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Climate, Latitude and Wealth

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CLIMATE, LATITUDE AND WEALTH

by

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ABSTRACT

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So many of the world's most impoverished nations are found in warm climate regions that some economists have referred to "tropical" as synonymous with "underdeveloped". In this paper I study the difference in GDP per capita throughout the world based on latitude, and show that there is a significant, positive correlation between distance from the equator and GDP per capita. I find that consumption is different in wealthier countries and that these differences are correlated with latitude. I use these differences in consumption as a new approach to evaluating the problem of what causes temperate climate nations to be rich and warm climate nations to be poor. I hypothesize that cold weather creates demand for greater fuel consumption, better built homes, warmer clothing, and automobiles for transportation, and that production of these goods increases total output. (31 pages)

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Introduction

A major concern for macroeconomists is the disparity of wealth around the world. Many studies have been conducted to determine what differences exist among countries which cause some to be poor and others wealthy. While there are many factors that may be important in determining the relative wealth of individual nations, this study focuses on relative distance from the equator as the primary explanatory variable. I do not assume, of course, that latitude in itself is a cause of prosperity, but that it is related to some other set of conditions that influences wealth.

I hypothesize that the reason countries farther from the equator enjoy higher GDP per capita is that in order to survive, people in cold regions are forced to greater consumption of certain types of goods than people in warmer areas. The use of furnaces for heating leads to higher fuel consumption. A tendency to spend the majority of time indoors, at least during the winter months, leads people to build bigger, more fully furnished and better insulated homes. The discomfort of walking or riding bicycles in cold weather leads the majority of households to own cars. Warm winter clothing is accumulated. More food is consumed, as more calories are expended in keeping a body warm.

Homes, cars and food are not merely additional expenses. They represent the largest portion of expenditures for most households in cold climates. In order for an economy to meet the demand for this type of consumption, it is necessary to build capital. Capital accumulation causes a permanent increase in output. More importantly, in the long run, technological innovation is needed to meet the demands for such capital. As a secondary effect, people strive to perpetuate this elevated level of consumption as a higher quality of life becomes the status quo.

In order to test this hypothesis, I have gathered data on consumption and separated these into two categories. The first, I classify as 'mandatory' (necessary for survival) consumption which includes the variables I mentioned above: food, clothing, housing, etc. The second category is 'elective', or nonessential consumption, which includes things like financial services and education. While the goods and services in this classification are not essential for survival, they may influence output.

I have taken the ratio of each of these two new variables to total consumption and found that when elective consumption is greater in respect to total consumption, output per capita is greater. This phenomenon occurs in positive correlation with distance from the equator. I have included a discussion of possible implications of this finding, including my theory that mandatory consumption is greater in colder climates—I have found that it is—and that this expands an economy, making way for greater elective consumption.

Literature Review

Not all impoverished countries are in the tropics, but with the exception of Hong Kong and Singapore, no tropical countries are ranked as high income by the World Bank. This is not new information and poverty in the tropics is not a new topic of discussion.

Since the time of the industrial revolution there has been an apparent disparity in the economic development of cold and warm regions. As a result, a wealth of literature has emerged. The literature can be separated into two categories: (1) theories that link the geographical differences in GDP per capita to climate either indirectly or not at all and (2) theories that link the differences to climate directly.

The circumstances by which the industrial revolution occurred and the location of its commencement come under close examination. The literature that links GDP directly to climate argues that England, being located in a temperate zone, began to industrialize because climactic conditions allowed it. The non-climate literature cites demographic conditions—such as the protestant work ethic (Weber 1958), or familiarization with *The Wealth of Nations* (Hall and Jones 1999)—as the driving force of industrialization. Perhaps the question is complex enough to allow for all of these factors to have played a role.

(1) Non-climate Literature

The non-climate literature faces some difficulty in explaining how industrialization spread so exclusively to temperate regions. There are, however, some plausible and even compelling hypotheses, most of which assume that the European influence—spread through colonization—was in some way geographically selective. Much of the world was populated by the time of the colonization period, but many of the regions that were most densely populated at that time were tropical.

