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Climate and Economic Development: Further Evidence in Support of "The Tropical Effect"

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Abstract

Economists have historically ignored the relationship between geographical factors and economic growth and development. However researchers in other fields, historians and biologists, have provided detailed and plausible explanations of the connection between geography/climate and economic progress. Recently, economists have also begun to examine the existence of this relationship by studying the effects of climate on agricultural and labour productivity, for example. Using both cross-sectional and panel data sets, studies have been conducted on the specific aspects of climate and weather that may influence economic outcomes. This paper adds to that literature by focusing in particular on the effects of climate as it pertains to temperature and rainfall, using ground station data from the Global Historical Climatology Network over a period of 30 years. The study finds empirical evidence suggesting that higher temperatures are negatively associated with the level of GDP per capita of a country. In addition, countries that have larger ranges of temperature extremes also have higher incomes. The relationship between temperature and GDP per capita growth rates turns out to be more complex but again the evidence indicates that temperature matters. Lastly, the paper discusses evidence that points to the importance of rainfall and stresses the need for further verification to pinpoint the relationship.

Keywords: Economic Growth, Economic Development, Climate, Geography, Empirical, Cross-Country

1. Introduction

The relationship between geographical factors and economic development has historically been ignored by economists. However, views about the correlation between temperature and climate have been expressed in works dating as far back as Montesquieu (1748) and Huntington (1915).

This paper examines specific features of climate, namely temperature and rainfall, as possible factors that might influence productivity and hence income per capita across countries. Building on previous studies by economists and ecologists who have studied the impact of climate on agricultural productivity and disease burden, this investigation seeks to pinpoint the characteristics of climate that are important in establishing that link.

Earlier works on this topic include Kamarck (1973) and later, economic historian Landes (1998). Researchers in other fields, Crosby (1986) and Diamond (1997), a historian and a biologist respectively, have provided detailed and plausible explanations of the connection between geographical, climatic and economic factors.

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Their studies have a historical focus extending over several centuries (Crosby (1986)) and several millennia (Diamond (1997)). Since then economists, beginning with Gallup et al. (1999) haveconducted comprehensive cross-country studies to investigate this relationship. They have demonstrated that being a tropical country is negatively related to output per capita both in levels and growth rates. However as Sachs (2001) eloquently stated:

"The most notable feature of global economic development – the continuing impoverishment of the tropics – remains to be explained".

Gallup and Sachs (2000a) controlling for differences in technology find that total factor productivity is less in tropical vs temperate climate zones. Most explanations of the geographical limitations of agriculture in the tropics focus on problematic soils in humid tropics, and rainfall variability and limited irrigation potential in the arid tropics. Some features of climate that can affect agricultural productivity have been studied along with effects on disease burdens (Gallup et al. (2000b)). The lack of freezing temperatures in the tropics causes a much greater number of agricultural pests.Masters and McMillan (2001) present convincing findings, which point to the presence or absence of frost as a significant factor influencing economic development.Human tropical diseases such as malaria reduce agricultural labor productivity.

Additional factors explaining lower agricultural potential in the tropics are pest and disease loads, and net photosynthetic potential differences.Although the tropics are generally warmer and sunnier throughout the year than temperate zones, the climate has disadvantages for photosynthesis.

The humid tropics are often cloudy, blocking sunlight, and the high nighttime temperatures cause high respiration that slows plant growth. While discussing the thermal physiology of organisms, Lafferty (2009) explains how warm temperatures speed up biochemical reactions which require higher food consumption rates. These in turn can decrease survivorship rates. Thus the relationship between an organism's productivity and temperature should follow a convex function.

Panel estimates by Schlenker and Lobell (2010) find that higher temperatures reduce agricultural yields.Using panel data on rice firms in Asia, Welch et al. (2010) find that higher minimum temperature reduces yields but higher maximum temperature increases yields. While studying land invasions in Brazil, Hidalgo et al. (2010) estimate that rainfall deviations lower agricultural incomes.Haile (2005) finds that the rainfall pattern in Sub-Saharan Africa is influenced by large-scale intra-seasonal and inter-annual climate variability.

