Geography and Socioeconomic Development

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Background paper examining the state of the Andean region for the Andean Competitiveness Project

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INTRODUCTION

Geography has strong and pervasive effects on economic and social development. The Andean countries, spanning the equator in the tropics, have an exceptional geographical diversity within each country that has strongly marked their development. Geography plays an important role in these countries' economic prospects, national integration, health conditions, and agricultural prospects.

Geography does not determine an inescapable destiny for Andean or any other countries. Geographical endowments present particular difficulties or opportunities for economic activity. Any geographical challenge can be overcome with sufficient effort and investment, but a difficult geography makes development that much harder.

Two simple facts suggest the magnitude of the economic impacts of geography. Tropical countries have an average income per capita of just one-third that of non-tropical countries. Likewise, landlocked countries have an average income per capita of only one-third the income of countries with access to the sea.[1]

Physical geography mainly impacts economic and social development through three pathways: accessibility, agricultural productivity, and disease. The accessibility of a region, especially to the sea, is crucial for making the region's industry and services competitive in world markets. Despite the abundance of air cargo services in modern times, almost all but lightweight, high value goods still trade internationally by sea. Large cities, the site of most industrial and service activity, are usually located near the coast or navigable rivers.

Agricultural productivity is fundamentally tied to climate and soils, causing geography to have its greatest impacts at the lowest level of development, when agriculture dominates the economy.

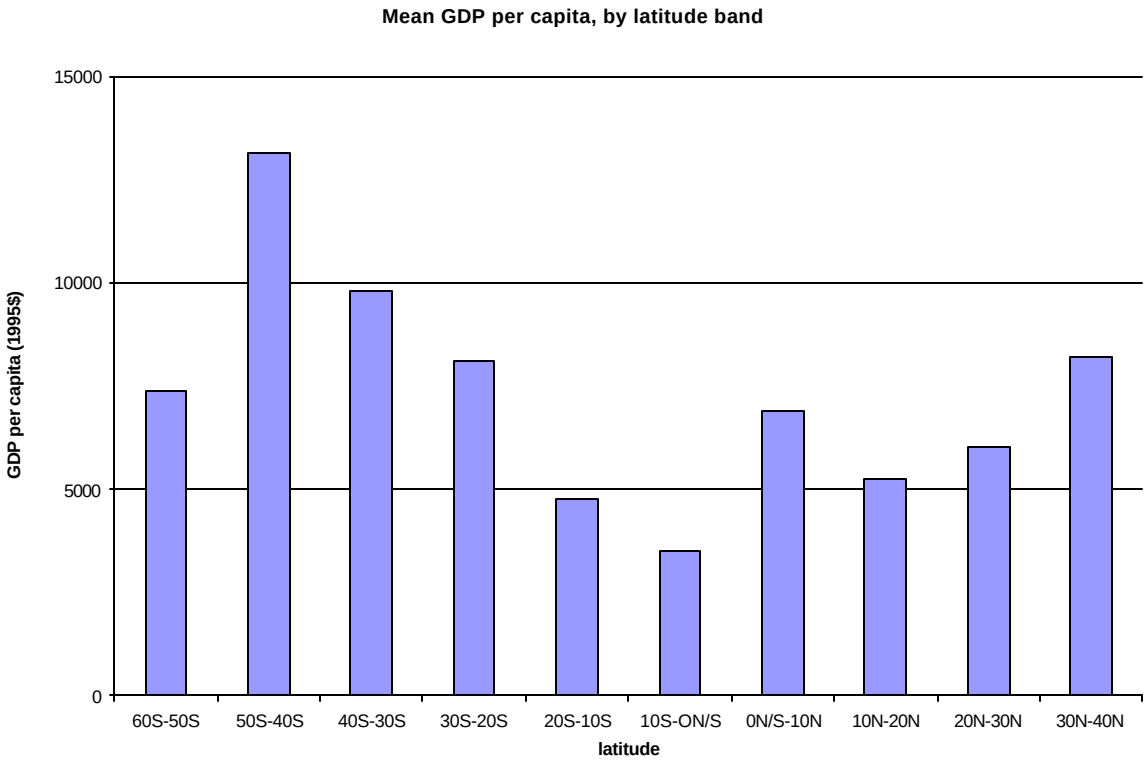
The range and intensity of many diseases, particularly vector-borne ones, vary according to climate. Malaria, hookworm, and schistosomiasis, in particular, are great debilitators, and have been relatively easy to control in temperate zones, by still defy major control efforts in the tropics.

How relevant is geography for the future development of Andean countries? The geographical gradients within Latin America are clear and dramatic, with Andean countries generally at a low point. As seen in Figure 1, the 1995 purchasing-power parity GDP per capita

[1] Specifically, using 1995 purchasing-power-parity GDP per capita estimates (World Bank, 1998), 72 tropical countries have an average GDP per capita of $3,326, while 78 nontropical countries have an average GDP per capita of $9,027. Tropical is defined as most of the land area being within ±23.45º latitude, the band within which the sun is directly overhead at some point in the year. The 29 non-European landlocked countries have a GDP per capita of $1,771, while the 105 non-European countries with access to the coast have a GDP per capita of $5,567. The European landlocked countries are surrounded by one of the richest markets in the world.

