climate and population, since most of this population lives in the highlands with a temperate climate.

Figure 3.10 Population Density by Latitude Band



Source: World Bank (1997) and ESRI (1992).

Figure 3.11 GDP Density by Latitude Band



Source: World Bank (1998) and ESRI (1992).

The low population density of the tropics in Latin America implies that the economic productivity of tropical land is even more unequally distributed than incomes in the region. Figure 3.11 shows that the economic output of land area in the tropical band of 10° south to 0° latitude is $39,000 per square kilometer, less than a quarter of output at 20° to 30° north and south.

Tropical Agriculture

With factors such as history and population ruled out, the evidence of economic disadvantage of tropical areas points to problems with agricultural productivity. Agricultural yields are particularly sensitive to climate, soil resources and technology.

Climate and soil conditions are different in temperate and tropical ecological zones. Furthermore, the tremendous differences in the natural plant and animal communities of the tropics and the temperate zones suggest that the productivity of the narrow range of plants used for agricultural staples would also be systematically different between the two regions. Although it is possible theoretically for food staples to be adapted to be equally productive in temperate and tropical zones, in practice this has not happened. Even after accounting for differences in input use in agriculture, tropical yields of principal crops are starkly lower than temperate yields.

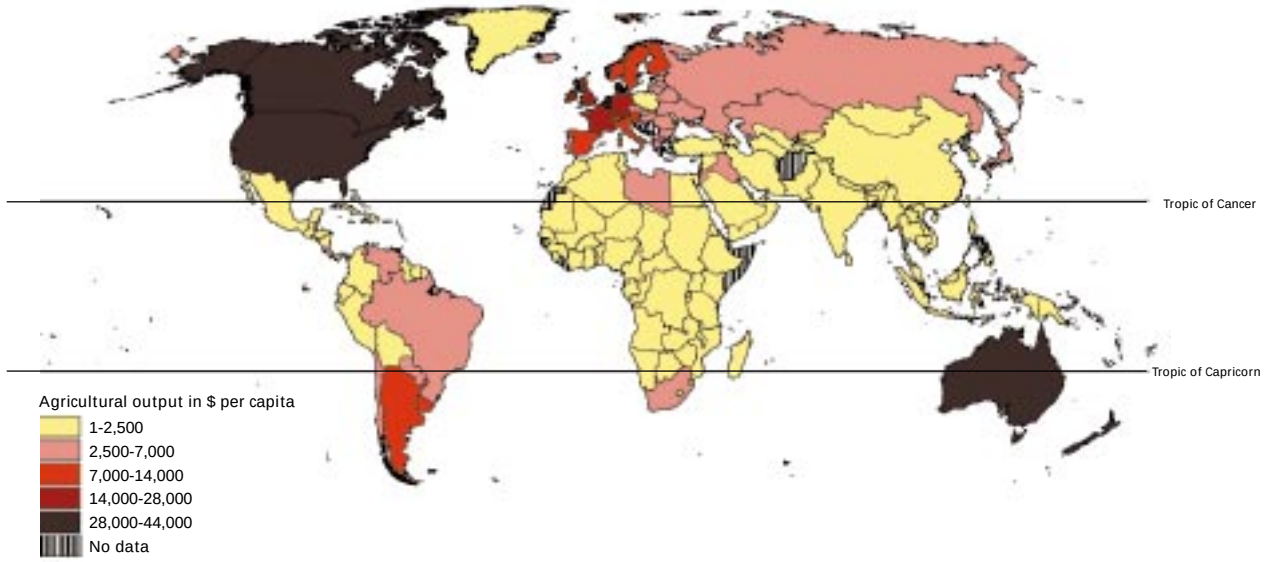
This is only partly a natural phenomenon. Its main cause may be found in the pattern of technological developments originally spurred by the distribution of agriculture and animal species and land conditions, and reinforced by centuries of technological changes biased toward the richer areas.

The disparity between tropical and nontropical agricultural output per farmworker (Figure 3.12) is even more pronounced than the disparity between tropical and nontropical income levels (Figure 3.5). Most individual crops tell the same story. Table 3.2 shows that nontropical yields are higher than tropical yields for 9 of 10 important crop categories. This is especially true for temperate crops like wheat, but also for some tropical crops like maize or sugar cane.

These differences could be due in whole or part to the inputs used. Fertilizers, tractors, improved seed and labor all affect yields, regardless of whether the climate is ideal for the crop. Farmers in wealthier countries use more nonlabor inputs per hectare, since these inputs are inexpensive compared to their own labor and land values. This suggests that low yields in the tropics are caused *by* poverty rather than being a cause *of* poverty. However, estimates in Gallup and Sachs (1999) show that tropical yields are much lower, even controlling for differences in input use.[16] Tropical and dry ecozones, which make up most of the geographical tropics, have yields 30 to 40 percent lower than temperate ecozones for the same input use.

[16] Pricing and other agricultural policy has a substantial effect on how much farmers produce and the amount of inputs they use, but to a first approximation, should not affect yields given inputs.

Figure 3.12 **Agricultural Output per Farmworker, 1994**



Source: FAO (1999).

Moreover, agricultural productivity grew about 2 percent per year more slowly in tropical and dry ecozones than temperate ones. Therefore, although the origin of the differences in productivity may be natural, there is no doubt that technological developments over time have widened the gap. Technological advances have been concentrated in the wealthier regions, whose more homogeneous ecology facilitates the diffusion of successful species and technologies.[17]

While some crops such as tree nuts or tropical fruits are clearly more productive in the tropics, few of them are major parts of the food system. Table 3.3 shows the contribution of different crop categories to the world food supply. Cereals provide almost half of all calories and almost as much of protein consumption. Oilcrops—the only crop category for which yields are higher in the tropical countries than in nontropical ones—contribute just 10 percent of food calories, and only 3 percent of protein.

The same pattern of differential agricultural productivity appears within Latin America, even though the region's countries are more similar to one another than the rest of the world. For most crops, yields in tropical Latin American countries are much lower. Sugar cane, oil crops and coffee are exceptions, but none of the yield differences between the tropics and nontropics for these crops are statistically significant (Table 3.4).

Technological developments have also favored nontropical agriculture in Latin America. While there has been rapid growth of crop yields in the region for most staple crops, the growth rates are quite different between tropical and nontropical regions (Table 3.5). Although the yields of a few crops (coffee, fruits, vegetables and oilcrops) grew slightly faster in the tropical countries, the largest improvements took place in the nontropical countries. Furthermore, the only statistically significant differences in productivity over the past 37 years favored the nontropical countries. It is no coincidence that the most successful exporters of agriculture-based goods in Latin America are nontropical countries. Chile has made great advances since the 1970s in the production of fruits for international markets because it has taken advantage of technological developments in California, a region with which it shares some important geographical and ecological similarities (in addition to the advantage of the opposite pattern of seasons).[18]

The diet in Latin America, especially in the tropical countries, is different from other parts of the

[17] For extensive analysis and documentation of this important point see Diamond (1997).

[18] This has been documented by Meller (1995 and 1996).

Table 3.2 **Crop Yields in Tropical versus Nontropical Countries of the World, 1998**

	Tropical yield (mt/ha)[1]	Nontropical yield (mt/ha)	Tropical/ Nontropical	Statistically significant difference[2]
Cereals (milled rice equivalent)	16.5	26.9	0.61	x
Maize	20.1	45.1	0.45	x
Root crops (potato, cassava, etc.)	105.0	200.0	0.53	x
Sugar cane[3]	647.0	681.0	0.95	
Pulses (beans and peas)	7.9	13.3	0.59	x
Oilcrops	5.1	4.0	1.28	x
Vegetables	113.0	177.0	0.64	x
Fruits	96.0	97.9	0.98	
Bananas	155.0	201.0	0.77	x
Coffee	6.5	15.4	0.42	x
Observations[4]	108.0	95.0		

[1] *Metric tons per hectare.*

[2] *x = p value less than 5 percent for t test that mean tropical yield is different from mean nontropical yield.*

[3] *Data are for 1996.*

[4] *This is the number of observations for cereals. Not all countries produce root crops.*

Source: FAO (1999).

world. If the crops eaten by people in tropical Latin American countries were relatively more productive in the tropics, the yield differences between the tropics and nontropics for other crops would be less of a problem. The last column of Table 3.3 shows that Central Americans eat much more maize, sugar and pulses, which make up 54 percent of their calorie consumption compared to only 16 percent for the rest of the world. However, maize and beans are among the least productive crops in the tropics compared to the nontropics, both in Latin America and worldwide.

Table 3.3 **Per Capita Food Supply by Product**
(In percent)

	World		Central America
	Calories	Protein	Calories
Total	100	100	100
Vegetable products	84	63	84
Cereals (milled rice equivalent)	50	45	47
Wheat	20	22	9
Rice (milled equivalent)	21	15	3
Maize	5	5	34
Other	3	4	1
Root crops (potatoes, cassava, etc.)	5	3	1
Sugars	9	0	16
Pulses (beans and peas)	2	5	4
Oilcrops and oils	10	3	10
Vegetables	2	4	1
Fruits	3	1	3
Alcoholic beverages	2	0	2
Other	1	1	0
Animal products	16	37	16
Meat and animal fats	9	18	9
Milk, eggs, fish	6	19	7

Source: FAO (1999).

Note: Totals may not equal the sum of their components because of rounding.

Health Conditions

The relationship between physical geography and development extends beyond land productivity or the quality and availability of natural resources. Tropical regions are also poorer due to a heavier burden of disease. Geographical factors affect health conditions through many channels. The range and intensity of many diseases, particularly vector-borne ones, vary with climate. Malaria, hookworm and schistosomiasis, in particular, are great debilitators that

Table 3.4 **Average Crop Yields in Tropical versus Nontropical Latin American Countries, 1998**

	Tropical yield (mt/ha)[1]	Nontropical yield (mt/ha)[1]	Tropical/ Nontropical	Statistically significant difference[2]
Cereals (milled rice equivalent)	22.9	33.8	0.68	x
Maize	24.6	51.4	0.48	x
Root crops (potato, cassava, etc.)	122.0	218.0	0.56	x
Sugar cane[3]	700.0	632.0	1.11	
Pulses (beans and peas)	7.5	10.4	0.72	x
Oilcrops	6.2	5.3	1.17	
Vegetables	143.0	161.0	0.89	
Fruits	135.0	142.0	0.95	
Bananas	166.0	214.0	0.78	
Coffee	7.1	6.1	1.16	
No. of observations[4]	33	7		

[1] *Metric tons per hectare.*

[2] *x = p value less than 5 percent for t test that mean tropical yield is different from mean nontropical yield.*

[3] *Data are for 1996.*

[4] *This is the number of countries with data for cereals. Not all countries produce root crops.*

Source: FAO (1999).

Table 3.5 **Growth in Average Crop Yields in Tropical versus Nontropical Latin American Countries, 1961-98**

	Tropical yield growth (%)	Nontropical yield growth (%)	Tropical/ Nontropical	Statistically significant difference[1]
Cereals (milled rice equivalent)	1.8	2.6	-0.8	x
Maize	1.8	3.1	-1.3	x
Root crops (potato, cassava, etc.)	0.6	2.1	-1.5	x
Sugar cane[2]	0.8	1.0	-0.2	
Pulses (beans and peas)	0.3	0.6	-0.3	x
Oilcrops	2.0	1.8	0.2	
Vegetables	2.5	1.6	0.9	
Fruits	0.3	0.1	0.2	
Bananas	-0.3	0.2	-0.5	
Coffee	1.0	0.5	0.5	
No. of observations[3]	33	7		

[1] *x = p value less than 5 percent for t test that mean tropical yield growth is different from mean nontropical yield growth.*

[2] *Data are for 1961-96.*

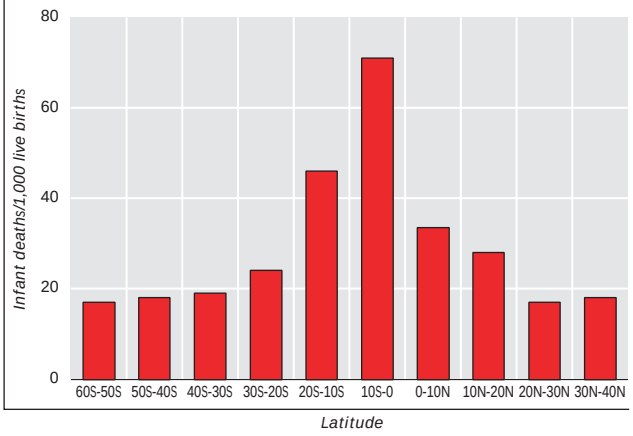
[3] *This is the number of observations for cereals. Not all countries produce root crops.*

Source: FAO (1999).

have been relatively easy to control in temperate zones but still defy major control efforts in the tropics. The lack of seasons makes control efforts more difficult because reproduction of the vectors of transmission takes place rather evenly throughout the year. And the allocation of technological investments has only reinforced the relative difficulty of controlling diseases typical of poorer areas, for the simple reason that those suffering from these diseases are too poor to pay for the vaccines or treatments, even if they have been developed or are available.