Europeans couldn't have as profound an influence in pre-populated regions as they could in areas where they made up the majority. Robert E. Hall and Charles I. Jones (1999) speculate that colonists were drawn to areas that were sparsely populated and had similar climate to that of their homelands. They focus on productivity of labor as the main explanatory variable for differences in output and claim that this is due to underlying differences in "social infrastructure", made up of institutions and government policies. They estimate the colonial European influence by the percentage of people who still speak English or other European languages in any given country.

A more complicated theory, presented by Daron Acemoglu, Simon Johnson and James A. Robinson (2001), argues that the rate of early settler mortality dictated whether they would remain in an area or not. In the presence of malaria and other diseases prevalent in tropical zones, Europeans opted not to settle but rather to set up extractive institutions which continue to hamper economic growth today. They show that there is a strong correlation between the mortality rates of certain early European settlers and wealth per capita in those regions today.

Jeffrey Sachs (2001) disagrees that European colonization has had such a large impact on economic progress in tropical areas. Africa was not colonized until the 1870s, before which, it already lagged behind the rest of the world economically. Central and South American countries, on the other hand, gained independence as early as the 1820s and have still not caught up to their temperate climate neighbors, which also emerged from European colonies. Sachs also cites the success of temperate East Asian countries as evidence against economic prowess being tied to European culture.

William Easterly and Ross Levine (2003) combine multiple approaches, insisting that climate and its inherent problems in the tropics affect economic development only through the institutions that arise in response to them. Similarly, Stanley L. Engerman and Kenneth L. Sokoloff (1997) argue that initial factor endowments and their effect on institutions have been the cause for the U.S. and Canada's rapid economic development relative to Latin America. In the colonial era, places like the Caribbean and Brazil were suitable for large sugar plantations which employed slave labor, promoting a disproportionate distribution of income and political power. Meanwhile, the northern colonies in North America were littered with small family farms that produced a relatively equal distribution of income, fostering a more democratic approach to government.

More generally, it is argued by Jeffery D. Sachs and Andrew M. Warner (1995) that countries with a great abundance of natural resources are prone to slower economic growth than countries with fewer natural advantages. This is hypothetically explained by a retardation of manufacturing or other sectors in favor of extractive activities—the so-called "Dutch Disease"—as well as rent seeking, government corruption and volatile commodity prices.

Sachs and Warner (1997) show that lack of trade openness and other poor economic policies are important in explaining slow economic growth in Africa. In some cases the problem is exacerbated by lack of access to sea ports. They estimate that with proper policies African economies could grow at an annual rate of 4% per capita.

(2) Climate Literature

Tatyana Deryugina and Solomon M. Hsiang (2014) show that climate and temperature are indeed directly related to economic activity. They use panel data for each day over a span of 40 years from each county in the United States to determine how temperature is related to individual income. They find that a weekday above 30°C (86°F) corresponds to $20 less income per person. They find that the 'optimal temperature' for per capita income lies between 9-15°C (48.2-59°F). They find that hot weekends have little effect on productivity.

The climate-based literature discusses a number of reasons that temperature, precipitation and humidity might tie GDP to latitude. Cold winters or hot summers may effect economic output and growth in several ways. William Masters and Margaret McMillan (2001) use winter frost as their primary variable in explaining the relative economic success of temperate and tropical economies. Frost kills many of the insects and other pests that compete with humans for food crops. Frost also kills the bacteria that would otherwise mineralize nutrients in the soil, making it unfertile. In regions with winter frost, layers of rich, fertile topsoil build up.

Climate's effect on soil is a recurring theme in the literature. Sachs (2001) argues that productivity of major staple crops is considerably higher in temperate regions. Grain is mainly exported from the U.S., Canada, Australia and Argentina. Problems in productivity come from soil erosion, pests and parasites, plant respiration and photosynthesis, and water control.