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 20° South to 0° latitude band. The average GDP per capita of $4580 U.S. dollars in the 20° South to 0° latitude band (spanning Ecuador, Peru, and Bolivia) is just under half the level at the temperate high points. The variation in income by latitude within Latin America is more striking given that the countries in the region share many common aspects of colonial and cultural history.

Figure 1: Mean GDP Per Capita, by Latitude Band



With the exception of oil-rich Venezuela, all of the (tropical) Andean countries have a lower average income than all the non-tropical Latin American countries (Table 1). The same pattern holds for health. Bolivia, Peru, Ecuador, and Colombia all have life expectancies lower then Uruguay, Mexico, Argentina, and Chile, and the Andean country life expectancies are typical of the other Latin American and Caribbean (LAC) countries.

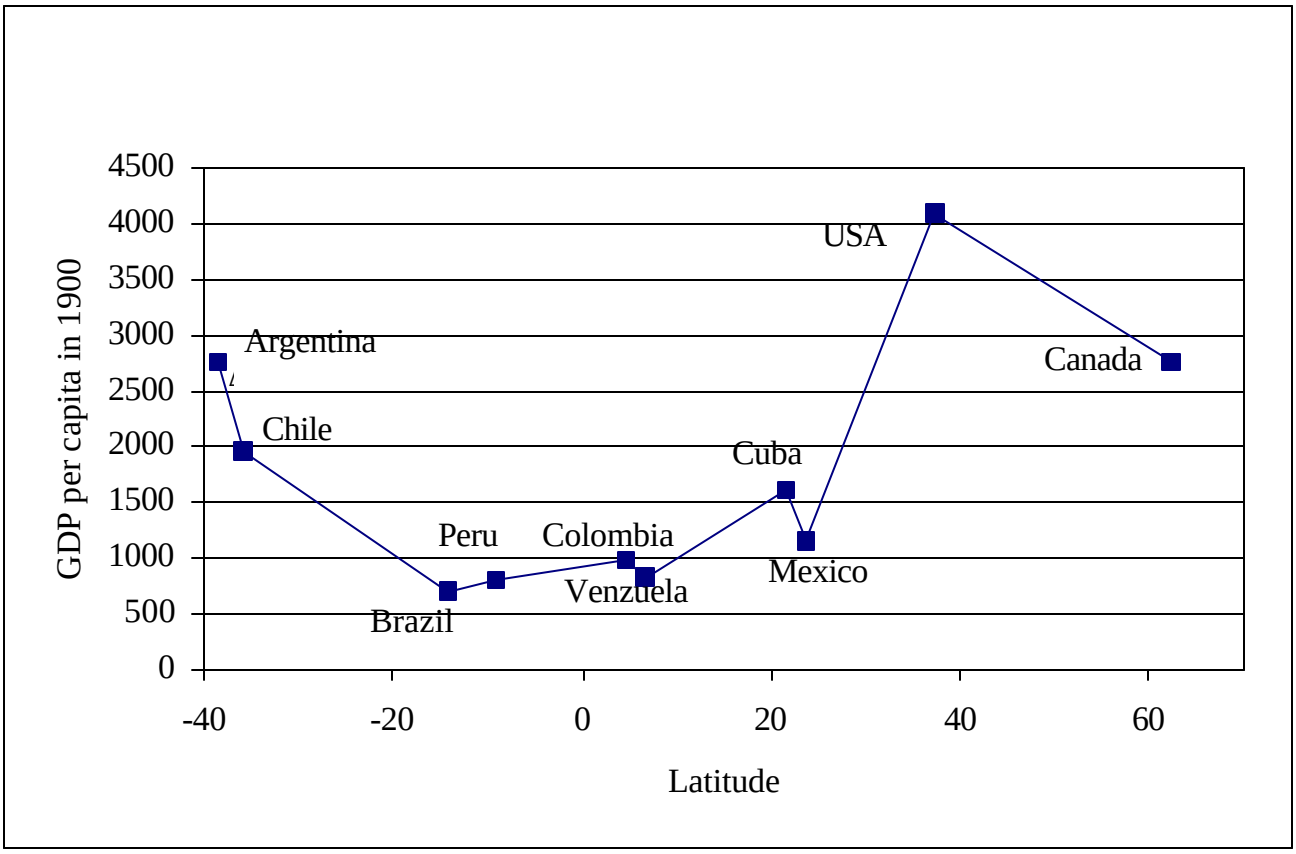
Table 1: Income and Health in Tropical and Temperate Latin America

Country	*GDP per person, 1995*	*Life Expectancy at Birth, 1995*
Bolivia	2,913	61.5
Other Tropical LAC Countries (18)	4,350	69.7
Peru	4,518	68.3
Ecuador	4,970	69.8
Colombia	6,915	70.9
Uruguay	7,246	72.9
Mexico	7,592	72.5
Venezuela	8,544	72.8
Argentina	9,287	73.2
Chile	11,162	75.3

The problem of poverty in the tropics is nothing new. The U-shaped gradient of income levels by latitude, with low incomes in the tropics and much higher incomes in the higher latitudes has persisted for as long as we have data. The data for GDP per capita is reliable for the larger countries in the Americas back to 1900, shown in Figure 2.[2] Incomes in the tropical Andean countries of Peru, Colombia, and Venezuela as well as Brazil were less than half the level of temperate Chile and Argentina, and lower than Mexico and Cuba on the tropical fringe.