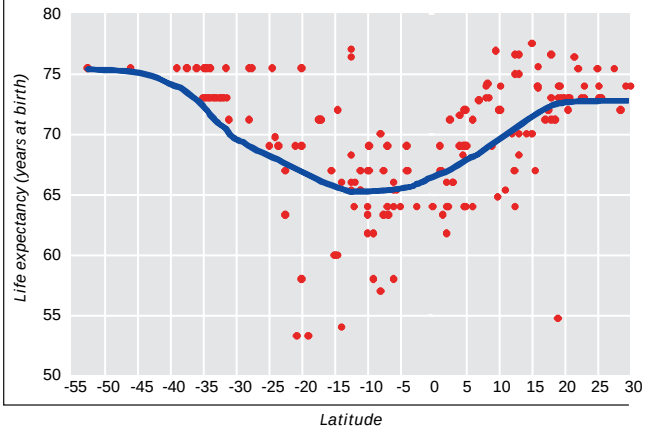
As a result, mortality is higher and life is shorter in the tropics. Latin American infant mortality rates peak in the tropics (Figure 3.13) and decline

Figure 3.13 Infant Mortality by Latitude Band



Source: World Bank (1998) and ESRI (1992).

Figure 3.14 Life Expectancy in Latin America by Latitude, 1995



Source: United Nations (1996) with subnational data from Alves et al. (1999); Bitrán and Má (1999); Escobal and Torero (1999); Esquivel et al. (1999); Sánchez and Núñez (1999); and Urquiola (1999).

more or less continually to either side of the peak. The highest rates in the 10° to 20° south are more than double the rate in the southern temperate zone, and 50 percent higher than that in the northern temperate zone. Life expectancy shows a similar pattern. Figure 3.14 shows that inhabitants of the temperate northern and southern ends of Latin America can expect to live about 75 years, but the trend line sags markedly in the tropical middle, dropping to 65 just south of the equator. The very low average lifespans of below 60 in provinces of Bolivia and Peru, and in Haiti, are all in the tropics. The two provinces close to the equator with life expectancies above 75 years are also in Peru: the capital Lima and its sister department of Callao, a clear sign of regional disparities within the country.

Since we have already seen that per capita income is lower in the tropics than in the temperate zones of Latin America, perhaps poor health in the tropics is simply due to poverty, not direct geographical influences. After all, Bolivia and Haiti have the lowest life expectancy and are also poor countries. However, life expectancy is also short in tropical countries that on average are less poor, like Peru. If we are concerned with life expectancy as a measure of human welfare, it doesn't matter much whether climate affects it directly or indirectly through economic development—the fact remains that welfare is lower in the tropics. If the goal is to improve health conditions, however, it matters a great deal whether the most effective approach is to curtail the transmission of disease directly, or to invest resources in economic growth that will solve the health problems indirectly.

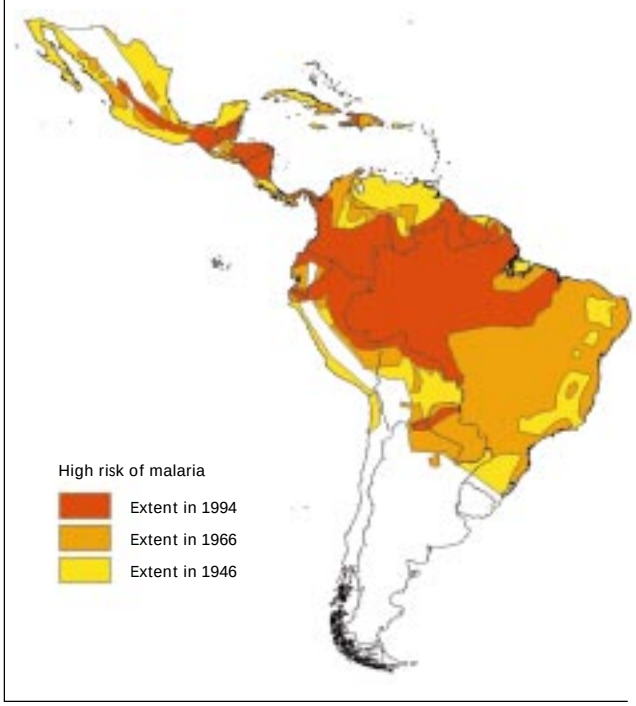
Climate and Health

Even after controlling for the influence of income levels, provincial life expectancy in Latin America is still strongly correlated with climate. This suggests that, indeed, climate affects health not only through income. Further evidence reinforces this, as we will see in the following empirical experiment.

One of the most robust correlates of health status is the education of mothers. When the influence of female literacy on health is included along with income levels, it is large and significant, and income loses its independent association with life expectancy.[19] Climate, however, is still strongly correlated with health outcomes. Controlling for female literacy and GDP per capita, life expectancy is four years lower in the wet tropics than in the humid temperate zone. These regression results, which are sum-

[19] GDP per capita, as argued above, is influenced *by* health as well as being an influence *on* health. While this two-way causality will be addressed later by correlating only initial health conditions with subsequent economic growth, reverse causality is also a statistical issue for the regressions in Appendix Table 3.1. The impact of health on income can be addressed with an instrumental variables regression, using openness of the economy as an instrument for GDP levels, as in Pritchett and Summers (1996). Openness is strongly correlated with GDP levels, but is unlikely to affect health conditions. There are no important changes to the coefficients after instrumenting (results not shown).

Figure 3.15 **Extent of Malaria in Latin America, 1946-94**



Source: Pampana and Russell (1955) and WHO (1967,1997).

marized in Appendix 3.1, predict that life expectancy is seven years lower in the wet tropics than in desert and dry regions with the same income and female literacy. Similar results pertain to infant mortality (which is a component of life expectancy). Infant mortality is four percent higher in the wet tropics than in humid temperate regions, and six percent higher than dry regions, other factors being equal.

One of the most conspicuous differences between the disease environment in tropical versus temperate areas is malaria. Only in tropical areas of the world does malaria remain a major and intractable health problem. Figure 3.15 shows the distribution of malaria in Latin America at three points in time: 1946, 1966, and 1994. Although malaria prevalence has been reduced, its core tropical zones resist control. Malaria is strongly related to climate, and there is no indication that it is affected by income levels or by female literacy.[20]

The role of geography in provincial health conditions across countries in Latin America is confirmed by within-country analyses of Brazil and Peru. The wide disparities in health status across communities within these two countries are largely tied to geographical differences. Table 3.6 shows that 62 to 76 percent of the variation in infant mortality and child malnutrition in the two countries is accounted for by geography (without controlling for other factors). Controlling for other community characteristics, Alves et al. (1999) find that Brazilian regions with higher temperatures have lower child and adult height, and lower rates of child survival.

Natural Disasters[21]

Although agricultural productivity and health conditions are the two main channels through which geography affects economic development in Latin America and worldwide, many countries suffer continuous setbacks to their development efforts because of frequent and devastating natural disasters.

Latin America has suffered a disproportionate number of natural disasters during its recent history. Natural disasters are defined as natural events whose impact in terms of injuries, homelessness, fatalities and destruction of assets creates severe economic and social hardship. There were 638 natural disasters in Latin America and the Caribbean between 1900 and 1995, accounting for 23 percent of reported disasters worldwide, behind only Asia (41.8 percent).[22] Between 1970 and 1995, natural disasters in the region are estimated to have killed 160,000 people, left 10 million homeless, and otherwise affected almost 100 million people (Table 3.7).[23]

The acute vulnerability of the region to natural disasters is the result of a combination of geographical and socioeconomic factors. Risks associated with natural events are a function of the magnitude of the physical phenomenon, frequency of occurrence, and the extent to which populations are vulnerable. All three elements are crucial to explaining why Latin America has suffered and continues to suffer significantly from natural disasters.

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[20] See Appendix 3.1.

[21] This section is based on IDB (2000).

[22] OFDA (1999). The database includes all natural hazards declared as disasters by the U.S. government as well as major undeclared disasters causing a substantial amount of deaths and injuries, and damage to infrastructure, agricultural production and housing.

[23] Ibid.

Table 3.6 **Geographical Variables Associated with Health Conditions within Countries**

Country (source)	Dependent variable	Level of observation of dependent variable	Independent variable	Level of observation of independent variable	Effect on dependent variable	R^2 (%)
Brazil (Alves et al. 1999)	Infant mortality rate	Household	-altitude -temperature -rainfall -region indicators	Municipal Municipal Municipal Municipal	positive * negative * positive **	76
Peru (Bitrán and Ma, 1999)	Infant mortality rate	Household	-latitude -longitude -altitude -temperature -rainfall	Provincial Provincial Provincial Provincial Provincial	negative ** negative ** positive * negative positive **	62
Peru (Bitrán and Ma, 1999)	Child nutrition	Household	-latitude -longitude -altitude -temperature -rainfall	Provincial Provincial Provincial Provincial Provincial	negative * negative positive * negative positive *	71

** Significant at the 1 percent level.*

*** Significant at the 5 percent level.*

Location is the primary explanation for Latin America's vulnerability. The region is extremely prone both to earthquakes and volcanic eruptions because its territory sits atop four active tectonic plates (Cocos, Nazca, Caribbean and South American plates) along the Pacific ring of fire, where 80 percent of the earth's seismic and volcanic activity takes place. Countries with the highest seismological risk include Mexico, which experienced 84 earthquakes measuring more than 7 on the Richter scale during the 20th century,[24] as well as Colombia, Chile, Guatemala, Peru, Ecuador and Costa Rica.

There is also extreme climatic volatility in the form of severe droughts, floods and high winds in Latin America due to the recurrent El Niño,[25] the annual north-south displacement of the Inter-Tropic Convergence Zone, and the passage of tropical storms and hurricanes born in the Pacific and Atlantic Oceans. Traditional zones of high climatic volatility include Central America, the Caribbean, Northeast Brazil, Peru, Ecuador, Chile and Argentina. Recent climatic changes seem to have aggravated climate volatility in the region.[26]

The region's overall vulnerability to natural disasters is not only determined by location and climate but also by various socioeconomic factors that greatly magnify the lethal and destructive potential of these events. These include patterns of settlements (particularly in vulnerable areas), the poor quality of housing and infrastructure, environmental degradation, the lack of efficient risk mitigation strategies, and types of economic activities.

High population density in disaster-prone areas contributes significantly to Latin America's vul-

[24] World Bank (1999).

[25] Every three to 12 years, El Niño produces changes in the atmospheric circulation over the Pacific, thereby bringing about modified water temperatures off South America as well as floods and droughts on the Pacific slope of the continent. For an in-depth analysis of the phenomenon and its consequences throughout history, see Fagan (1999).

[26] According to Munich Reinsurance Group (1999), the number of major natural disasters between the 1960s and 1990s rose by a factor of three, with economic losses multiplied by nine. In 1998, more natural disasters occurred worldwide than in any other year on record. Note, however, that these comparisons may be affected to some degree by a more accurate and comprehensive report of natural disasters in recent years.

Table 3.7 **Major Natural Disasters in Latin America and the Caribbean, 1980-99**

Year	Country	Location	Disaster	Killed	Affected	Homeless
1979-83	Brazil	Northeast, Sertão	Drought	0	20,000,000	na
1980	Haiti	Southwest, Port-au-Prince	Hurricane Allen	300	330,000	na
1982	Peru	Huallaga, Cuzco	Flood	332	20,000	na
1982	Peru	Cuzco	Flood	200	na	na
1982	Mexico	North Pacific Coast	Hurricane Paul	225	50,000	na
1982	El Salvador	Sonsonate, Huachapan	Flood	500	50,000	na
1982	Guatemala	Western Coast	Flood	620	20,000	20,000
1983	Ecuador	Entire Coast	Flood	307	700,000	na
1983	Peru	North Coast	Flood	364	700,000	na
1983	Argentina	Northeast	Flood	0	5,580,000	250,000
1983	Bolivia	Altiplano	Drought	0	1,583,049	na
1983	Bolivia	City of Santa Cruz	Flood	250	50,000	na
1983	Colombia	Popayan	Earthquake	250	35,000	35,000
1983	Brazil	Minas Gerais	Flood	68	3,000,000	8,000
1984-85	Brazil	Espirito Santo, Minas Gerais, Rio de Janeiro	Flood	200	60,000	60,000
1985	Mexico	Mexico City, Michioacan, Jalisco	Earthquake	8,776	100,000	100,000
1986	Colombia	Amero, Calda, Tolima	Volcano	21,800	7,700	7,700
1987	El Salvador	San Salvador	Earthquake	1,100	500,000	250,000
1987	Ecuador	Carchi, Imbabura, Pastaza, Napo	Earthquake	300	150,000	na
1987	Colombia	Medellin, Vila Tina Barrio	Landslide	240	na	2500
1988	Brazil	Petropolis, Rio de Janeiro	Flood	289	58,560	58,560
1988	Argentina	Buenos Aires Province	Flood	25	4,600,000	na
1988	Dominican Republic	North and Southeast	Flood	0	1,191,150	na
1988	Mexico	Yucatan and Gulf Coast	Hurricane Gilbert	240	100,000	100,000
1990	Peru	Highlands	Drought	0	2,200,000	na
1992	Peru	16 Departments	El Niño Floods	0	1,100,000	na
1993	Ecuador	Nambija in Zamora-Chinchipe	Landslide	300	na	na
1994	Colombia	Cauca and Huila	Earthquake	271	24,797	na
1994	Haiti	Jacmel, Port-au-Prince	Tropical Storm Gordon	1,122	1,500,000	87,000
1997-98	Ecuador, Peru	na	El Niño floods	550	na	400,000
1998	Argentina	na	El Niño floods	na	na	100,000
1998	Dominican Rep.	Countrywide	Hurricane Georges	208	400,000	na
1998	Brazil	Northeast	El Niño drought	na	na	4,800,000
1998	Honduras	Countrywide	Hurricane Mitch	6,600	2,100,000	1,400,000
1998	Nicaragua	Countrywide	Hurricane Mitch	2,055	868,000	na
1998	Guatemala	Countrywide	Hurricane Mitch	268	na	750,000
1999	Colombia	Central-Quindio	Earthquake	1,117	425,000	150,000
1999	Venezuela[1]	Caracas + 8 states	Floods, landslides	25,000-50,000	600,000	51,000

Note: The table includes natural disasters starting or ongoing between 1980 and 1999 that either affected over 1 million people or resulted in at least 200 fatalities.