Douglas H. K. Lee (1957) presents data on low productivity of cultivated land in the tropics. He argues that this is directly caused by the climate's effect on the soil. Heavy rainfall carries away nutrients or pushes them deep into the soil where they can only be accessed by deep-rooted plants. The climate is also prohibitive of the production of many of the most useful plant species for food. In other cases, at the time of his writing, crops had not been tested in those regions for their ruggedness to withstand the climate and disease that is prevalent there. At that point, little had been done to breed plants that were genetically able to withstand these conditions. Lee also brings into question the farmers' methods of crop production in dealing with the climate.

Andrew Kamarck (1976) argues that the harsh sunlight and intense heat in the tropics burns away the organic material that would otherwise make the soil fertile. Continued cultivation has leached away the phosphorous and other plant food leaving behind red or yellow soils called laterites, which are composed mostly of clay that is high in iron and little else. Kamarck claims that most tropical soils are in this condition and that even in tropical rain-forests there is a shortage of nutrients, which are replenished mostly by the perpetual decay of existing plants. A one to three month hot season before the planting season yields the soil hard, dry and difficult to prepare.

Conversely, in temperate regions, precipitation is greater than evaporation, leaving the soil moist and easier to work.

R. Lal and P. A. Sanchez (1992) refute these arguments of universally poor soil conditions in the tropics, stating that many of them are based on antiquated soil maps. Despite the fact that these maps give oversimplified categorizations of tropical soils, many of the conclusions drawn from them are widely accepted. The types of soils that meet Kamarck's description—such as oxisols and ultisols—make up perhaps less than 2% of tropical soils. In fact, tropical soils are very diverse, and in many cases, fertile and productive. Soils in the tropics are formed by the same processes, and largely from the same minerals, as temperate soils.

Sachs (2001) and Lee (1957), among other authors, discuss pests, plant disease and plant respiration as factors affecting agriculture. In areas without winter frost, there is far less control of pests and crop parasites. In areas with high temperatures, plants lose a great deal water through respiration and incidentally have low yields. A secondary effect of these conditions is reduced output of livestock—which rely on plants as food—as well as reduced supply of animal products such as milk and cheese.

Disease and infection are discussed throughout the literature as explanations for low labor productivity in the tropics. Sachs (2001) points to lost work days and reduced cognitive ability due to chronic illness. Several authors discuss Malaria, Yellow Fever and Dengue, along with other diseases endemic in the tropics. Kamarck (1976) presents surprising (though now dated) data on the rates of parasitic infections such as hookworm and roundworm in Africa. While some headway has been made in curing and prevention—such as the yellow fever vaccine in 1937—disease is still very prevalent in the warmest parts of the world. Output is affected in the present, and development has been retarded in the centuries leading up to it.

Lee (Lee 1957) observes that the heat itself has a direct effect on humans. Careful to cite the stochastic method employed in deriving his conclusions, he points out some physiological and psychological effects, including “increased disinclination for work which tends to reduce normal output” (Lee 1957, 99), and “some loss of mental initiative” (Lee 1957, 100). While some later authors hesitate to accept the point of view that “heat makes people lazy”, there must be some validity to the notion that high temperatures negatively affect people’s ability to work, thereby reducing labor productivity.

The literature is rich with examples of economic disadvantages for tropical countries, but there is far less theory on advantages for temperate countries—except for their lack of tropical problems. Hernando Zuleta’s 2012 paper on seasonal fluctuations is an exception. The most important mechanism described by Zuleta to account for greater prosperity in temperate countries is that savings are greater and, as a result, capital is greater. Because savings are used to smooth consumption in the presence of output fluctuations, savings must be greater in areas where these fluctuations are more severe. In turn, because of an abundance of supply-factors to innovation—in the form of savings—these economies are more likely to adopt capital-intensive technologies.

Theory of Geographical Advantage

In the following sections I will test the argument that the geographical economic advantages of a country located far from the equator are born out of situations that are not advantageous at all. Some level of consumption is necessary for survival no matter where one lives, but it varies depending on the environment. The types of goods necessary for survival are, for the most part, the same, but the amounts of these goods needed may differ a great deal. The central theory of this paper is that these differences are largely based on climate and therefore closely related to distance from the equator, and that they affect GDP per capita.