[2] The GDP per capita data for 1900 are from Maddison, 1995, Table C-16d, p. 188, except for Cuba in 1913, from Coatesworth, 1998, Table 1.1, p. 26.

Figure 2: Income by Latitude in 1900



Dividing Latin America into zones of similar geography, the highlands, coastal regions, and Amazon region of the Andean countries have distinctive characteristics (see Table 2). All three of these zones typical of the Andean countries have low income per person within Latin America (compared to the temperate Southern Cone and Mexican regions) with the highlands the very poorest with a GDP per person of about $4300. The coast and highlands are also the highest population density areas, while the Amazon has extremely low population density. In addition, coastal access is lowest for the Amazon and highlands regions compared to all other Latin American zones, with only 1% and 11% of their populations within one hundred kilometers of the coast, respectively.

Table 2: Characteristics of Latin American Geographical Zones

Geographical Zone	*GDP per person (1995$)*	*Population Density (persons/sq km)*	*GDP Density ($1000/sq km)*	*Area (million sq km)*	*Population within 100 km of coast (%)*
Tropical Highlands	4343	52	226	1.9	11
Lowland Pacific Coast	4950	61	302	0.8	95
Lowland Atlantic Coast	5216	46	240	2.2	83
Amazon	5246	6	31	9	1
Temperate Southern Cone	7552	35	264	3.2	31
Mexican-U.S Border	7861	17	134	1.1	30
Highland and Dry Southern Cone	9712	7	68	2.2	16

Source: Author's calculations.

Not only do geographical zones characterize certain Andean countries, but they indicate the geographical splits within the countries as well. The Tropical Highlands has a substantially lower income level than either the coastal areas or the Amazon.

Geographical variables are strongly correlated with recent economic growth in cross-sectional studies (Gallup, Sachs, and Mellinger, 1999). After controlling for other factors that affect economic growth like initial income, education levels, the openness of the economy to international trade, and the quality of public administration, several geographically related variables all have strong correlations with economic growth: a coastal population, general level of health, tropical location, and malaria prevalence. According to these estimates, landlocked countries, with no population within 100 kilometers of the coast, experience 1.0 percentage point per year slower growth in GDP per capita than coastal countries. Tropical countries grow at 0.9 percentage point per year slower than temperate countries, and countries at high risk of malaria grow at 1.2 percentage points slower than countries free from malaria.

Except for Bolivia and Colombia, the Andean countries have good access to the coast for most of the population. Bolivia is completely landlocked and in Colombia almost three quarters of the population are further than 100 kilometers from the coast. The other Andean countries still have large population concentrations in the less accessible highlands, including the capital city in Ecuador (like Colombia). The general levels of health are low in Andean countries compared to the rest of Latin America, and all the Andean countries are tropical. All of these countries also continue to have major malaria problems, especially in the jungle regions. Poor health, tropical location, and malaria are all potentially damaging for the economic growth of Andean countries.

Geography has strong correlations with differences in income levels and economic growth across countries. Does geography also explain differences in income across regions *within* countries? A set of studies for Mexico, Colombia, Peru, Bolivia, and Brazil addresses the role of geography within countries. Table 3 shows the percent of income level variation "explained", or accounted for, by geographical variables in these countries. The geographical variables used (as well as the measure of income used) differ substantially across the studies, ranging from measures of climate to soils to proximity measures. For countries with province level income measures, geography accounted for the majority of income variation, from 66 to 72 percent. The percentage of household income variance explained was 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.

Table 3. Percentage of Variation in Income Levels "Explained" by Geography

Country	R^2 (%)
Bolivia I	68[a,h]
Bolivia II	66[b,i]
Brazil	47[c,j]
Colombia	36[d,k]
Mexico I	70[e,l]
Mexico II	72[f,m]
Peru	7[g,n]

Included variables are:

[a] Altitude, border crossing, regional center and department capital

[b] Altitude and urbanization

[c] Rainfall, temperature, and latitude

[d] Rainfall, altitude, soils, and distance to market, sea, and 2 rivers

[e] Rainfall, temperature, coast, border, population density

[f] Humid, cold, forest, and agricultural land types

[g] Altitude, rainfall, temperature, soils, earthquake

Dependent variable is:

[h] Provincial unsatisfied basic needs

[i] Provincial unsatisfied basic needs

[j] Log household income per person

[k] Log municipal GDP per capita

[l] Log state GDP per capita

[m] Log state GDP per capita

[n] Log household expenditure per capita

Source: IDB studies. Bolivia and Mexico each had two studies using different geographical variables.

Latin America is famous for its unequal income distribution. These estimates in Table 3 imply that a large part of regional disparities within these Latin American countries are tied to geographical factors, and even a substantial share of between-household inequality is correlated with geography.