[1] Preliminary estimates.

Source: IDB (2000, Chapter 2).

nerability to disasters. Overall population density has increased due to demographic growth, resulting in a de facto heightened vulnerability. Migration patterns have also exacerbated vulnerability in some countries. In Peru, the proportion of residents now living in coastal areas (within 80 kilometers of the sea) more susceptible to El Niño and other phenomena is 73 percent, compared to only 54 percent three decades ago.[27]

Rapid urbanization fueled by demographic pressure in rural areas has amplified the adverse consequences of natural disasters on economic activity and populations. At least two of the largest and fastest growing cities in Latin America—Mexico City and Lima—are located in zones with high seismic activity. The Mexico City earthquake in 1985 caused 8,700 fatalities and $4 billion of damages.[28] Lima has been badly damaged or destroyed by six earthquakes since 1856. Since 1940, the date of the last major earthquake, its population has increased sixfold, reaching 8.5 million. The risk of a major earthquake in Lima over the next 100 years has been estimated at 96 percent.[29]

Furthermore, due to rapid demographic growth and rural-urban migration, most cities have expanded without proper city planning, building codes or land use regulations adapted to their geographical environment. Given a rate of urbanization of above 76 percent, it is estimated that 90 million Latin Americans will live in urban areas by the year 2000.[30] Cities in the region are extremely vulnerable to earthquakes and floods because of high population density, narrow streets, adobe or dry stone construction, and a lack of paved roads and green spaces. Migration to cities has increased demand for urban space and resulted in the expansion of poor neighborhoods on low-value terrain in risk-prone areas. Examples include the favelas on the slopes overlooking Rio de Janeiro, the shantytowns of Guatemala City in ravines prone to landslides, and the slums of Tegucigalpa on flood plains and steep hillsides. Not surprisingly, city slums are usually the first neighborhoods—and sometimes the only ones—to be wiped out by natural disasters, as happened with the floods of 1999 in Caracas and 1988 in Rio, and the 1976 earthquake in Guatemala City.[31]

The poor quality of housing in the region, which also exacerbates the consequences of natural disasters, is primarily a result of rapid urbanization and widespread poverty. As of 1993, 37 percent of the total existing housing stock in Latin America provided inadequate protection against disaster and illness.[32] The OAS Caribbean Disaster Mitigation Project estimates that 60 percent of the total housing stock in the Caribbean is built without any technical input.[33] Obviously, the poor quality of housing is closed linked with widespread poverty. In general, poor households lack the knowledge, technical skills and income to deal with problems such as surface water drainage or the danger of collapse of dwellings built on the roofs of other dwellings. It has been reported that 40 percent of accidents in the favelas of Rio de Janeiro were caused by building collapses and another 30 percent by landslides.[34] Furthermore, the enforcement of building codes is weak in risk-prone areas, even in high-income neighborhoods, formal sector companies and public infrastructure. On the Caribbean island of Montserrat, 98 percent of the housing collapses from the 1989 hurricane was due to noncompliance with wind and hurricane-resistant building codes. Damage totaled some $240 million, equal to five years of GDP.[35]

Lagging investment in basic infrastructure also puts populations and assets at greater risk. As shown by the impact of Hurricane Mitch in Central America and El Niño in Peru and Ecuador, poor quality roads, bridges, airports, dams and dikes are often destroyed during hurricanes and floods. This damage to infrastructure leads to higher numbers of fatalities, as well as wider and longer disruption of food distribution and economic activity. In the case of Hurricane Pauline in Mexico in 1997, half of the 400 fatalities were due to the inability to reach populations in isolated areas.[36] In Peru, total damage to infrastructure during the 1997-98 El Niño reached 5

[27] IFRC (1999, p. 88).
[28] OFDA (1999).
[29] IFRC (1993, pp. 48-50).
[30] Ibid., p. 44.
[31] Albala-Bertrand (1993, p. 93).
[32] PAHO (1998).
[33] IFRC (1997, p. 80).
[34] Hardoy (1989).
[35] IFRC (1997, p. 80).
[36] PAHO (1998).

percent of the country's GDP, causing a serious and long-lasting decline in several key economic sectors, including mining, the most important industry in the country.[37] Similarly, the vulnerability of health infrastructure to disasters because of the use of nondisaster-resilient building techniques and lack of maintenance decreases access to and the quality of care in the post-disaster emergency and recovery phase. In Mexico City, the modern wing of Juárez Hospital collapsed during the 1985 earthquake, causing many fatalities and paralyzing critical social infrastructure in a time of crisis.[38] Poorly designed and maintained potable water and waste management systems are also frequently damaged by disasters, increasing health risks such as cholera and leptospirosis.

The degradation of the environment also plays a crucial role in transforming natural events into disasters. Throughout the region, risk of flooding and landslides is exacerbated by deforestation of watersheds, the absence of soil conservation programs, and inappropriate land use. Environmental degradation in the region is the result of higher population density in fragile ecosystems, as well as destructive agricultural activities. Instead of relying on more traditional and environment friendly cultivation techniques (such as terracing hillsides or planting crops in soil secured by roots of trees), the Latin American agricultural sector often uses methods that lead to widespread deforestation and erosion of soils, both of which increase vulnerability to floods, drought and landslides.

Most countries in the region still do not have efficient risk management policies in place, although considerable progress was achieved during the 1970s and 1980s. Agencies in charge of risk mitigation and preparedness are grossly underfunded relative to the costs of the risks from which they are supposed to protect the population. According to the Coordination Center for the Prevention of Natural Disasters (CEDEPRENAC), none of the governments of Central America allocates enough resources from their national budgets for natural hazard management.[39] Despite their proven efficiency, essential risk mitigation activities such as drainage, flood control and reforestation of watersheds are sparse in risk-prone areas. Though equally important for risk reduction, land use regulation and building codes are rarely enforced. Furthermore, most life-line infrastructure, such as hospitals, utilities and airports, lacks proper emergency contingency plans. Finally, early warning, evacuation and shelter systems do not cover all risk-prone areas and remain largely disorganized. Much of the mortality associated with Tropical Storm Gordon in Haiti in 1994 and Hurricane Cesar in 1996 in Costa Rica has been attributed to problems with local warning and evacuation systems.[40]

In addition to being physically vulnerable to natural disasters, Latin American countries are also economically vulnerable. The macroeconomic impact of natural disasters mainly depends on the degree of vulnerability, the importance of the economic activities affected, and their impact on other productive and public finances. The impact of natural disasters also depends on the overall resilience of the country's economy, which is a function of the macroeconomic conditions before the disaster, the degree of diversification of the economy, and the size of financial and insurance markets. The lack of sectoral diversification in the region helps to explain why natural disasters have a significant adverse impact on the aggregate level. Agriculture, which is directly linked with climatic conditions, is still a key sector in terms of its share of GDP and employment. The weight of the agricultural sector in rural areas, coupled with the absence of alternative occupational options, creates greater risks of massive unemployment, income loss and recession in areas with high climatic volatility. In Honduras, the country hardest hit by Hurricane Mitch, the agricultural sector represents 20 percent of GDP, 63 percent of exports, and 50 percent of total employment.

The limited capacity of insurance and reinsurance markets also makes the region more vulnerable to natural disasters by preventing risk pooling and burden sharing. It is left to the state, companies and individuals to absorb the brunt of the shock created by the destruction of physical capital and the decline in economic activity. El Niño caused $2.8 billion in damage to public infrastructure in Peru, of which only $150 million was insured.[41]

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[37] IFRC (1999, p. 88).

[38] PAHO/WHO (1994, p. 72).

[39] CEDEPRENAC (1999, p. 13).

[40] PAHO (1998).

[41] IFRC (1999, p. 97).

Access to Markets

So far, we have discussed the three main channels through which *physical geography* affects economic and social development: land productivity, disease and natural disasters. We now turn to the two main channels through which the settlement patterns of populations, or *human geography*, affect development: access to markets and urbanization.

For economic development, access to the main world markets is crucial. Only world markets provide the scale, degree of competition, and access to technological and organizational changes needed to efficiently produce most goods. Access to world markets depends on the factors that determine the cost of seaborne transport—the distance of the country from principal world markets, and whether the bulk of economic activity is located close to the coast or a large navigable river.

Why are these factors so important? For most goods, the world markets are dominated by a relatively small number of industrialized countries in Europe, North America and Japan. Proximity to these regions is a substantial economic advantage. For the few developing countries that have in fact enjoyed rapid economic growth over the past generation, the export of labor-intensive manufactures has played a prominent role. Trade in these goods depends largely on seaborne transport. But since the actual cost of transport is but a fraction of the value of the final goods, why do transport costs have such a significant economic impact? When investment goods are imported, as they almost always are outside of the most prosperous countries, transport costs serve as a tax on investment that varies depending on the country's accessibility. If the inputs to production are also imported, as they usually are in export manufactures, the impact of this tax is greatly magnified.[42] It is not unusual in offshore assembly manufacturing for the value of inputs to be 70 percent of the value of the finished export. If shipping costs are 10 percent of the value of the goods shipped, applied both to the imported inputs and the exported finished good, transport costs make up a remarkable 56 percent of the domestic value added.[43] If transport costs are half this rate, at 5 percent, then the ratio of shipping costs to value added falls to 25 percent. Such a difference in transport costs is often enough to render the higher shipping cost to a more distant location entirely unprofitable.

Access to the sea is as important for economic accessibility as is distance from international markets, if only because overland transport costs are much higher than sea shipping, especially in poor countries with limited infrastructure. The cost of shipping goods overland within a country can be as high as the cost of shipping them by sea to a far-flung foreign port.[44] As shown in Radelet and Sachs (1998), almost all countries with macroeconomic success in labor-intensive manufacturing exports have populations almost completely within 100 kilometers of the coast.

From the point of view of access to markets, the countries of the Caribbean basin are ideally situated. They are close to the large U.S. market, and most of their populations and economic activities take place near coastlines. With conducive trade policies and complementary infrastructure, Caribbean and Central American countries should have a competitive advantage over the more successful East Asian export manufacturers. Why would U.S. firms go all the way across the Pacific to take advantage of low wages for manufacturing assembly if educated, low-wage workers are only a couple of hundred miles away?

Trade policies in the Caribbean and the development of export processing zones (EPZs) have started to take advantage of this potential. The role of EPZs as a stepping stone to the development of an export manufacturing sector highlights the importance of coastal access. As shown in Figure 3.16 and Table 3.8, of the 210 export processing zones in Latin America in 1997, 152 (or 72 percent) were within 100 kilometers of the coast. Most of the inland EPZs are

[42] This is shown formally in Gallup, Sachs and Mellinger (1999).

[43] The ratio of transport costs to local value added is equal to the costs of shipping the input in and the export out, all divided by the value of the output less the value of the imported inputs. For an export with a value of one, the cost of shipping is the value of inputs (0.7) plus the value of the export (1) times the shipping cost (10 percent), all divided by value added (1-0.7 = 0.3), or 0.1(1.7)/0.3 = 56 percent. If shipping costs are only 5 percent, then the landed price of inputs is 5 percent less, or 0.7(1-0.05) = 0.665, and value added is 1-0.665 = 0.335. The ratio of shipping cost to value added is 0.05(1.665)/0.335 = 25 percent.

[44] Shipping cost data are hard to come by, but a recent UNCTAD study showed that for landlocked African countries, the cost of shipping a sea crate overland could be up to 228 percent of the cost of shipping the crate by sea from the nearest port to Europe. See Radelet and Sachs (1998).

Table 3.8 **Access to the Sea by Latin American Export Processing Zones**

	Coastal	Noncoastal
Export processing zones	152	58
Percent of all EPZs	72%	28%
EPZs excluding Mexico and Bolivia	112	7
Percent of all EPZs	94%	6%

Notes: Includes free trade and maquiladora zones. Coastal sites are within 100 kilometers of the sea coast. Many EPZ locations in Figure 3.16 have more than one export processing zone.

Source: WEPZA (1997).

Figure 3.16 **Export Processing Zones in Latin America, 1997**

Source: WEPZA (1997).

in northern and central Mexico, with good overland access to the U.S. market, and in Bolivia. Excluding Mexican and Bolivian EPZs, 112 of 119 EPZs, or 94 percent, are on the coast.

Caribbean and Central American economies are benefiting from deepening trade ties with the United States, while many South American countries are currently facing economic crises. Economic performance within Mexico shows this trend. Per capita GDP growth in the Mexican states that border the United States grew 0.3 percent slower than the other Mexican states from 1960-80, when the economy was largely closed to external trade (Figure 3.17). With trade liberalization in the 1980s opening the economy to the U.S. market, growth in the border states was 0.4 percent *faster* than the other states (though the country as a whole had declining GDP per capita). Over 1990-95, with the advent of NAFTA, the northern border states grew 0.8 percent faster than the rest of the states, despite the continuing decline in overall GDP per capita.