For example, I make the assumption that clothing is necessary for survival. However, for an individual living in the rainforest in Central America, little or no clothing may be necessary in order to keep an individual warm. A thin layer may be needed to protect the body from the sun and from mosquitos and other pests, but probably not much more. In Alaska, on the other hand, heavy winter coats, boots and gloves are worn over layers of underclothing in order to battle the harsh elements. I assume that the greater per capita expenditure for clothing is incurred in Alaska.

Housing, transportation, fuel and food consumption, like clothing, are all affected by climate. While these things all exist in the tropics, there is greater consumption per capita in each category in temperate climates. With all of this extra consumption, it is no wonder that GDP would be higher in countries farther from the equator.

The ironic twist is that the high 'mandatory' consumption in colder climes is not directly responsible for higher GDP per capita in those countries. My theory is that meeting the high demand for mandatory consumption goods causes an accumulation of capital, and a high level of technological innovation, facilitating high productivity in all areas of the economy. Then, it is the consumption of non-essential, 'elective' goods that drives GDP. In the section labeled **Results** I will show that where the ratio of elective goods to total consumption is higher, GDP per capita is higher. I will also discuss why—after my statistical analysis—I prefer the theory I have just described over other theories on the subject.

Data Used in this Study

In order to test some of the existing theories on causes of poverty in the tropics, I have borrowed a couple of key variables from the literature. The first is the social infrastructure variable—*SocInf*—from Hall and Jones (1999). This variable includes a measure for risk of expropriation by government and a measure for trade openness. The same measure for risk of expropriation was later used by Acemoglu et al. (2001). The concept that differences in social infrastructure cause differences in GDP is central to the non-climate literature. These differences are linked to latitude for reasons not directly related to climate.

The second variable I have included is a ground frost variable—*plfst5*—from Masters and McMillan (2001). This variable represents the percentage of land mass in each country that is subject to winter frost for at least five days each year. Because the majority of the climate-based literature is founded on agricultural and health-related advantages to freezing temperatures, this variable is a good representation of the climate side of the argument.

I have also created some of my own variables to add to the regressions, most significant of which is a measure of natural resource endowments. Surprisingly, natural resources are largely left out of the latitude-based output literature. The variable I have included—*EnProdCap*—is total energy production in each country divided by the country's population. The variable is both significant in explaining GDP and positively correlated with distance from the equator.

Two of the variables I have included are based on differences in types of consumption. To model the difference between cold and warm climate regions in terms of consumption, I have made a distinction between 'mandatory' consumption, and 'elective' consumption. All consumption C required to maintain a certain quality of living—e.i. food, clothing, housing, transportation and fuel—I have classified as M. All other consumption I have classified as E so that:

$$C = M + E$$

To approximate the values of *M* and *E*, I used data from the World Bank that breaks each country's average household consumption into twelve categories. I gave the label *M* to the sum of dollars spent in the following categories: food & beverages, clothing & shoes, housing, transportation, water and health. The remaining categories I labeled as *E*: education, personal care, Information & communications technologies, financial services and other.

Table 1 shows the Pearson's correlation coefficients of the variables. Note that *ShareE* is more correlated with both *latitude* and *GDP.Capita* than *SocInf* is, and more correlated with *GDP.Capita* than *plfst5.* It is difficult to say why there is a positive correlation between *latitude* and *EnProdCap.* This might be of interest for further research. The fact that *EnProdCap* this is negatively correlated with *SocInf* might reflect the "Dutch Disease" discussed by Sachs and Warner (1995). The negative correlation between *SocInf* and both *M* and *E* can probably be attributed to higher prices of consumption goods in closed economies.