The role of geography in shaping economic development in Andean countries has been important historically and in the present. In Colombia, for example, trade between the major regions was minor. Until this century, roads only connected villages within each region, with no roads across regions. In 1930, the main link from the capital, Bogotá, to the outside world was a twelve day steamboat trip down the Magdelena River. The geographical barriers still mean that Colombia has one of the lowest road densities in Latin America. In most countries, there has been a strong tendency for income levels to converge across states or regions. This is so regular a tendency in many of the countries studied that it seems to occur at similar rates (Barro and Sala-i-Martin, 1995). In Colombia, however, there is no clear sign of convergence across the departamentos, probably due in substantial measure to the geographical barriers between them. The mountains make access difficult and the wide variation in ecological zones between the high mountains and the tropical lowlands means that many techniques, such as agriculture, are not transferable. When trying to explain the causes of municipio[3] growth, proximity to regional markets remains the most important explanatory variable, and there are strong effects of tropical disease (malaria and cholera) on municipio growth. The tropical disease effect is even larger in a subsample of the poorer municipios (Sanchez and Nuñez , 1999).

AGRICULTURE

Agricultural yields are particularly sensitive to climate and soil resources. Climate and soil conditions are characteristically different in temperate and tropical ecological zones. One of the basic reasons why economic development is depressed in the tropics is lower agricultural productivity. The disparity between tropical and non-tropical agricultural output per farmworker is even more pronounced than the disparity between tropical and non-tropical income levels. Most individual crops in Latin America (and elsewhere) tell the same story: yields in tropical countries are much lower than non-tropical yields. A few crops are exceptions: sugarcane, oilcrops, and coffee, but none of the yield differences for the tropics and non-tropics for these crops are statistically significant (Table 4).

[3] Municipios are the second level administrative subdivision, below departamentos. If departamentos correspond to U.S. States, municipios correspond to U.S. counties.

Table 4. Crop Yields in Non-Tropical versus Tropical Countries in Latin America and the Caribbean, 1998

	Tropical yield (MT/Ha)	*Non-tropical yield (MT/Ha)*	*Tropical/ Non-tropical*	*Statistically significant difference a)*
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	218	0.56	x
Sugarcane b)	700	632	1.11	
Pulses (Beans and Peas)	7.5	10.4	0.72	x
Oilcrops	6.2	5.3	1.17	
Vegetables	143	161	0.89	
Fruits	135	142	0.95	
Bananas	166	214	0.78	
Coffee	7.1	6.1	1.16	
Observations c)	33	7		

a) $x = p$ value less than 5% for t test that mean tropical yield is different from mean non-tropical yield.

b) Data are for 1996.

c) This is the number of observations for Cereals. For some crops, not all countries grow the crop.

Source: FAO (1999).

The difference between tropical and nontropical yields could be due, in whole or part, to the inputs used. Fertilizers, tractors, improved seed, and labor will all affect yields whether or not the climate is ideal for the crop. Farmers in wealthier countries will use more non-labor inputs per hectare since these inputs are inexpensive compared to their own labor and land values. So the low yields in the tropics could be due to poverty in the tropics rather than contributing to poverty. However, estimates in Gallup and Sachs (1999) show that tropical yields are much lower after controlling for differences in input use.[4] Tropical and dry ecozones, which make up most of the geographical tropics, have yields thirty to forty percent lower than temperate ecozones for the same input use. Moreover, agricultural productivity grew about two percent per year more slowly in tropical and dry ecozones than temperate ones.

Crop yields have grown tremendously in the last few centuries, so it is difficult to speak of inherent levels of agricultural productivity in one region of the world or another. This is equally true in recent times of Latin America. Table 5 shows the rapid growth of crop yields in the region for most of the staple crops, but the growth rates are quite different between tropical and non-tropical regions. The growth of yields of a few crops (coffee, fruits, vegetables, and oilcrops) was slightly higher in the tropical countries (and not statistically significantly different), but the staples all grew more slowly. Cereals in general as well as maize in particular, potatoes and root crops, and pulses all had clearly lower growth rates in the tropics. The disappointing tropical trends for these crops in the Latin American region are also similar for the world as a

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

whole. Bananas, an important export crop in Ecuador among other countries, actually saw a decline in average Latin American yield in the last 37 years.

Table 5. Average Crop Yield Growth, 1961-1998, in Tropical versus Non-Tropical Countries in Latin America and the Caribbean

	Tropical yield growth (%)	*Non-tropical yield growth (%)*	*Tropical - Non-tropical*	*Statistically significant difference a)*
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
Sugarcane b)	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	
Observations c)	33	7		

a) $x = p$ value less than 5% for *t* test that mean tropical yield growth is different from mean non-tropical yield growth.
b) Data are for 1961-1996.
c) This is the number of observations for Cereals. For some crops, not all countries grow the crop.
Source: FAO (1999).

Individual Andean countries show the same pattern of lower yields for staples compared to the non-tropical countries. Cereals including maize and roots and tubers have substantially lower yields in each Andean country compared to non-tropical Latin American countries (Table 6). Andean yields in these crops are typical of crop yields in other tropical countries in the region. Just as for Latin America as a whole, there are no clear differences in pulse yields between the Andean countries, other tropical countries, and non-tropical countries in Latin America. Andean and tropical countries, with the exception of Bolivia, seem to have an advantage in oil crop yields compared to the non-tropical Latin American countries.