Other Latin American countries are less favored than Mexico or the Central American and Caribbean countries in terms of their access to markets. Bolivia and Paraguay are landlocked, which reduces their trade possibilities. Despite Colombia's access to the Atlantic and the Pacific, the bulk of the country's economic activities are far away from the coast. Until recently, the country even lacked good roads to connect its main regions. Roads in Colombia up until the 20th century only connected villages within each region, with no roads across regions. As late as 1930, the main link from the capital of Bogota to the outside world was a 12-day steamboat trip down the Magdalena River. Because of its geographical barriers, Colombia still has one of the lowest road densities in Latin America. And while in most countries there has been a strong tendency for income levels to converge across states or regions,[45] that does not appear to be the case in Colombia. Convergence rates have been more influenced by proximity to regional markets than by access to the coast, probably because of high transportation costs associated with geographical barriers and the location of the country's main urban centers.[46]

The importance of geographical barriers and problems of location can change over time. As we will see in the following section, the lowlands of Bolivia have experienced a major boom over the last two decades due to the combination of new road connections and expanded trade opportunities with neighboring countries. Of course, the location of cities can still be a major obstacle to exploiting these new op-

[45] Barro and Sala-i-Martin (1995).

[46] Sánchez and Núñez (1999).

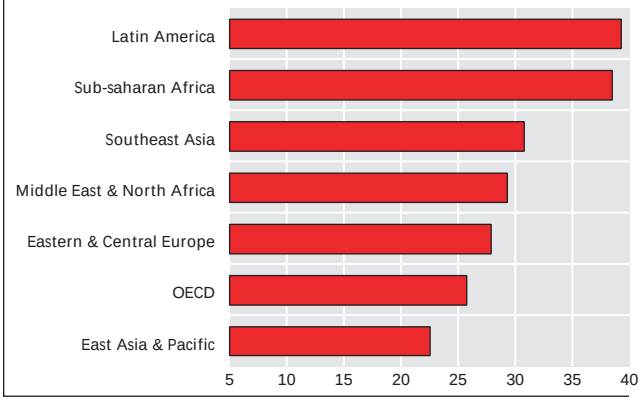
Figure 3.17 **Difference in Growth between Mexican Border States and the Rest of Mexico**

(In percent)

Source: Esquivel et al. (1999).

Figure 3.18 **Urban Concentration around the World in the 1990s**

(In percent)



Source: UNDP (1996).

portunities, especially when a country's largest city is home to a very large proportion of the population, as is usually the case in Latin America.

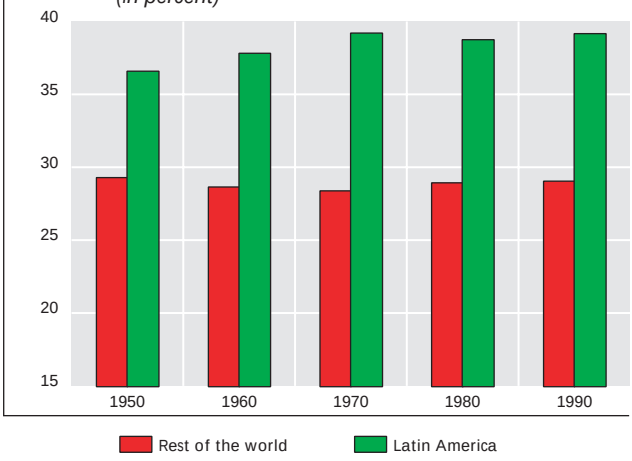
Urban Primacy in Latin America

Development and urbanization have moved together at least since the dawn of the industrial revolution in the 19th century. Urbanization has brought advantages to many people, from better sanitary conditions to higher wages. Still, there is no singular urbanization process. The size and distribution of cities vary widely from one country to another. While in some countries urban residents tend to agglomerate around one large city, in others they may be spread over several cities, both large and small. These differences affect development outcomes in various and complex ways, as long recognized by urban economists and other social scientists.

Urbanization has most often been accompanied by the concentration of the population in one "primal" city. This urban concentration, once limited to developed countries, has recently become a staple feature of many developing countries, especially in Africa and Latin America. Figure 3.18 shows that urban concentration, or the percentage of the urban population living in a country's main city, is larger today in Latin America than in any region of the world. Only sub-Saharan Africa has levels that are even comparable. Figure 3.19 shows that Latin America's pre-

Figure 3.19 **Urban Concentration in Latin America and the Rest of the World**

(In percent)

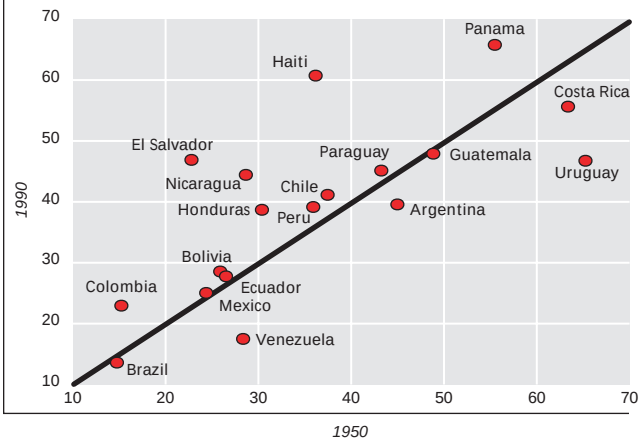


Source: UNDP (1996).

eminence in terms of urban concentration is no recent phenomenon. As far back as the 1950s, average urban concentration in Latin America was six percentage points larger than that of the rest of the world. This difference grew somewhat in the 1960s and 1970s and has since remained stable.

Within Latin America, the process of urban concentration has varied from country to country. Differences across countries are evident in Figure 3.20, not only in levels of urban concentration but also in how it has progressed over time. Current urban con-

Figure 3.20 Urban Concentration in Latin America
(In percent)



Source: UNDP (1996).

centration ranges from around 15 percent in Brazil to more than 65 percent in Panama. While the range of variation has remained stable, the evolution of urban concentration has differed widely from one country to the next. Thus, some countries show steady increases in urban concentration (Colombia, Chile, Haiti, Nicaragua, Peru and El Salvador), some countries persistent declines (Argentina, Uruguay and Venezuela), and others stable patterns (Brazil and Ecuador).

How Geography Drives Urban Concentration

Urban concentration is associated with some basic country characteristics in predictable ways. Gaviria and Stein (1999) show that urban concentration is lower in smaller countries (it drops by one percentage point for every million square kilometers), and lower in richer countries (it drops by one percentage point for every $1,000 per capita). On average, urban concentration is 10 percentage points higher in countries where the primal city is also the capital and two percentage points higher in countries where the primal city is a port.

Natural geography also affects urban concentration, at least in terms of providing the backdrop against which urban concentration evolves. Of course, the pathways through which geography affects urban concentration are not always direct and are difficult to capture in the aggregate. Given this, case studies are the key to understanding the role of geography in the evolution of urban concentration.

Urquiola et al. (1999) have studied the interplay between geography and urbanization in Bolivia. Urbanization in Bolivia has followed a peculiar path: urban concentration has steadily declined as La Paz has lost preeminence and Cochabamba and Santa Cruz have emerged as alternate population centers. Geography is arguably the ultimate cause behind this trend. Bolivia is a country with three distinct geographical regions: the Andean (or highland) region, the sub-Andean (or valley) region, and the lowlands. These regions overlap closely with the main ethnolinguistic divisions of the country: Aymara is the more common native language in the Andean region, Quechua, the language of the Incas, is common in the sub-Andean region, and Guaraní is common in the lowlands. The crux of the argument is simple: geographic and ethnic divisions have raised the cost of migration between regions, and hence migration within regions has been much greater than it would have been were geography and population more homogenous. The larger flows of migration within regions have in turn given rise to three main population centers, one in each region. Urban concentration is low in the country as a whole, but very high within each region.

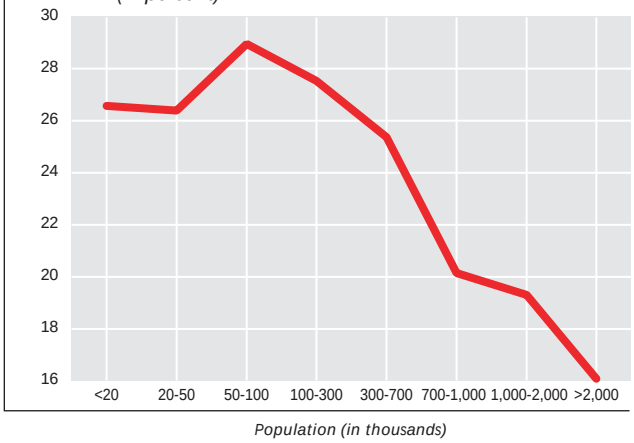
Needless to say, geography is only one force among many. Economic and political factors also affect urban concentration.[47] Although their effects are generally difficult to measure, some conclusions emerge from the few studies that have examined the most immediate determinants of urban concentration. First, urban concentration grows faster in politically unstable regimes and more volatile economies. And second, urban concentration grows faster in more open economies if and only if the primal city is a port.

The most conspicuous effect of urban concentration is the emergence of "urban giants." Giant cities have long terrorized urban planners who cannot understand why people insist, against their admonitions, to live there. By contrast, urban giants fascinate urban economists who have long suspected that people live there for a reason. Urban giants are riddled with problems and full of possibilities.

[47] Ades and Glaeser (1995) use a cross-section of 85 countries to study the effects of political and economic variables on levels of urban concentration. Gaviria and Stein (1999) use a panel of 105 countries and five decades to study the effects of a similar set of variables on changes of urban concentration.

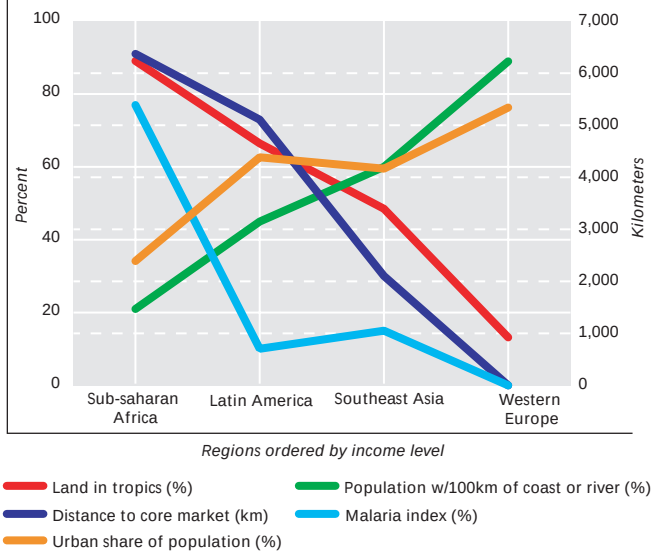
Figure 3.21 **Interpersonal Trust and City Size in Latin America**

(In percent)



Source: Latinobarómetro, various years.

Figure 3.22 **Geography Matters: Regional Differences**



Sources: ESRI (1992), Tobler (1995), UNDP (1996), WHO (1997).

Urban giants suffer from a long list of maladies, from pollution to traffic congestion and longer commuting times. In Los Angeles, for example, more than 2.3 million person-hours are lost to traffic delays in a typical year.[48] In all likelihood, these numbers are even higher in many cities in the developing world, from São Paulo to Bangkok. Urban giants (and large cities in general) also suffer from higher crime rates, although these appear to level off once cities reach population levels over one million (see Box 3.3). Moreover, larger cities have lower levels of social capital (from weaker community ties to lower interpersonal trust). Figure 3.21 shows, for example, that the proportion of people who report trusting others falls sharply with city size in Latin America.

Further, the concentration of a country's economic activity in a single city can have deleterious consequences. Dominant primal cities are often forced to subsidize stagnant regions, and subsidies can in turn cause all kinds of distortions. And overly dominant primal cities can create resentment and exacerbate ethnic and racial conflicts.

Having summarized the negatives, it must also be said that their large size can bring benefits to cities and their residents as well. Large cities enjoy significant economies of scale in providing basic public services, including education and health. They also enjoy significant agglomeration economies, stemming from both knowledge spillovers within industries and cross-fertilization between industries. And finally, large cities give rise to large markets, which in turn facilitate the division of labor and reduce transport costs. All these forces certainly should make primal cities more productive, and, therefore, the focal points of any strategy to spur economic growth.[49]

Economic development in Latin America, then, will hinge heavily on the fates of primal cities. If primal cities are unable to harness their many possibilities and cope with their mounting problems, economic development will be very difficult, to say the least. Herein lies one of the main challenges for the region in the years to come.

Will Geography Matter in the Future?

The previous sections have examined how the five channels of physical and human geography—agricultural productivity, health conditions, natural disasters, access to markets and urbanization—can affect economic and social development. But these associations

[48] See Gleick (1999).

[49] See Glaeser (1998) for a complete analysis of the many agglomeration forces that affect productivity in cities.