Table 1: Pearson's Correlation Coefficients

	GDP.Capita	*latitude*	*M*	*E*	*SocInf*	*plfst5*	*shareE*
latitude	0.4906						
M	0.3749	0.3044					
E	0.3504	0.2909	0.9902				
SocInf	0.2642	0.1109	-0.0063	-0.0131			
plfst5	0.4948	0.8134	0.3159	0.3113	0.1550		
share	0.5449	0.3513	0.3339	0.3566	0.3416	0.3922	
EnProdCap	0.6638	0.2987	0.2433	0.2262	-0.0845	0.3141	0.1867

Table 2 hints that there may not be an ideal amount of variation in the data used for this study. There were a total of 62 countries that had available data for all of the variables included, and they seem to be skewed somewhat to the poorer and more tropical parts of the world. Although this may introduce some bias to the regressions below, the coefficients on *shareE* and *M/E*—my primary variables of interest—are significant enough (see Table 4) that I have found no reason to believe that a more randomized sample of countries would behave much differently than this one.

Table 2: Summary Statistics

	Mean	*Median*	*Min*	*Max*	*Sd*
GDP.Capita	3419.27	2252.98	250.96	14041.81	3333.61
Latitude	17.17	15	1	60	11.86
SocInf	0.35	0.31	0.11	0.86	0.15
plfst5	0.2	0	0	1	0.35
share	0.18	0.17	0.06	0.32	0.06
EnProdCap	0.03	0.006	0	0.37	0.07

Results

Table 3 represents a few simple regressions to relate back to the literature. *Latitude* by itself is significant in explaining GDP per capita, as is *plfst5*. Because there is a strong correlation between *latitude* and *plfst5*, when both variables are included in regression 2 below (as well as in regressions 1 and 2 of Table 4), estimates are biased and neither appears to be statistically significant. In regressions 3-5 the two variables are treated as substitutes for one another. The fact that *plfst5* is more significant than *latitude* in explaining output lends plausibility to the climate literature.

Table 3: Simple Regressions of Variables Borrowed from the Literature

	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5
Latitude	137.94	73.24		131.31	
	(4.361)***	(1.360)		(4.217)***	
plfst5		2709	4737.7		4452.4
		(1.477)	(4.410)***		(4.161)***
SocInf				4724.99	4273.8
				(0.060) .	(1.719) .
Intercept	1050.8	1621.91	2475.2	-511.15	1016.3
	(0.116)	(2.140)*	(5.779)***	(0.492)	(1.073)

T stats in parentheses. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

While *SocInf* is not statistically very significant in regressions 4 and 5 it is economically significant. It is still less so than *plfst5*, but Table 4 will show that once we control for natural resource endowments, this is no longer the case. This likely stems from rent seeking behavior and government corruption in the presence of natural resources (see Sachs and Warner, 1995). In any case, in countries where these problems do not exist we can assume that climate plays a slightly larger role than social infrastructure.

Table 4: Regressions Including my Added Variables

Variable	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 6
Latitude	75.71	55.35		78.28		
	(1.431)	(1.392)		(3.220)**		

plfst5	2348.98 (1.296)	1002.73 (0.731)	2511 (2.956)**		1587.2 (1.948) .	1549.0 (1.904) .
SocInf	4366.93 (1.772) .	6149.94 (3.297)**	6109.7 (3.249)**	6327.19 (3.435)**	4002.2 (2.212)*	3992.1 (2.218)*
EnProdCap		28795.14 (6.806)***	29238.4 (6.875)***	29240.6 (7.012)***	27497 (7.047)***	27570.9 (7.099)***
Share					17532.1 (3.602)***	
E/M						11387.8 (3.678)***
(Intercept)	102.43 (0.090)	-884.67 (1.025)	-235.5 (0.322)	1156.42 (1.490)	-2453.8 (2.704)**	-1862.9 (2.334)*

T stats in parentheses. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

My climate-based geographical advantage hypothesis is difficult to test, but in thinking about it, I have found some interesting results. I found that both *M* and *E* increase with distance from the equator and that, as I anticipated, *M* type consumption is more closely correlated with absolute latitude than *E.* However, as distance from the equator increases, it is type *E* consumption that grows more quickly. In Table 4 I include the variable *shareE* which represents the average total expenditure on *E* type consumption per household divided by total consumption—that is, the ratio of *E* to *C*. The regressions in Table 4 are variations of the function:

$$Y/population = \alpha + \beta_1 Geography + \beta_2 Social\ conditions + \beta_3 Resource\ endowments + \beta_4 Consumption + u$$

There is more than one reason that *shareE* might be significant in explaining GDP. First of all, it is important to note that *E* and *M* do not represent the number of goods consumed, but instead the total expenditure in each of these categories. Whether the prices of *M* or *E* type goods change with latitude is unknown. Whether or not prices for these goods are determined in the global market is controlled for by including *SocInf,* which includes a measure for trade openness. For simplicity's sake, in each of the following scenarios I will assume that prices of *M* and *E* are about the same everywhere.