Table 6. Crop Yields in Andean versus Temperate and Tropical Countries in Latin America and the Caribbean, 1998

Country	*Cereals*	*Maize*	*Roots and Tubers*	*Pulses*	*Oil Crops*
Bolivia	1.2	1.7	4.8	1.0	0.3
Ecuador	1.4	1.2	8.5	0.7	1.5
Tropical (18)	2.1	2.3	10.3	1.0	0.7
Peru	2.3	2.1	9.4	1.0	0.6
Colombia	2.3	1.8	12.9	1.0	1.8
Venezuela	2.5	2.6	11.7	0.7	0.7
Non-tropical (5)	3.0	3.4	16.4	1.0	0.4

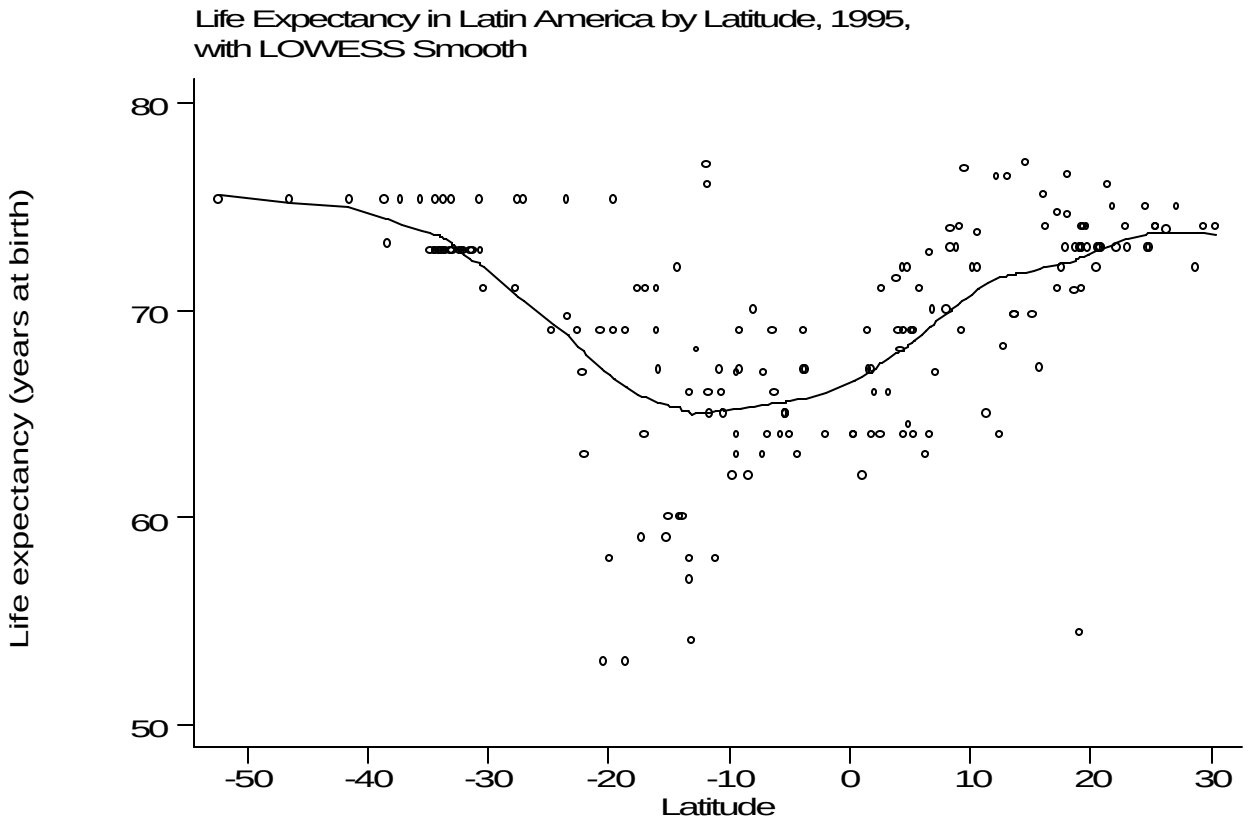
Source: FAO (1999).

HEALTH AND DISEASE

Life is short in the tropics. Figure 3 combines state or provincial life expectancy data for Bolivia, Peru, Brazil, Colombia, and Mexico in 1995 with national data for the other Latin American countries.[5] 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 down to 65 years just south of the equator. The very low average lifespans, below 60 years, are all in the tropics, seeming to drip from the sagging trend line. The below-60 life expectancies are in provinces of Bolivia and Peru, and in Haiti. The two provinces close to the equator with life expectancies above 75 years are also in Peru: the capital Lima and its sister departamento of Callao, a clear sign of the regional disparities within the country.

[5] The subnational state and provincial data come from various national sources compiled by the author. The national data are from World Bank (1998).

Figure 3



Poor health and poverty are closely linked. Bolivia and Haiti, with the low life expectancies, are poor countries. Peru is not as poor, on average. To distinguish the influence of climate on disease from the effects of poverty, we control for the influence of income levels and women's education. Provincial life expectancy in Latin America is still strongly correlated with climate after taking into account these other influences. After accounting for female literacy and GDP per capita, life expectancy is four years lower in the wet tropics as in the moist temperate zone.