Box 3.3

Crime and Cities in Latin America

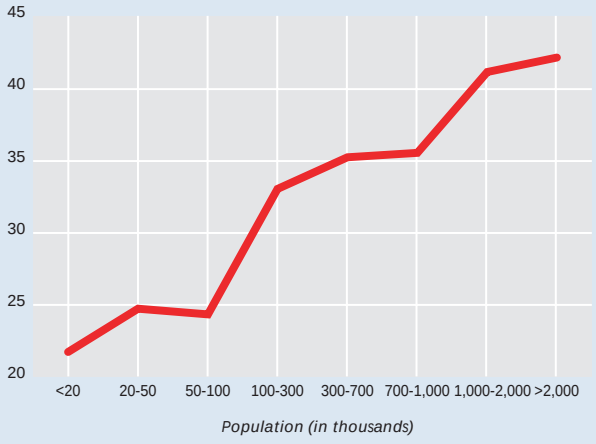
In Latin America and the world in general, crime is much worse in urban areas than rural ones, and within urban areas, much worse in large cities than small ones. Although this connection is rarely quantified, it is already part of the collective unconscious: our bands of criminals are no longer found in desolate landscapes in the countryside, but in the heart of large cities, among tall skyscrapers and impassive pedestrians. [1]

Several hypotheses have been suggested for explaining the positive association between crime and city size. One possibility is that large cities present better victims: their inhabitants are wealthier and generally have more goods that can be stolen and disposed of. Another possibility is that people with a greater propensity to become criminals are overly concentrated in large cities, whether because the urban environment favors criminal behavior or because young men or other high-risk groups are more disproportionately likely to migrate to cities. Yet another possibility is that those who violate the law are less likely to be arrested (and sentenced) in large cities, either because of the existence of "declining yields" in producing arrests, or because large cities—usually overwhelmed with all kinds of needs—do not invest enough in police and the justice system, or even because there is less cooperation with law enforcement in urban areas.

The purpose here is more descriptive than analytical: rather than sorting out the hypotheses mentioned above, the objective is simply to establish to what extent there is a positive connection between city size and the prevalence of crime in Latin America. This is not easy, since crime statistics are scarce, and when they do exist, they are rarely comparable between countries.

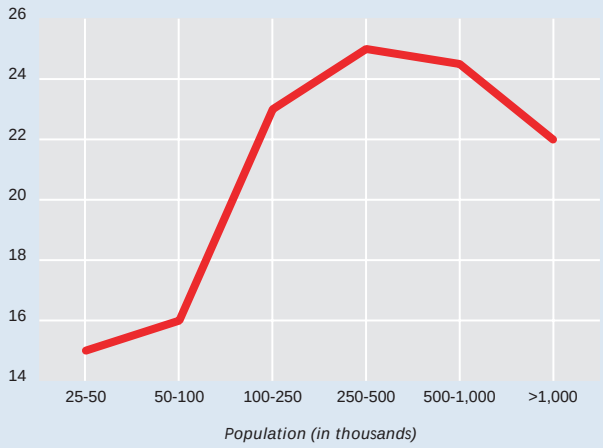
Fortunately, the Latinobarómetro survey system can be used to study the correlation between crime and city size. This system offers several advantages. In particular, it provides comparable information on crime rates (victimization in this instance) for 17 countries in the region and, even more importantly, for many cities in the interior of each country. Latinobarómetro pro-

Figure 1. City Size and Victimization in Latin America
(In percent)



Source: Gaviria and Pagés (1999).

Figure 2. City Size and Victimization in the United States
(In percent)



Source: Glaeser and Sacerdote (1999).

between development outcomes and geographical features may be due to *past* influences that no longer affect the potential for future improvement. So this section puts these strands together in order to assess whether or to what extent geography can be expected to matter in the future.

The first step in answering this question is obviously to control for the past and to establish, on the basis of recent experience worldwide, whether geography is still important to prospects for development. This requires selecting a set of simple indicators that synthesize the main channels of influence of geography, as shown in Figure 3.22.

The first indicator is tropical location, a proxy for land productivity and agriculture technological disadvantages, which is measured by the percent of the country's land area within the geographical tropics. Malaria prevalence, the second indicator, is a prime

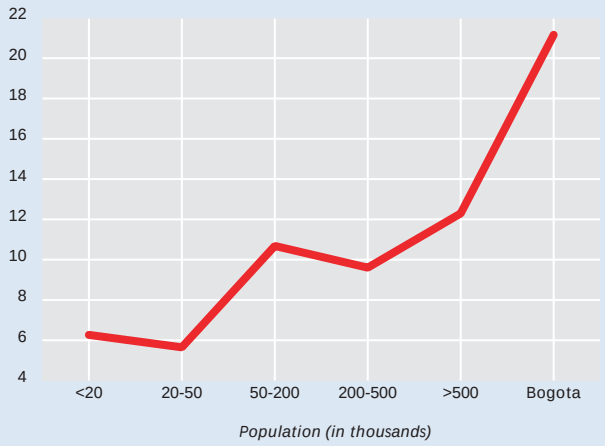
vides information on victimization rates for over 80 cities in Latin America, including all the region's large cities.

Figure 1 shows the pattern of change in victimization rates vis-à-vis city size. The relationship is clearly a rising one, although it is not exactly linear.[2] In general, three groups of cities can be distinguished: a first group made up of cities of under 100,000 inhabitants, which on average have low crime rates, a second group with between 100,000 and one million inhabitants, and a third group with populations of over a million inhabitants that have high crime rates.

Gaviria and Pagés (1999) show that the positive association between criminality and population occurs not only in the aggregate but also, and without exception, in each country in Latin America by itself. Something similar can be seen if one analyzes other sources of information and other regions of the world. Figures 2 and 3 show, for example, that the association between victimization and city size is quite strong in Colombia and is clearly apparent in the United States.[3]

Figure 3. City Size and Victimization in Colombia

(In percent)



Source: Gaviria and Pagés (1999).

Gaviria and Pagés also show that there is a positive correlation between criminality and population growth. Hence, not only do large cities have more crime, cities that have grown more rapidly suffer from the same affliction. Naturally, in many instances these two trends are one and the same: large cities keep adding new inhabitants while helplessly watching crime and violence increase.

It is quite difficult if not impossible for lack of information to directly examine the hypotheses mentioned above regarding the positive association between crime and city size. However, some evidence seems to run counter to the first two hypotheses (more victims in large cities or greater percentages of potential criminals). Gaviria and Pagés find that the positive association between crime and city size remains even after controlling for the wealth of inhabitants and the social and economic characteristics of cities. This would not be the case if large cities had more crime due to the presence of more and better victims or the presence of a greater proportion of individuals at a higher risk of committing crimes (young men, migrants, or youth who are not part of the education system).

Latin American cities today face many challenges: they must not only deal with growing demands for public services and infrastructure, but they must also assure citizen safety in an ever more complicated setting. There are no easy answers to the problem of urban violence. But it is clear that investment must be made in policing, and the most obvious risk factors (alcohol and weapons) must be controlled. And it must also be kept in mind that once the forces driving crime gather momentum, they are hard to stop.

[1] Based on Gaviria and Pagés (1999).

[2] Victimization rates measure the proportion of families who report that at least one of their members was the victim of some crime during the most recent 12 months.

[3] Figures on Colombia come from DANE (1997) and U.S. figures from Glaeser and Sacerdote (1999).

measure of the burden of disease caused by purely geographical factors. It is an index that weighs both the percent of the population at risk for malaria, and the percent of the infected population that suffers from the most severe kind of malaria.[50] The third indicator reflects the proximity of countries in each region to core world markets by measuring the distance of the capital city in kilometers from Tokyo, New York and Rotterdam. Fourth, within-country access to the sea is measured by the percentage of the population living within 100 kilometers of the coast or an ocean navigable river. Finally, urbanization is measured as the percentage of the population living in urban areas.[51]

[50] More detailed descriptions of these variables can be found in Gallup, Sachs and Mellinger (1999).

[51] As defined by each country. See UNDP (1996).

These five simple indicators provide a good summary of the geographical advantages or disadvantages of each of the major regions of the world.[52, 53] Latin America as a whole fares reasonably well when comparing its geographical endowments to the rest of the developing world. Most countries in Latin America have good access to the sea. The population is mostly concentrated on the coasts. The states bordering the Caribbean are all close to the large North American commercial market. Urbanization rates are high in most countries. Agriculture in the region benefits from large areas with temperate climate due to latitude or elevation. Most vector-borne diseases, including malaria, do not have the virulence found in Africa.

This favorable geography accounts for Latin America having many of the higher income countries in the tropics worldwide. However, although Latin America compares favorably in terms of geography and income levels with the rest of the developing world, it does not compare well on either count with highly industrialized countries in Europe and North America, nor with Japan or Australia. Further, the relationship of each of these geographical indicators with income levels does not make clear whether they will continue to be relevant to future economic development.

For example, income levels could well be affected by historical processes that depended on geography, while future economic growth would be largely independent of physical geography. The "new economic geography" espoused by Paul Krugman, Anthony Venables and others follows this line of reasoning. Locations with initial geographical advantages serve as catalysts for developing networks, but once the networks are established, physical geography ceases to have an impact on economic activity.[54] The forces of agglomeration can create a differentiated economic geography even if there was little geographical variation in the first place.

The endogenous processes described in economic geography models reinforce and magnify the direct impact of physical geography and help to explain the dynamics of the process. Natural ports, for example, become focal points for the development of cities, which can become more dominant over time if the economies of agglomeration outweigh the costs of congestion. If these processes dominate, though, we are unlikely to find a strong relationship between geography and economic growth, once we have controlled for the initial conditions. Is it true, for instance, that Hong Kong and Singapore still depend on their excellent access to major shipping lanes for their economic success? Or was that just important to get them started? Is the disease burden in Africa just a reflection of the continent's poverty, perhaps due to the accident of colonization, or will it be an independent drag on African development because it is tied to the tropical climate?

To address the continuing relevance of geography to economic development, the rest of this section examines cross-country relationships of geographical variables to economic growth, controlling for other important determinants of growth, including initial conditions. This allows for measuring the impact of geographical factors for current economic growth prospects. The presentation that follows is nontechnical, but the more inquisitive reader may want to scrutinize the details, which are contained in Appendix Table 3.2.

Influence of Natural and Human Geography on Growth

We start with a baseline equation similar to those in Barro and Sala-i-Martin (1995), in which average income growth between 1965 and 1990 is a function of initial income in 1965, initial level of education in 1965 (measured by average years of secondary school), the log of life expectancy at birth in 1965, openness of the economy to international trade, and the quality of public institutions.[55] We find the standard results for these variables: conditional on other variables, poorer countries catch up by growing faster, and output is an increasing function of education, life expectancy, openness, and the quality of public institutions.

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[52] See Table 2 in Gallup, Sachs and Mellinger (1999).

[53] Notice that we lack a synthetic indicator for one of our channels of influence of geography, namely propensity to natural disasters. However, in one of the regressions reported in Appendix Table 3.2, we use as a rough indicator the reported rates of mortality caused by earthquakes and volcano eruptions between 1902 and 1996, which is computed from data compiled by OFDA (1999).

[54] See Fujita, Krugman and Venables (1999).

[55] The dates are determined by data availability. The specifics of the variables used are found in Gallup, Sachs and Mellinger (1999).

We stress the fact that these results are conditional on other factors because, as we have seen, a large number of poorer countries do not grow faster than richer ones. As we will see below, this is due to a large extent to their unfavorable geographical conditions. To these variables we add different combinations of geographical variables, allowing us to test the consistency and robustness of the results. We find that the five basic indicators of physical and human geography described above consistently show the expected signs and are, in general, highly significant.

According to these results, countries fully located within the tropics grow around 0.3 percentage points less than nontropical countries. This is because the disadvantages imposed by natural geography are more difficult to overcome for poor countries than for rich countries. Although a single estimate for all types of countries is extremely imprecise and the significance of this variable is not high, when tropicality is interacted with *initial* income levels, the results become very significant. The estimated coefficients imply that a country fully located within the tropics that starts with a level of per capita income twice that of another tropical country will be able to grow around 0.7 percentage points faster. As intuition suggests, the limitations imposed by natural geography become less restrictive as countries become richer.[56] This is both good news and bad news, as it confirms that geography is not destiny—after all, there are also some rich countries in the tropics—but suggests that the initial effort required to break away from poverty is much harder for a tropical than for a nontropical country. A bigger push is required to take off in the tropics.

The results also give support to the hypothesis that health conditions related to geography may be a major obstacle to development. Thus, countries at high risk of malaria grow 0.6 percentage points slower than countries free from malaria. Such a large estimated impact of malaria on economic growth is striking, especially since the estimates control for general health conditions (life expectancy), and for a general tropical effect. The one country in the Americas with a malaria index of 1, Haiti, is also the poorest country in the hemisphere. A reduction in malaria could give Haiti and some other Latin American countries a big economic impulse. Yet, disappointingly, there has been little malaria reduction in most Latin America countries in recent decades. Although Latin America experienced the largest reduction of any region since the mid-1960, it totaled only 6 index points out of 100.

There is some evidence that natural disasters may also affect growth. Although we lack an appropriate indicator for this influence of geography, an indicator of the mortality caused by earthquakes and volcanic eruptions between 1902 and 1996 is inversely and significantly associated with growth (after controlling for other main determinants of growth, including physical geographic variables). The problem with this variable is that it captures only some types of disasters, and the mortality due to a given natural disaster depends on the country's poverty, so it is not an independent cause of development. Therefore, it is excluded from other regressions.

The econometric evidence suggests that population settlement patterns may have implications for growth. Areas with populations located away from the coast experience lower rates of growth. The estimates also support the notion that there are agglomeration effects from population concentrations on the coast, but diminishing returns to dense populations in the interior. Countries with high population density near the coast grow faster, and countries with high population density in the interior grow more slowly. The results also suggest that distance to principal international markets affects growth. In general, however, the precision of the estimates is rather low, and parameters vary significantly from one specification to another.