Scenario 1

Let us assume that there is some level *S* of consumption of *M* type goods, below which, one cannot survive. Let us also assume, as suggested by Lee (1957) and Kamarck (1976), that production possibilities are different for countries closer to the equator. Specifically, countries closer to the equator cannot produce as much of type *M* goods as countries that are farther away. Because all of the countries are constrained by *S,* those closer to the equator may be stuck in a situation where the majority of their resources go to producing *M* type goods, but because of weak production possibilities in *M*, total output is lower. Expressed graphically:

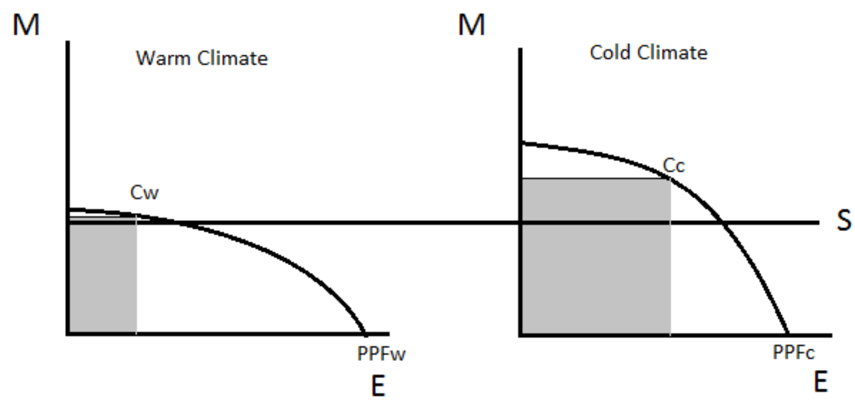

Figure 1: Scenario in which *S* is Constant and PPF Varies by Latitude

In this situation we see that the ratio of *E* to total consumption increases as output increases—as shown in regression 5 of Table 3—but *M* is not necessarily higher in the cold climate than in the warm climate.

Scenario 2

Another situation in which *E* would increase in proportion to *C* at different latitudes is one in which production possibilities are about the same everywhere, but *S* varies by latitude. If the subsistence level of *M* type consumption is higher in warm climates than in cold ones then more resources in those countries would be allocated to production of *M* type goods, producing a similar result to that of the last example. Graphically:

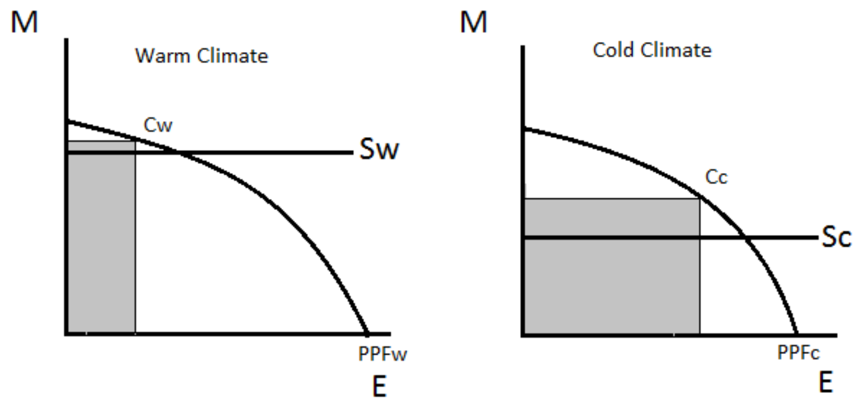

Figure 2: Scenario in which *S* Varies by Latitude and PPF is Constant

This scenario, however, does not allow for to *M* increase as output increases, so it seems unlikely.