The role of geography in provincial health conditions in the Andean region is confirmed by a within-country analysis of Peru. In these two studies, 61 to 71 percent of variation in infant mortality and child malnutrition was accounted for by geography (without controlling for other factors) as shown in Table 7.

Table 7. Percentage of Variation in Health "Explained" by Geography

Country	R^2 *(%)*
Brazil	76[a,c]
Peru	62[b,d]
Peru	71[b,e]

Included variables are:

[a] Rainfall, temperature, altitude, and region indicators,

[b] Rainfall, temperature, altitude, longitude and latitude

Dependent variable is:

[c] Municipal infant mortality rate

[d] Provincial infant mortality rate

[e] Provincial child nutrition

Source: IDB studies.

Although geography is largely immutable, the disease prevalence in particular climates are not. Our results suggest that rising income levels *per se* will not take care of health in the tropics; direct action is required. For some tropical diseases there are few affordable and effective treatment and control strategies; for others the means of conquering the disease are well known, but major efforts of education and mobilization required. The prime example of the former is malaria. Vector control in the worst effected areas is at best a holding action, and the effective drugs are rapidly losing their effectiveness due to drug resistance. Vaccines are still many years from development, due to little 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 significant tropical developed countries. The tropical countries are too poor to offer an attractive stand-alone market to induce pharmaceutical firms to invest in drug development for tropical diseases. Pharmaceutical firms have been dropping the production of many standard drugs for tropical diseases due to lack of profitability, despite a steady or increasing burden of disease.

GEOGRAPHY, INEQUALITY, AND SOCIAL COHESION

The relationship between geography and inequality is more ambiguous than the other roles of geography. Some strong patterns exist, but they are difficult to explain. Notably, inequality rises as latitude falls: the South has much more income inequality than the North (Figure 4). Despite the geographical diversity within the Andean countries, most of them have lower than average income inequality for Latin America (Bolivia, Ecuador, Peru, and Venezuela). Only Colombia has very high income inequality (Table 8).

Figure 4

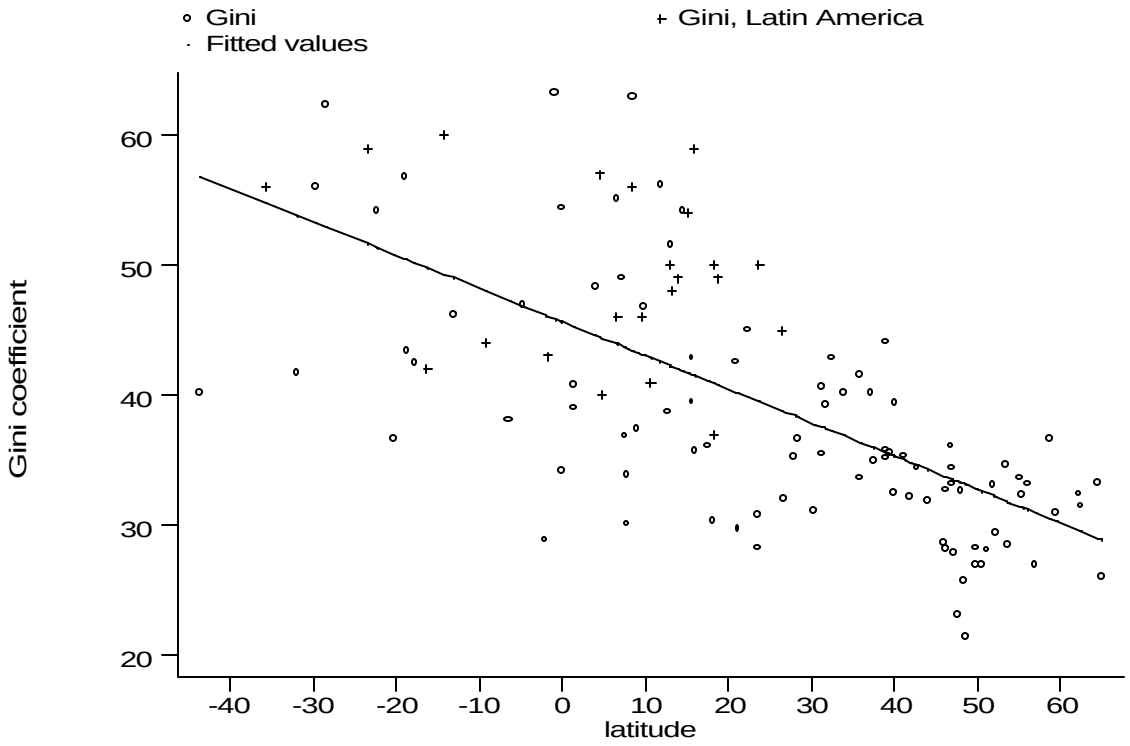

Gini
Fitted values
Gini, Latin America
Gini coefficient
60
50
40
30
20
-40
-30
-20
-10
0
10
20
30
40
50
60
latitude

Table 8. Income Inequality in Latin America and the Caribbean by Spanish Colonization