Finally, the estimates strongly support the hypothesis that the economic benefits of urbanization outweigh the costs, allowing more urbanized countries to grow faster. A country that starts with a rate of urbanization 50 percentage points higher than another can be expected to grow at a rate about 1 percentage point higher. This also offers support to the big push thesis, but applied to the process of urbanization.

[56] The results could suggest that, eventually, tropical countries with income levels beyond a certain threshold may even grow faster. However, the number of observations beyond that threshold is too small to warrant that conclusion.

Table 3.9 **Decomposition of the Difference in GDP Per Capita Growth between Latin America and Other Regions of the World, 1965-90**

	With respect to	
	Developed countries	East Asia
Controls	0.564	3.293
GDP per capita, 1965 (log)	-3.499	1.404
Years of secondary schooling, 1965 (log)	0.025	0.008
Life expectancy, 1965 (log)	0.755	0.017
Trade openness, 1965-90 (0-1)	1.487	1.227
Institutional quality (0-10)	1.796	0.637
Physical geography	0.682	-0.519
Share of land in tropics (and its interaction with income)	0.594	-0.392
Falciparum malaria index, 1965 (0-1)	0.088	-0.127
Human geography	0.598	0.101
% population urban, 1965	0.423	-0.042
Coastal population	-0.007	0.135
Distance to main markets	0.183	0.008
Total geography	1.280	-0.418
Total explained	1.844	2.875
Total observed	1.697	3.771
Unexplained	-0.147	0.895

Source: IDB calculations based on regression (5) of Appendix Table 3.2.

Geographical Influences on Differences in Growth between Regions

Table 3.9 shows the estimated impact of specific variables on differences in growth between Latin America, the developed countries, and East Asia. Average growth of GDP per capita in Latin American countries over 1965-90 was 0.9 percent per year, less than half of the 2.7 percent growth rate of the OECD countries, and much lower than East and Southeast Asia's dramatic 4.5 percent growth per year. The "total explained" row in the table shows the sum of the predicted contribution of the explanatory variables, and is quite close to the actual differences in the regional growth rates.

The first block of explanatory variables comprises controls that capture initial conditions (other than geography), policy and institutional characteristics of the countries. These factors explain around a third of the growth gap of nearly 1.7 points between Latin America and the developed countries, and 3.3 of the 3.8 point difference between Latin America and the East Asian countries. Most of these differences come from the fact that policies and institutions have been less favorable to growth in Latin America than in these two groups of countries.

Geographical factors explain a large portion of the remaining growth gap between Latin America and the developed countries, but not between Latin America and East Asia. The developed countries enjoy more favorable physical and human geographical factors, each of which explains roughly a third of the growth gap. The main advantages of developed countries stem from their location in temperate zones and their higher urbanization rates. Latin America and East Asia have rather similar geographical characteristics, and only a small fraction of the growth gap between the two regions can be attributed to geography. Furthermore, geographical factors would tend to make East Asia grow slightly *less* than Latin America. This point is crucial, because it reinforces the argument that geography is not destiny, and that adequate policies and institutions can offset its adverse effects. This in turn points to the importance of

great strides made by Latin America since 1965 in pursuing policies conducive to international trade and making government institutions more efficient and responsive (see Chapter 4).

In principle, infrastructure can help overcome many of the obstacles imposed by geography, but often at costs beyond the reach of poor countries. In areas where geography poses particularly difficult problems—such as mountainous regions, humid tropical zones where soils and torrential rains make it difficult to build durable roads, and regions far from the sea or without good natural ports—building such infrastructure is much more expensive than in coastal, temperate states. Furthermore, those investments may be less productive than in better-endowed areas that support much more economic activity.

To see if infrastructure investment is less productive in geographically difficult environments, we examine whether infrastructure has a smaller impact on economic growth in countries with limited access to the coast. In landlocked countries, initial road stocks and electricity generation capacity are positively correlated with subsequent growth, but at low significance levels. In coastal countries, there is no significant effect of initial infrastructure on subsequent growth (after accounting for policies, institutions, etc.). The results suggest that there might be some room to achieve better rates of return from infrastructure in noncoastal areas, but the effect is far from warranted. These weak associations may reflect the fact that the quality of investments is less determined by geographical conditions than by the quality of institutions and the extent of corruption. As discussed in Chapter 4, the size, composition and effectiveness of public expenditure is affected by the quality of public institutions—many of which in Latin America leave much to be desired.[57]

Geographical Influences on Economic Differences between and within Latin American Countries

To what extent is the strong correlation across the regions of the world between physical and human geography and income levels and economic growth relevant within Latin America itself? A cursory look suggests that differences in development within the region and even within countries are also affected by these geographical variables.

The geography of Latin America is in fact a good predictor of differences in economic development. The tropical Caribbean and the temperate Southern Cone differ greatly by almost any measure of development. Within Brazil, there is a gulf between the dry and poor Northeast, the rich and temperate Southeast, and the still sparsely populated and wet tropical Amazon region. In all of the neighboring countries with an Amazonian frontier, the jungle regions are a world apart. In Nicaragua, the malarial eastern coast is isolated from the more productive western coast. In Bolivia, the highlands, the valley region and the tropical lowlands have each developed separate urban centers with limited connections between them. Similar patterns hold for the distinct geographical zones of Colombia, Ecuador and Peru.

Using a more systematic approach, studies for Mexico, Colombia, Peru, Bolivia and Brazil have addressed the role of geography within countries through the use of rigorous econometric techniques. Table 3.10 shows the percentage of income level variation "explained" by geographical variables in these countries. Some of these studies analyze income levels at the regional level (departments, provinces or municipalities), while others use household level information. The geographical variables used also differ substantially across studies, ranging from measures of climate and soils to proximity measures. For countries with regional-level income measures, geography accounts for from 66 to 72 percent of income variation. The percentage of household income variance explained is less (from 7 to 47 percent), but given the many factors that affect household outcomes, these are still large numbers. The strength of the association between geography and regional income levels is impressive, since, due to migration and government transfers across regions, income varies less within countries than across countries.

Latin America is notorious for its unequal income distribution, and the estimates in Table 3.10 imply that a large portion of the regional disparities within these Latin American countries is tied to geographical factors. Even a substantial share of between-household inequality is correlated with geography.

[57] See Tanzi and Davoodi (1997) for an analysis of the deleterious effects of corruption on the quality of infrastructure investments.

Table 3.10 **Geographical Variables Associated with Income Levels within Countries**

Country (source)	Dependent variable	Level of observation of dependent variable	Dependent variables	Level of observation independent variable	Effect on the dependent variable	R^2 (%)
Bolivia (Urquiola et al., 1999)	Unsatisfied basic needs	Municipal	• altitude • border crossing • regional center • department capital	Provincial Provincial Provincial Provincial	negative ** negative ** negative *** negative **	68
Bolivia (Morales et al., 1999)	Unsatisfied basic needs	Municipal	• altitude • urbanization	Provincial Provincial	negative * negative **	66
Brazil (Azzoni et al., 1999)	Income per capita	Household	• latitude • temperature • rainfall	State State State	positive *** positive ** positive ***	47
Colombia (Sánchez and Núñez, 1999)	GDP per capita	Municipal	• altitude • rainfall • type of soils • distance to seaports • distance to markets • distance to rivers	Municipal Municipal Municipal Municipal Municipal Municipal	positive* negative * positive* positive* negative* negative**	36
Mexico (Blum and Cayeros, 1999)	GDP per capita	State	• rainfall • temperature • coast • border crossing • population density	State State State State State	negative * negative positive positive ** positive *	70
Mexico (Esquivel et al., 1999)	GDP per capita	State	• humidity • cold • forest • agriculture	State State State State	negative * positive * negative * negative *	68
Peru (Escobal and Torero, 1999)	Expenditure per capita	Household	• altitude • rainfall • temperature • type of soils • volcanic area	Provincial Provincial Provincial Provincial Provincial	negative** negative ** negative *** negative ** negative **	4

** Significant at 1 percent.*

*** Significant at 5 percent.*

**** Significant at 10 percent.*

In sum, the influence of geography is pervasive in Latin American economic development, explaining a substantial share of household, regional, cross-country and even economic growth differences for the whole region compared to the other regions of the world. All this suggests not only that geography has had a deep influence on the patterns of development of Latin American societies, but also that it will most likely continue to do so in the future. The question then arises: What are the most effective policies to ameliorate the negative influences of geography, and to best take advantage of positive possibilities that geography has to offer?

Policies to Overcome the Limitations of Geography

Geography may be largely immutable, but its impact on the economy and society is not. The right policies or technological developments can overcome many geographical obstacles.

Tackling geographical problems has important "public good" aspects: investments in disease control, roads or disaster mitigation typically benefit whole regions rather than particular individuals. But making these investments at the level that is socially desirable requires coordination between the government and other institutions. On an individual level, a citizen who contributes to these investments will not necessarily capture the benefits that he or she is contributing to society as a whole, and thus is less likely to want to contribute what is needed. No individual would likely take upon himself the task of controlling a dispersed disease vector, for example, and yet everyone benefits when each person contributes a small amount to the eradication of the disease. The sharing of the burden requires coordination and the creation of market-based incentives.

Latin America has large population concentrations in geographically difficult environments such as the highlands of Central America and the Andean region, the Brazilian northwest, and Haiti. If nearby areas develop rapidly, some of the problems of these difficult environments may be spontaneously solved by migration to the dynamic neighboring regions. For many people, migration may be the only way to escape the constraints of geography, and therefore it should not be discouraged. However, the persistence of poverty in these population concentrations over the centuries indicates that migration is unlikely to be a lasting solution. Population growth is often higher in poor, geographically disadvantaged regions, offsetting the benefits of outmigration. In addition, massive migration to economic centers and to some coastal areas might cause additional problems, such as increased vulnerability to natural disasters. Avoiding such adverse effects of migration requires close monitoring of migration patterns, creation of incentives for settlements in safe areas, and adaptation of city and land use planning.

Infrastructure

More active approaches to reducing geographical disparities through infrastructure investments face all the difficulties of regional development programs. The nature of isolated areas makes extension of infrastructure there more expensive, so the benefits to residents living in such areas must be large indeed to support these costs. If the goal is to bring industry and white-collar services to these areas, the problem becomes the strong synergies, or economies of agglomeration, attached to these activities. These synergies make returns to new infrastructure investments higher in the already well-connected, accessible cities. Bringing industrial and service activities to an isolated area is a chicken and egg problem—that is, firms do not want to set up there unless the infrastructure and services are already in place and other firms are also going to establish themselves there. Cost recovery for the infrastructure is not possible unless it attracts a good number of firms. To get this all moving simultaneously is expensive and risky, and governments that have attempted it have poor track records (Richardson and Townroe, 1986). In contrast to government-sponsored export processing zones, which are usually located in geographically favorable areas and have often been successful, industrial estates in lagging regions have often ended up empty. They were built, but nobody came.

Neither have more systemic approaches to disadvantaged regions in the form of regional development agencies been much more encouraging. These sizable regional development bureaucracies usually have trouble putting together the complex

coordination necessary to get economic networks established in places where this has not occurred spontaneously. There is a long history of such efforts in Brazil's poor northeast. Helped by decades of migration out of the region, the northeast has caught up only a little with the wealthier southeast. The poorest Brazilian state in 1960 was Piauí in the northeast, with per capita GDP totaling only 11 percent of that of the richest state of São Paulo in the southeast. In 1995, 35 years later, Piauí was still the poorest state in Brazil, and its per capita GDP had risen to only 16 percent of that of São Paulo (Azzoni et al., 1999). The strategy of opening up the Amazonian frontier for poor settlers from the northeast has caused major environmental damage, had limited economic success, and exacerbated problems of tropical disease.

Despite the limited success of grand regional infrastructure projects, it remains difficult to accept simply leaving isolated areas to their own devices. Lack of access to infrastructure is closely associated with poverty, since infrastructure provides the enabling environment for economic activity. Inadequate and poorly maintained infrastructure can also result in the isolation of entire regions in the event of a natural disaster. Therefore, a basic needs approach to infrastructure may be the most effective way to reduce poverty in geographically disadvantaged regions, and may also have a higher economic rate of return than large-scale infrastructure projects. Rudimentary feeder roads, electricity, and telecommunications are needed to integrate isolated regions into the rest of the economy. New technologies for micro electricity generation and stand-alone telecommunications links may also prove most cost-effective.

Providing cost-effective infrastructure in isolated regions is easier said than done, however. Centralized provisioning is not always the best method, since infrastructure investment projects and the services they provide are inherently located in and serve particular areas, customers and interests. Some form of decentralization is granted for most infrastructure investment and services, but the precise form it takes may depend on a number of factors, as will be discussed in a subsequent section.

While a basic needs approach should guide infrastructure investment decisions for geographically disadvantaged areas, the evidence presented in this chapter suggests that access to international markets should be the primary criterion for investments in roads, ports, railways and airports. Of course, the potential benefit of these investments depends on a number of variables, and overexpenditure is always a risk. Few of those investments can be profitable in the absence of adequate trade and macroeconomic policies, which encourage producers to seek international integration over the long term. But the potential benefit of a trade liberalization policy may in turn be severely limited by lack of infrastructure. Internal transportation bottlenecks can prevent the development of potentially successful exporting sectors, especially primary ones, while high value-added imports may soar. A basic needs approach should also bear in mind the risks associated with natural disasters, ensuring that destruction of private and public infrastructure be minimized and that sudden cutoffs from markets be avoided. Similarly, governments should focus efforts on reinstating access to markets in the aftermath of disasters by rebuilding critical infrastructure.