Scenario 3

If the scenario were reversed, as in my hypothesis, and more of *M* type goods were required for subsistence in colder climates, the only way that *E* could increase with output is if the greater production of *M* type goods caused an increase in production possibilities. This could be accomplished, as I stated before, if production of *M* type goods required accumulation of capital, and increased technological innovation. Note that an increase in production possibilities would not necessarily create more *E* type consumption than in a warmer climate, but this is the case shown in Figure 3 below.

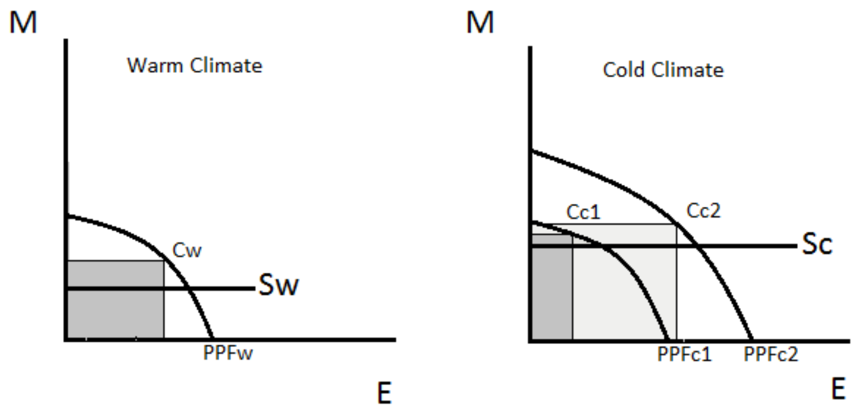

Figure 3: Scenario in which *S* Varies by Latitude and PPF Changes as a Result

I have presented this hypothesis as an alternative to the conventional one in the climate-based literature, but further research will be required to test whether this phenomenon occurs.

Scenario 4

One final reason that *E* could increase as output increases at higher absolute latitudes is that production possibilities are greater in both *M* and *E* in temperate zones for some reason other than climate—such as more favorable social infrastructure. In this case both *M* and *E* could increase and assuming that there is a subsistence level of *M* type consumption, *E* might tend to increase more than *M*. See Figure 4 below.

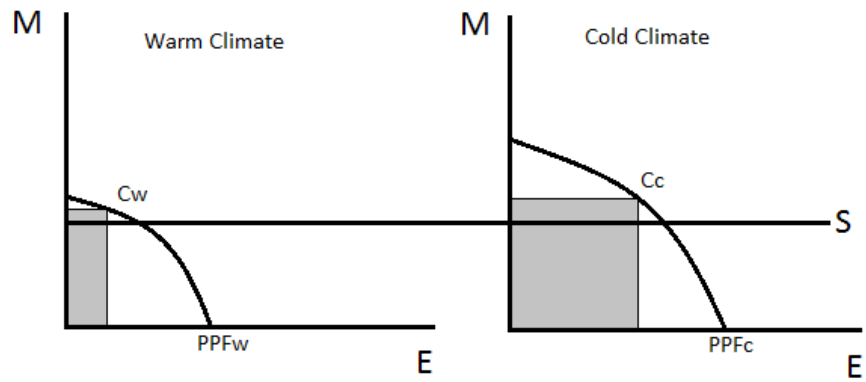

Figure 4: Scenario in which PPF Varies by Latitude for Reasons Other than Climate

Referring back to Table 1 we can see that while *shareE* is significant in explaining GDP per capita, *M* is more closely correlated with both *latitude* and *GDP.Capita* than *E* is. Scenario 3 above is the only one that might explain why this is the case. This, of course, is not definitive evidence that my hypothesis is correct, but it is still my preferred explanation of why GDP per capita increases as one moves farther from the equator.

There is another possible explanation for *E* vs *M* type consumption being present in more productive countries. If the noted high ratio of expenditure in *M* type consumption in poorer countries is due to high prices of *M* type goods, instead of high rates of consumption of these goods, then this might indicate that the cost of living is repressing economic activity in these countries. We can see that M type consumption is not negatively correlated with output.