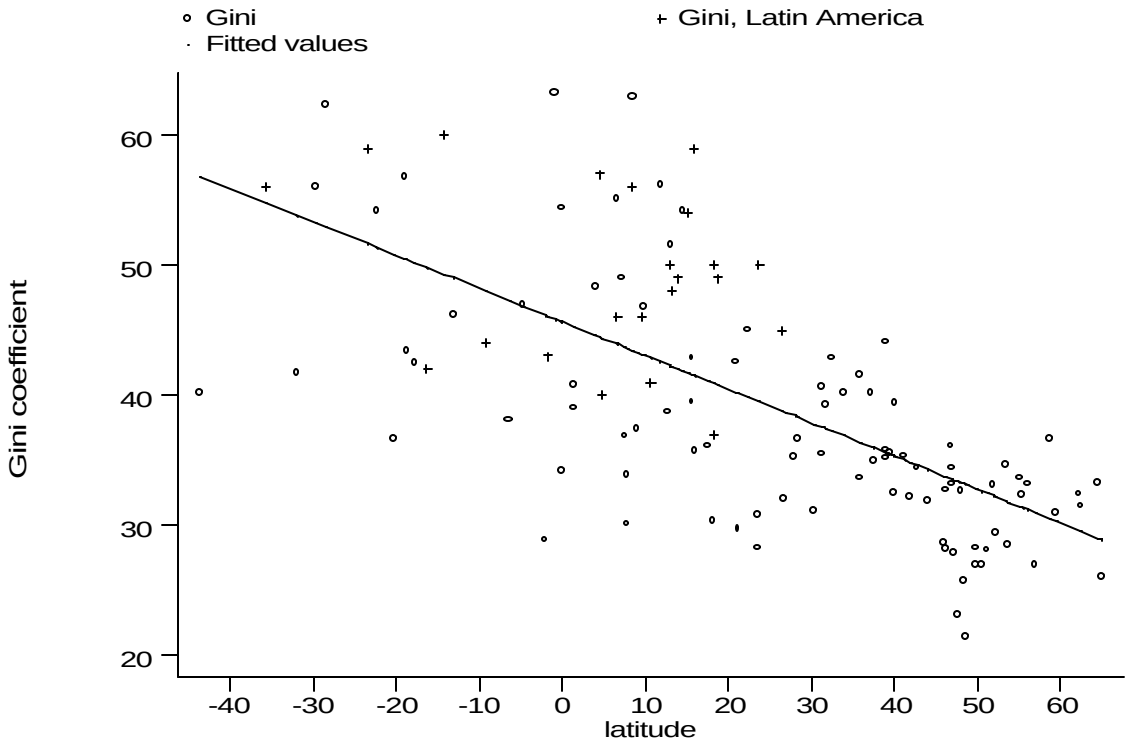
Country	*Gini Coefficient*
Non-Spanish Colonies	45.7
Jamaica	38
Guyana	40
Trinidad	42
Bahamas	45
Barbados	49
Brazil	60
Former Spanish Colonies	51.0
Bolivia	42
Ecuador	43
Peru	45
Costa Rica	46
Venezuela	47
Dominican Republic	49
El Salvador	50
Mexico	50
Nicaragua	50
Honduras	54
Chile	56
Panama	57
Colombia	57
Guatemala	59
Paraguay	59

Source: Most recent year's data in World Bank (1998).

In the Andean countries, language is a source and a mark of inequality. The non-Spanish speaking indigenous people are mostly very poor and marginalized. Their language difficulties working in the mainstream economy keeps them that way. The social exclusion due to language barriers can be roughly measured by the fraction of the population, which does not speak the most widely spoken language in the country.[6] Figure 5 shows that this measure of linguistic diversity is much higher for the tropics in the world as a whole, and in Latin America. The sparseness of the fundamental network of language in the tropics is consistent with the notion that the tropics is a difficult environment for the creation a range of essential networks: trade and division of labor as well as social intercourse needed for effective institutions. Disease creates barriers to the movement and mixing of people; tropical climatic and soil conditions makes the building of infrastructure networks difficult; and low incomes due to geographical obstacles makes it difficult for communities to look towards broader horizons.

[6] This is the variable "Gunn2" from Easterly and Levine (1997).

Figure 5: Linguistic Diversity versus Latitude



The Andean region has large population concentrations in geographically difficult environments such as the highlands. If nearby areas develop rapidly, some of the problems of these difficult environments may be spontaneously solved by migration to the dynamic neighboring regions. However, the persistence of poverty in these population concentrations over the centuries indicates that migration is unlikely to be the main solution. Population growth is often higher in poor, geographically disadvantaged regions, offsetting the benefits of outmigration.

INFRASTRUCTURE

More active approaches to reducing geographical disparities through infrastructure investments face all the difficulties of regional development programs. By the nature of isolated places, infrastructure is typically more expensive to extend there (i.e. it exhibits strong scale economies), so the benefits to those living in isolated areas must be large indeed to support these costs. Bringing industrial and service activities to a disadvantaged region is a chicken and egg problem. These activities depend on the presence of other industry and services as well as a range of complementary infrastructure. Firms do not want to establish in an isolated place unless the infrastructure is in place and the other firms are also going to establish themselves there. To get this all moving simultaneously is expensive and risky. Government efforts to provide these elements in a coordinated package have a poor track record (Richardson and Townroe, 1987). In contrast to government-sponsored export processing zones, which have often been successful and are usually sited in the most geographically favored locations, industrial estates in lagging regions have often ended up empty. They were built, but nobody came.