Finally, a basic needs approach to infrastructure should also be based on the principle that adequate maintenance of basic services is more important than new and big investments that are usually more expensive to run and keep up. The lack of adequate infrastructure in poor regions is more often due to poor maintenance policies than to insufficient expenditure. As has been analyzed and stressed by the World Bank,[58] new economic and political institutions and incentives, particularly if they are not decentralized in some fashion, usually lead to costly and inefficient new investments. A fraction of those same resources could often provide better services were they devoted to maintenance.

Technologies for Tropical Agriculture and Health

Although geography is largely immutable, the prevalence of disease in particular climates need not be. Direct action is required because rising income levels per se will not take care of health in the tropics.

There are few affordable and effective treatment and control strategies for some diseases, while

[58] See World Bank (1994).

for others the means of conquering the disease are well known but require a major education and mobilization effort. A prime example of the former is malaria. Vector control in the worst areas is at best a holding action, and the medicines being used are rapidly losing their effectiveness due to drug resistance. Vaccines are still many years away because of shortages in funding and the extraordinary complexity of the pathogen and its life cycle. Tropical diseases do not get the benefits of spillovers from biomedical and pharmaceutical research in the developed countries because there are no significantly large tropical developed countries. The tropical countries are too poor to offer an attractive stand-alone market to induce pharmaceutical firms to invest in tropical disease research.

Similar problems are faced in developing agricultural technology for soils and products characteristic of the tropics. Almost all scientific research and development, and hence most technological advances, occur in the developed world. At least some of these advances have the potential to be adapted to poor tropical countries, but significant hurdles must be overcome because of the differences in the biological process in the tropics.

In the developed world, more and more cutting-edge scientific research in health and agriculture is being carried out by large private firms rather than in government and academic research institutes. These firms have no financial incentive to invest in similar research on tropical problems. Since developing country consumers cannot afford to pay premium prices for new drugs and vaccines, they are not a profitable market.

At the same time when the tropics are being left out of the revolution in corporate scientific research, public funding for research on tropical agriculture and disease has been declining. The research and development budget of the entire CGIAR system of institutes studying developing world agricultural problems is less than half of the research and development budget of one life-sciences multinational, Monsanto.[59]

Despite these limitations, a new era of rapid advances in biology has allowed for promising applied research on the obstacles to tropical agriculture. Tropical agricultural research, most of it public, has had high rates of return. Table 3.11 presents estimated rates of return on agricultural research in Latin America as compiled by Echeverría (1990). The study assessed research on different crops in different countries using different methodologies, yet the estimates are uniformly and strikingly high. Of the 58 rates of return, only four are below 15 percent per year, with an average of 57 percent and a median of 44 percent. These huge returns on what little research investment has been made suggest that not enough agricultural research has been undertaken. Even if agricultural research did not have such high economic returns, investing in agricultural improvements could still be justified in terms of its impact on the poor. The near-term welfare of more than half the households in low-income countries (69 percent of the labor force in 1990),[60] and an even higher proportion of the poorest households, still depends on agriculture.

The rate of return to investing in tropical medical research is difficult to calculate, and in any case is secondary to the principle benefit of such research, which is better human health and welfare. Not surprisingly, the level of funding for research on tropical health problems is pitifully low. The prime example is malaria, one of the most deadly tropical diseases in the world. An estimated 2.4 billion people are at risk worldwide, with 300 to 500 million clinical cases and 1.5 to 2.5 million deaths per year. Yet because of the lack of market incentives, there is essentially no malaria research by private pharmaceutical firms. Total worldwide research funding was only $84 million in 1993,[61] much of it by the military of wealthy countries concerned about the readiness of their soldiers overseas.

In spite of this limited funding and research, Latin America overall has better health than would be predicted by its income levels, especially for a region that is highly tropical.[62] A series of successful control programs and strong public health institutions such as the Pan American Health Organization—

[59] Sachs (1999, p. 19).

[60] World Bank (1997, p. 220).

[61] Welcome Trust (1999).

[62] Using a simple regression to predict average life expectancy in 1995 using the natural logarithm of GDP per capita, Latin American countries have an average life expectancy four years longer than would be predicted by GDP alone. If one also controls for tropical location, life expectancy in the region is eight years higher than expected.

Table 3.11 **Rates of Return to Agricultural Research and Extension in Latin America**

Author	Year	Country	Commodity	Period	Annual rate of return (%)
Ayer	1970	Brazil (São Paulo)	Cotton	1924-67	77
Barletta	1970	Mexico	Crops	1943-63	45-93
			Wheat		90
Elias (revised by Cordomi)	1971	Argentina (EEAT-Tucuman)	Sugar cane	1943-63	33-49
Hines	1972	Peru	Maize	1954-67	35-55
Patrick and Kehrberg	1973	Brazil (Eastern)	Aggregate	1968	0
del Rey (revised by Cordomi)	1975	Argentina (EEAT-Tucuman)	Sugar cane	1943-64	35-41
Monteiro	1975	Brazil	Cocoa	1923-85	19-20
Fonseca	1976	Brazil	Coffee	1933-95	17-27
Hertford et al.	1977	Colombia	Rice	1957-80	60-82
			Soybeans	1960-80	79-96
			Wheat	1927-76	11-12
			Cotton	1953-72	0
Wennergren and Whittaker	1977	Bolivia	Sheep	1966-75	44
			Wheat		-48
Scobie and Posada	1978	Colombia	Rice	1957-64	79-96
Moricochi	1980	Brazil (São Paulo)	Citrus	1933-85	18-28
Avila	1981	Brazil (R.G. Sul)	Irrigated rice	1959-78	83-119
		Brazil (Central)			83-87
		Brazil (N. Coast)			92-107
		Brazil (S. Coast)			111-115
		Brazil (Frontier)			114-119
Cruz et al.	1982	Brazil	Physical capital	1974-81	53
			Total investment	1974-92	22-43
Evenson	1982	Brazil	Aggregate	19??-74	69
Ribiero	1982	Brazil (Minas Gerais)	Aggregate	1974-94	69
			Cotton		48
			Soybeans		36
Yrarrazaval et al.	1982	Chile	Wheat	1949-77	21-28
			Maize	1940-77	32-34
Avila et al.	1983	Brazil (EMBRAPA)	Human capital	1974-96	22-30
Cruz and Avila	1983	Brazil (EMBRAPA)	Aggregate	1977-91	38
Martinez and Sain	1983	Panama (IDIAP-Caisan)	Maize	1979-82	188-332
Ambrosi and Cruz	1984	Brazil (EMBRAPA-CNPT)	Wheat	1974-90	59-74
Avila et al.	1984	Brazil (South Central)	Aggregate	1974-96	38
Feijoo (revised by Cordomi)	1984	Argentina (INTA)	Aggregate	1950-80	41
Pinazza et al.	1984	Brazil (São Paulo)	Sugar cane	1972-82	35
Roessing	1984	Brazil (EMBRAPA-CNPS)	Soybeans	1975-82	45-62
Silva	1984	Brazil (São Paulo)	Aggregate		60-102
Ayres	1985	Brazil	Soybeans	1955-83	46-69
		Brazil (Parana)			51
		Brazil (R.G. Sul)			51-53
		Brazil (S. Catarina)			29-31
		Brazil (São Paulo)			23-24
Muchnik	1985	Latin America	Rice	1968-90	17-44
Norton et al.	1987	Peru (INIPA)	Aggregate	1981-2000	17-38
			Rice		17-44
			Maize		10-31
			Wheat		18-36
			Potatoes		22-42
			Beans		14-24
Echevarria et al.	1988	Uruguay	Rice	1965-85	52
Evenson	1988	Paraguay	Crops	1988	75-90
Luz Barbosa	1988	Brazil (EMBRAPA)	Aggregate	1974-97	40
Evenson and da Cruz	1989	South America (PROCISUR)	Wheat	1979-88	110
			Soybeans		179
			Maize		191
Average					57
Median					44

Source: Echeverría (1990, Table 1).

many supported early on by the Rockefeller Foundation—have had a remarkable impact on the disease burden in the region. These programs have included control of yellow fever in the early 1940s, the elimination of the malaria-carrying *Anopheles gambiae* mosquito in Brazil in the 1930s, and hookworm control in the 1920s.

The Rockefeller Foundation also supported agricultural research in Mexico in the 1940s that eventually became CYMMIT, bringing elements of the Green Revolution to Latin America. The foundation funded the respected CIAT agricultural research institute in Colombia and others in the region.

Although many of these health and agricultural organizations and initiatives continue to contribute influential research, some of the technological challenges posed by geographical and ecological conditions in Latin America today require investments beyond their reach. Besides, they may lack the comparative advantage to develop certain products or technologies developed by private high-technology firms.

With regard to malaria, for example, Jeffrey Sachs has suggested a coordinated pledge by rich countries promising an attractive market to the firm that succeeds in developing the vaccine.[63] A guaranteed minimum purchase price or fixed amount per dose would be paid when the vaccine actually exists. Similar pledges could spur cures for other diseases such as tuberculosis, or for the development of crop varieties or agricultural technologies adequate to the geographical and climatic conditions of the poor countries.

Of course, there are other forms of international cooperation that could promote these advances. Depending on the scale, the type of externalities of the problem, and the likely costs of finding a solution, cooperation might be most effective at either the subregional, regional or global level. It may also require the involvement of international organizations, some of which could also play a role in identifying global and regional priorities in health and agriculture and in mobilizing private sector research and development.

New telecommunications technologies and the Internet may also play a future role in reducing the significance of geographical barriers. Although these advances could reduce isolation, however, they most likely will benefit already accessible locations at least as much. And despite the dramatically lower user cost of modern telecommunications, a large initial investment in infrastructure investment is required. One might have expected similar revolutionary change in access from the telephone, but it has not made geographical barriers obsolete. One key area where the use of new technologies could bring dramatic improvements is in development of emergency communications systems for disaster-prone areas. More effective emergency communications would lessen the human and economic costs associated with disasters by providing populations with early warnings and by facilitating communication with isolated areas in the aftermath of disasters.

Information and Market Signals

Because many Latin American countries are so geographically diverse, different regions within a country may offer very marked comparative advantages or disadvantages for certain activities. The yield from investments in infrastructure or health care interventions, for example, may differ dramatically from one zone to another and between different-sized cities and towns because of population settlement patterns. Disaster prevention efforts may be best directed to certain locations because they are more prone to hurricanes, floods or earthquakes.

Keeping these geographical variables in mind when developing a range of economic and social policies requires good information, which is unlikely to be provided by the market of its own accord given the nature of information as a public good. Some of the larger Latin American countries have geographical and statistical institutes primarily devoted to gathering information on the human and geographical factors that affect development. The Instituto Brasileiro de Geografía (IBGE) and Mexico's Instituto Nacional de Estadística, Geografía e Informática (INEGI) enjoy international prestige for their technical and analytical ability. Nevertheless, such efforts are just beginning in many countries where the agencies responsible are not guided by clear economic and social policy objectives and do not provide significant support to policymakers. Hence, geographical considerations often are not factored into decisions on infra-

[63] Sachs (1999, pp. 17-20).

structure investment, allocation of health care expenditures, or plans for urban development, settlement or disaster prevention.

The gathering, processing and dissemination of geographical information must be the responsibility of central bodies. These are complex tasks that require considerable costs, offer major economies of scale, and give rise to significant externalities. There may even be a need for supranational agencies to deal with phenomena that transcend national borders, such as hurricanes or El Niño. Still, a great deal of information related to geography can be generated at the decentralized level. In Costa Rica, for example, the National Biodiversity Institute (INBio) is involving local communities in drawing up a biodiversity inventory. And in cases where data collection takes place at a decentralized level, policy decisions based on geographical information need not be centralized either. The level at which policy decisions must be made should respond essentially to the scope of the externalities generated by such decisions. Decisions having to do with providing urban infrastructure or regulations on land use may be better made at the local level, provided the information exists and is known by the relevant decisionmakers. On the other hand, decisions involving broad geographical externalities—such as controlling water or air pollution or infectious diseases—naturally are better made at the national, regional or even international levels.

Effective dissemination of information is essential not only for government policymakers, but also for those who may suffer the consequences of problems caused or influenced by geography, most of whom are poor. Urban zoning regulations are sometimes so vague and obscure that they can be used as a means to extort money from people after they have invested in houses or businesses on inadequate sites.

People often build homes in high-risk zones because there is no information available to them on the risks involved, or because that information has been manipulated or concealed. Huge losses suffered by agricultural producers could often be avoided if information on weather and other natural hazards were better disseminated. Although it is difficult to predict the occurrence of such phenomena, just having available information on the frequency and intensity of such risks could facilitate development of insurance markets, which are still at an incipient stage in Latin America. Countries where producers and investors are covered for hurricane risks by insurance do not suffer the recessionary effects following the disaster that countries without such coverage do. The Dominican Republic received compensation following Hurricane Georges in 1998 that amounted to around 2 percent of GDP, a powerful stimulus for the construction industry and a factor in sustaining a high economic growth rate even in the aftermath of a disaster. Access to insurance and other financial services is particularly crucial for low-income households, the informal sector and small businesses.

The problem of risk is obvious in the case of natural disasters, but there is also climatic risk associated with agriculture, the risk of disease, and the risk of isolated places being cut off. Again, making information available can help. National governments can help people overcome adverse effects of geography by disseminating information on production technologies for low-productivity or erosion-prone lands, methods of pest or disease control, and suitable techniques for building homes in geographically vulnerable areas.