The variable *E/M* in regression 6 of Table 4 is related to *shareE*, and represents the ratio of *E* to *M* type consumption rather than *E* to total consumption. The fact that

ShareE is more significant than *E/M* reflects the fact that growth in *M,* as well as *E,* increases output. Because *shareE* is the more significant of the two, this is the variable I have chosen to focus on.

Since we assume that prices are determined in a world market for countries with open economies, we can test whether prices of *M* type goods are repressive in those that are closed. To test this, I included an openness variable—*YrsOpen*, from Hall and Jones (1999)—in regression 2 of Table 5**,** along with *shareM*—the ratio of *M* to *C*. Because *YrsOpen* measures the 'degree' of openness, I have also included a manipulation of it—*open*—in regression 3, which is a simple dummy variable for openness. Once again, in this model the dependent variable is *GDP.Capita*. I control for latitude, and in regressions 4 and 5 I control for energy production.

Table 5: Observing the Effect of Openness on *shareM*

Variables	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5
Latitude	95.96	96.5	97.42	56.01	56.73
	(3.166)**	(3.154)**	(3.182)**	(2.345)*	(2.534)*
YrsOpen		406.2			
		(0.307)			
open			404.51		1665.64
			(0.542)		(3.001)**
shareM	-23864.67	-23409.5	-22511.76	-21064.78	-15121.08
	(3.943)***	(3.729)***	(3.421)**	(4.548)***	(3.168)**
EnProdCap				25834.19	29275.2
				(6.601)***	(7.616)***
Intercept	21268.8	20807.2	19890.37	18794.59	12789.17
	(4.121)***	(3.843)***	(3.440)**	(4.756)***	(3.038)**

T stats in parentheses. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The coefficient on *ShareM* changes enough in the presence of the openness variables—especially controlling for energy production—that I conclude that there is some degree of economic repression from high prices of *M* type goods in countries with closed economies. This, however, does not account for very much of the effect of *E* vs *M* type consumption on output per capita.

Conclusions

There is an obvious correlation between wealth and absolute latitude, and a large body of research linking this phenomenon to climate. A few prominent theories link the differences to other factors such as social infrastructure. I have taken a new approach to evaluating the problem by categorizing consumption in a way that may help to separate trends by latitude. I have shown that the higher the output per capita, the greater the share of nonessential consumption. This may seem obvious, but the mechanism by which it occurs may be less so.

I theorize that the farther a country is from the equator, or in other words, the colder the climate, the more need there is for consumption of fuel, warm winter clothing, well built homes, and automobiles rather than bicycles for transportation. As economies stretch to meet these needs, capital is accumulated and innovation is accelerated. These conditions, in turn, enable an economy to produce a great number of goods and services that are not as essential to survival, but that improve economic performance—such as information and communications technologies.

I have concluded that in closed economies, high prices of goods essential to survival are repressive to economic activity. This is not really new information and not the only economically damaging aspect of a country being closed to trade—indeed there is a great deal of literature on the subject—but this in itself must account for a portion of the world's poverty.

Like any economic problem, the answers are complex. Social infrastructure, agricultural conditions and natural resource endowments all play a role in determining output per capita. The difficulty is determining how all of these variables are related. I suspect that economic conditions determine social infrastructure as often as the other way around—for better or worse. This appears not to be the case in modern day Hong Kong and Singapore. Both countries are extremely open to trade and while they have different economic structures both have striven to foster social infrastructure that is conducive to growth (Young 1992)

While economists have developed some understanding of why tropical economies haven't grown with the rest of the world, we are still far from repairing them. More research is needed in this area. Perhaps, as suggested by Easterly and Levine, climate tends to influence social infrastructure—perhaps by means related to my theory of geographical advantage. Whereas Hong Kong and Singapore were once impoverished nations they have found a way to advance economically. If other tropical countries follow their lead in creating favorable social infrastructure in spite of geography and corresponding environmental conditions, perhaps they will achieve similar success.

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