Despite the limited success of grand regional infrastructure projects, it is difficult to accept leaving isolated regions to their own devices. Lack of access to infrastructure is closely associated with poverty, since infrastructure provides the enabling environment for economic activity. A "basic needs" approach to infrastructure may provide an effective approach to reducing poverty in geographically-challenged regions, and may also have a higher economic rate of return than large, top-quality infrastructure projects. Rudimentary feeder roads, electricity, and telecommunications are needed to bring isolated regions into the rest of the economy. The new technologies for micro electricity generation and standalone telecommunications links may prove most cost-effective precisely in these isolated places. Basic connections to the rest of the economy are essential not only for stimulating the local economy but to give residents the links necessary to take advantage of opportunities in the outside world, by migrating.

Bolivia illustrates the close relationship of geography and infrastructure. Each of the three major geographical zones, the altiplano, the valley region, and the lowlands, has been focused on a major city within it. Until recently, there was little commerce between the regions due to the difficulty of transporting goods across the zones. With the construction of a high quality highway linking the three zones, there is now substantial trade across the zones, and a movement of population to the more prosperous lowlands.

A different approach to providing cost-effective infrastructure in isolated regions is decentralization, already well advanced in many Latin American countries. Decentralization can be a two-edged sword for overcoming geographical obstacles. Decentralization allows greater adaptation of government to local conditions, especially helpful in geographically varied countries, but it may reduce the cross subsidization of poor regions by wealthier regions (unless, of course, the poorer regions were previously subsidizing the richer regions). In a decentralized system, local services are only as good as the capacity and quality of local government, which may be low in isolated, poor regions.

AGRICULTURE AND HEALTH POLICY IN THE TROPICS

The failure of economic development in much of the tropics is due in part to the difficulty of fostering productive agriculture and good health there. Basic and applied research in tropical agricultural and health problems are high priorities. Most technological advances in the wealthiest countries, which carry out almost all scientific research and development, hold at least the potential of being adopted by the poor countries in the tropics. The big exceptions are in the areas of agriculture and disease because their biological processes are distinct in the tropics. Malaria, for instance, simply is not a serious problem for rich countries.

In the developed world, more and more of the 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 presently have no financial incentive to invest in similar research on tropical problems. Developing country consumers cannot afford to pay premium prices for new drugs and vaccines, so they do not provide a profitable market. At the same time the tropics is left out of the revolution in corporate scientific research, public funding for research on tropical agriculture and disease has been, if anything, declining. The research and development budget of the entire Consultative Group on International Agricultural Research system of institutes studying developing world agricultural problems is less than half of the R&D budget of one life-sciences multinational, Monsanto (Sachs 1999, p.19).

With a new era of rapid advances in biology, applied research on the obstacles to tropical agriculture and disease appears promising. Tropical agricultural research, most of it public, has had very high rates of return. Echeverría's (1990) compilation of the estimated rates of return on agricultural research in Latin America is striking for how uniformly high the estimates are. Of the 58 rate of return estimates, only 4 are below a 15 percent rate of return per year. The average rate of return is 57%, and the median is 44%. These huge paybacks on research investments indicate that not enough agricultural research is being undertaken. Even if agricultural research did not have such high economic returns, investing in agricultural improvements can 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% of the labor force in 1990) and an even higher proportion of the poorest households, still depends on agriculture (World Bank, 1997, p. 220).

The level of funding for research on tropical health problems is pitifully low. A good example is malaria, one of the most important tropical diseases. An estimated 2.4 billion people are at risk worldwide, with 300-500 million clinical cases of the disease each year, and 1.5 to 2.5 million deaths per year. Due to lack of market incentives, there is essentially no malaria research by private pharmaceutical firms. Total worldwide research funding was only $84 million in 1993 (Welcome Trust, 1999), much of it from the militaries of wealthy countries, who are concerned about the readiness of their soldiers overseas.

CONCLUSIONS

The Andean countries, with the exception of Venezuela, have made great strides in terms of pursuing policies conducive to economic growth, open international trade and government institutions more efficient and responsive to citizens, which this simple analysis suggests is crucial. Geography appears also to play an important role in Latin America's performance compared to the most industrialized countries. Improving health, including malaria, and overcoming other tropical and accessibility problems could help Latin America to catch up economically with the more developed countries in the world.

Geography may be largely immutable, but its impact on the economy and society are not. The right policies or technological developments can overcome many geographical obstacles. Tackling geographical problems has important "public good" aspects. Investments to overcome these obstacles, such as disease control or roads, typically benefit whole regions rather than particular individuals. To make these investments at the socially desirable level, they need coordination by the government or other organizations.

In the future, the new telecommunications technologies and the Internet may reduce the significance of geographical barriers, but they are not panaceas. The widespread use of these technologies, especially to make money providing services to the outside world, will require a highly educated population beyond the reach of all but a small elite in poor countries in the near future. Although this sort of technical change could reduce isolation, it may benefit the already accessible locations at least as much. Despite the dramatically lower user cost of telecommunications in recent years, the infrastructure investment required is often large. One could have expected similar revolutionary change in access from the telephone, but it has not made geographical barriers obsolete.

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