Although it is essential that governments generate and disseminate such information, the marketplace nevertheless remains the more effective dissemination mechanism if it operates correctly. Low land prices in areas that are disaster-prone or outside the scope of urban public services often attract the poor, leading to construction of vulnerable settlements. The marketplace can be used to head off such developments. For example, a system of subsidies for those who build new houses may be more effective than an administrative or policing procedure in resettling the inhabitants of a high-risk area. The most effective way to contain erosion may be the use of a subsidy to encourage use of a new technology to displace inappropriate ones. To encourage a community to preserve a scarce resource (a nature reserve, for example), the best approach may be to promote a market for that resource (ecological tourism, for example) rather than preventing it from being used, which reduces its potential value.

To respond to market signals, people must have mobility. An area of low agricultural productivity with poor health conditions can become a poverty trap if policies discourage migration toward areas with better opportunities. Fear of migration from the coun-

tryside to the city, deeply rooted in the minds of Latin American leaders, has often translated into subsidies to unproductive farming sectors and rural areas. Further, according to surveys in the mid-1990s, nearly half of the small farmers in Honduras, Paraguay and Colombia do not have land titles.[64] This not only limits their mobility but limits access to credit and discourages investment.[65] In disaster-prone areas, lack of land titling discourages owners from making investments that could lower risks and hinders any resettlement policy. In short, problems that limit mobility reinforce rather than alleviate the adverse effects of geography.

Decentralization and Organization

Decentralization is an important tool for taming and exploiting geography because of the wide variety of ways that human and physical geography can affect development, ranging from natural disasters to population trends. It is difficult to imagine a centralized decisionmaking system that could respond adequately to the variety of needs and restrictions imposed by geography on different locations, especially in countries as geographically heterogeneous as those in Latin America.

Nor can a single decentralization model be effective. In Latin America, local governments within each country—municipalities, provinces or districts, according to the term used in each country—are organized basically in the same manner, without taking into account differences in size, location or other basic geographical and socioeconomic conditions. The result in more prosperous locations is that potential for better organization and service delivery goes untapped, especially in countries with more centralized government structures. Meanwhile, less geographically and economically fortunate localities can be overwhelmed by administrative demands and responsibilities.

Some countries have begun to break this straitjacket by using more flexible and adaptable decentralization processes. In Colombia and Venezuela, some responsibilities for providing road infrastructure and other public services are assigned by contract to subnational governments according to their administrative and technical capability. In Colombia, the process has also involved nongovernmental bodies such as the coffee producers' association or oil companies, which have assumed some responsibilities for providing infrastructure.

A single decentralization structure is ineffective from a geographical standpoint as well, since some of the most important effects of geography are not clearly localized, or because they generate externalities that are significant for other localities or regions. For example, illnesses or plagues affecting several localities cannot be eradicated by any locality by itself. An appropriate technology for containing erosion in river basins and preventing risks of mudslides or floods is unlikely to be developed by the locality causing the problem, partly for cost reasons, but particularly because other localities may be more affected by the danger than is the locality where the problem originates. Hence, the locality where the problem lies will expect other affected localities to help solve it. A highway built to end the geographical isolation of one region will have to cross many other areas to be useful, and obviously will not be undertaken by any one locality by itself.

Each of these examples suggests the need for a different level of geographical organization. The problem of a pest that affects a specific crop may require only the organization of producers, while a tropical disease may demand national or even global intervention. Mitigating the risk of natural disasters demands central organization with acknowledged leadership capable of assigning specific responsibilities to other levels. Addressing a problem of erosion may involve a group effort by municipalities that share a river basin. Construction of a highway may require cooperation both by the isolated areas to where the road is being built as well as by others that may benefit in some other way from the new investment.

Hence, the form of decentralization suitable for solving some problems may be very different from that needed to solve others. It is not just a matter of different levels of aggregation (municipal, state, national), but also of different types of groupings (groups of municipalities or zones that may or may not correspond to existing territorial units, or combinations of different levels of government).

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[64] See López and Valdés (1996) cited by López (1996).

[65] See López (1996) and Carter and Olinto (1996). Nevertheless, where efficient credit markets do not exist, a massive land titling policy can have adverse effects on distribution.

Although in principle it might be possible to define the level and type of grouping of localities sharing the same geographical problem or benefit, this does not mean that cooperation will be easy or even feasible. Problems of coordinating more than a few municipalities may prove intractable, and are not always necessarily solved by grouping the municipalities at an intermediate territorial level. In other words, geographical heterogeneity imposes demands for institutional development that may be difficult to meet, trapping the more geographically fragmented countries in situations of low economic and social development. Chapter 4 will examine this point more rigorously and discuss some of its implications for the organization of political systems and governability. At this point it is important to note only that the excessive number of political jurisdictions exacerbates these problems in many Latin American countries. That is, political fragmentation of territory hinders solving economic and social problems, particularly those that are geographical in origin. In Mexico, states with a greater density of municipalities (vis-à-vis population) have significantly lower levels of development. According to econometric estimates, per capita income will be from 10 to 20 percent lower in a state with double the municipal density of another, other determining conditions of development being similar.[66] Many Latin American countries have an excessive number of political jurisdictions, especially at the municipal level. Panama, with a population of 3 million, has 67 municipalities, while El Salvador, with a population only twice as large, has 262 of them. The number of municipalities in Venezuela rose from 200 in 1985 to 333 in 1998, and in Colombia there are now over 1,000 municipalities.

Although political fragmentation usually has deep historical roots, the trend has been reinforced by laws that encourage the creation of new municipalities. For example, the setting of a fixed component of fiscal transfers per municipality (in addition to the variable component by population or by other variables) leads to the creation of small municipalities. Electoral rules that assign to each territorial unit a basic number of seats in legislative bodies have the same consequence.

All of these complications point up the fact that while decentralization is an essential instrument for taming geography, it is not a simple instrument. In principle, three conditions are needed for successful decentralization.[67] First, the local decisionmaking process must be democratic, in the sense that the costs and benefits of decisions are transparent and all those affected have an equal opportunity to affect those decisions. Second, the costs of local decisions must be borne completely by those making them, and not transferred to other territorial units or to the central government. And third, the benefits must also be circumscribed to the participants. When these conditions are all met, the responsibilities and their financing can be totally transferred to subnational governments or organizations. Unfortunately, few if any of the problems posed by geography allow for these conditions to be fully met. This does not mean that decentralization must be rejected, but rather that it ought to be designed in each case in such a way that all participants have incentives similar to those that would exist if such conditions were indeed met.

Solving the problem of transparency requires systems of democratic participation in decisionmaking and public control of local government (as well as the generation and dissemination of information, as discussed in the previous section). Although municipal governments are now popularly elected in most Latin American countries, municipalities are not always the most suitable entity for decentralization. Decentralizing responsibilities to other units or organizations must be backed by similar democratic decisionmaking procedures. For example, in instances where coffee producer organizations have responded to a set of information externalities and problems that are largely of geographical origin, the most favorable results have occurred in countries where those organizations used democratic procedures.[68]

To prevent the costs of local decisions from being transferred to other entities or government levels, clear and credible budgetary restrictions must be imposed. That requires clearly defining the responsibilities to be assumed by the subnational government or the relevant decentralization entity. Similarly, if

[66] See Blum and Díaz Cayeros (1999).

[67] For a broader description of the benefits, risks and best practices associated with decentralization, see IDB (1997, Part Three, Chapter Three).

[68] Bates (1997).

transfers are received from the national government for fulfilling these functions, such transfers must be determined by the level and quality of the services provided, not by the costs incurred or by an acquired right, as happens when transfers are a percentage of central government revenues. Finally, the lower-level government must also have very strict debt limits in keeping with its own revenue generating ability.

Avoiding deficiencies or excesses in the provision of certain services that generate positive (or negative) externalities to other territorial units requires creation of a system for transfers (or taxes) from the central government to providers. Some countries have set up joint financing procedures for certain investments that generate significant geographical externalities, such as highway construction, wastewater treatment, or control of air pollution.

Latin American countries are abandoning the traditional centralism of their institutions and policies in favor of more decentralized and participatory systems. The success of that strategy will depend largely on its ability to incorporate new dimensions of human and physical geography into the design and implementation of new policies.

Appendix Table 3.1 **Geography and Health, 1995**

	(1) Life expectancy (years at birth)	(2) Infant mortality rate (infant deaths per 1,000 live births)	(3) Falciparum malaria index 1994 (0-1)
Log GDP per capita (PPP)	0.416	0.024	-0.014
	(0.64)	(0.01)	(0.42)
Female literacy rate (%)	0.286	-1.452	0.000
	(9.29)**	(7.66)**	(0.24)
Tropical, wet (%)	-4.332	40.722	0.275
	(4.01)**	(4.88)**	(5.22)**
Tropical, monsoon (%)	0.882	3.999	-0.019
	(1.45)	(0.61)	(0.09)
Tropical, some dry (%)	0.850	5.354	0.083
	(1.20)	(1.04)	(2.78)**
Dry steppe (%)	3.210	-18.505	-0.011
	(2.14)*	(2.27)*	(0.72)
Desert (%)	2.481	3.724	-0.012
	(4.27)**	(1.14)	(0.81)
Temperate, dry summer (%)	3.729	-8.720	0.000
	(3.69)**	(1.36)	(.)
Temperate, dry winter (%)	-3.557	26.959	-0.049
	(2.78)**	(1.59)	(1.34)
High elevation and polar (%)	-0.769	3.651	0.012
	(0.89)	(0.77)	(0.26)
Constant	41.716	156.385	0.165
	(8.79)**	(4.68)**	(0.42)
No. of observations	178	178	139
R^2	0.64	0.49	0.26

Notes: Robust t-statistics in parentheses.

** Significant at the 5 percent level.*

*** Significant at the 1 percent level.*

Appendix Table 3.2 **Determinants of GDP Per Capita Growth, 1965-90**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Control								
GDP per capita, 1965 (log)	-2.329*	-2.533*	-2.908*	-2.878*	-3.239*	-2.880*	-3.893*	-3.994*
	(-7.64)	(-7.28)	(-6.91)	(-7.02)	(-7.46)	(-5.65)	(-9.47)	(-10.20)
Years of secondary schooling, 1965 (log)	0.265	0.177	0.057	0.108	0.029	0.015	0.038	0.074
	(1.85)	(1.20)	(0.42)	(0.71)	(0.21)	(0.10)	(0.19)	(0.55)
Life expectancy, 1965 (log)	6.506*	4.731*	4.608*	4.702*	3.839*	3.953*	5.351*	4.059*
	(7.30)	(4.27)	(4.40)	(4.24)	(4.34)	(4.52)	(4.93)	(4.07)
Trade openness, 1965-90 (0-1)	1.889*	1.795*	2.110*	1.864*	1.866*	1.950*	1.590*	1.587*
	(5.47)	(4.58)	(5.15)	(5.02)	(3.97)	(4.03)	(3.01)	(3.58)
Institutional quality (0-10)	0.282*	0.357*	0.390*	0.431*	0.382*	0.345*	0.484*	0.468*
	(3.30)	(3.32)	(3.52)	(4.40)	(3.75)	(3.33)	(3.61)	(4.25)
Physical geography								
Share of land in tropics (0-1)		-0.333	-8.915*	-8.311*	-8.180*	-5.842	-9.504*	-10.681*
		(-0.73)	(-2.86)	(-2.70)	(-2.86)	(-1.76)	(-3.41)	(-3.64)
Share of land in tropics times (log) GDP per capita, 1965			1.111*	1.077*	0.992*	0.682	1.184*	1.293*
			(2.82)	(2.77)	(2.74)	(1.62)	(3.37)	(3.54)
Falciparum malaria index, 1965 (0-1)		-1.404*	-0.902	-1.113*	-0.602	-0.717	-0.650	-0.717
		(-2.39)	(-1.64)	(-2.05)	(-1.26)	(-1.43)	(-1.14)	(-1.19)
Earthquakes and volcanos index (0-1)				-1.651*				
				(-3.06)				
Human geography								
% Urban population, 1965					2.249*	1.457	2.290*	2.471*
					(2.86)	(1.71)	(2.70)	(3.46)
Coastal population					0.602		2.710	1.977*
					(1.26)		(1.73)	(2.13)
Distance to main markets (log)					-5.90	-2.93	-7.29	-6.85
					(-1.08)	(-0.48)	(-1.16)	(-1.17)
Coastal population density, 1994 (log)						0.170*		
						(2.25)		
Inland population density, 1994 (log)						-0.087		
						(-1.19)		
Infrastructure								
Total road length, 1965 (log)							0.196	
							(1.22)	
Coastal population share times (log) road length							-0.244	
							(-1.50)	
Electricity generating capacity, 1965 (log)								0.220
								(1.55)
Coastal population share times (log) electricity generating capacity								-0.223
								(-1.93)
Constant	-8.792*	0.014	3.143	2.329	7.811*	4.878	4.580	11.175*
	(-2.92)	(0.003)	(0.75)	(0.53)	(2.11)	(1.11)	(0.96)	(2.43)
R^2	0.70	0.75	0.77	0.79	0.79	0.80	0.84	0.85
Number of observations	77	77	77	72	76	76	58	71

Source: Authors' calculations.

Note: Robust t-statistics in parentheses.

** Significant at 5 percent or more.*

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