Dell at al. (2014) provide anextensive summary of the literature on studies using panel data to estimate the effect of temperature and precipitation on industrial output. They note that the studies consistently estimate a 2 percent loss of output per 1°C. These studies are consistent with micro-level studies of labour productivity as well (Niemila et al. (2002)).

Another climate related factor potentially affecting productivity is humidity. As temperature and humidity increase, malaria transmission can increase from zero to epidemic rates (Lafferty (2009)).The diversity of infectious diseases of humans is higher in countries near the equator than in countries at higher latitude (Guernier et al. 2004). The diversity of all disease categories increases with the maximum range of precipitation, and most disease categories increase with monthly temperature range. Wolfe et al. (2007) found that infectious diseases of humans were equally likely to have originated in tropical or temperate regions. The early humans that migrated out of Africa and into temperate latitudes initially left several infectious diseases behind: only one of the 10 major tropical diseases, cholera, followed into temperate latitudes. However 11,000 years ago, several infectious diseases of newly domesticated temperate animals jumped to humans and most of these novel infectious diseases subsequently spread into the tropics (Wolfe et al. 2007).

The high diversity of infectious diseases in the tropics could result from a high diversity of vectors, perhaps due to differences in vector diversity. The inability of human tropical diseases to spread from the tropics to temperate regions may be due to the higher fraction of tropical diseases that have a specific vector (80% tropical vs. 13% temperate) and/or a wild animal reservoir (80% tropical vs. 20% temperate; Wolfe et al. 2007).

A seminal paper by Acemoglu, Johnson and Robinson (2001) takes a different route and suggests that the quality of institutions plays a more prominent role in comparative development outcomes. They further pinpoint the type of colonization that a country was subjected to as being responsible for institutional quality. In the end though, even this finding traces back to climate because Acemoglu et al. (2001) conclude that the type of colonization was determined by the mortality rates of the colonizers in the conquered countries, which in turn were determined by the disease ecology of those lands. An important caveat to keep in mind with studies that control for the effects of institutions is one suggested by Dell et al. (2014). The authors point out that if hot climates caused low-quality institutions which in turn lead to low income, then controlling for institutions can have the effect of partially eliminating the explanatory power of climate, even if climate is the underlying cause. Thus claims by researchers as to the supremacy of institutions as the primary determinant of income may be subject to this critique (Rodrik et al. 2004).

Studies measuring aggregate economic activity and climate have also found a link between the two. Nordhaus (2006) introduces data on global economic activity, the G-Econ database, which measures economic activity for all large countries, measured at a 1° latitude by 1° longitude scale. Amongst other results, he finds that the relationship between temperature and output is negative when measured on a per capita basis. Dell et al. (2009), using data for 12 countries in the Americas find a statistically significant negative relationship between income and average temperatures but little or no impact of average precipitation levels. Newer studies using panel data (Dell et al. 2012, Hsiang (2010)) report a negative link between temperature and per capita income but again no effects of precipitation. Barrios et al. (2010) demonstrate that higher rainfall is associated with faster growth in sub-Saharan Africa but not elsewhere.

Thus the summary evidence on climate and average income, demonstrates a definite link for temperature but a weaker one for precipitation.

Following that thread, this paper focuses its attention on climate specific variables to try to weed out the effect that 'the tropical effect' could have on levels and growth rates of GDP per capita. Instead of a broad category that represents the percentage of land that lies in the tropics as inGallup et al. (1999), the contribution of this paper is to use data on temperature and rainfall to examine whether or not those particular variables contribute to the 'tropical effect' or whether it is other features of the geographical tropics that are more significant.

The next section describes the data used in the study. This is followed by an analysis and interpretation of the results. The last section concludes with some comments on the direction of future research on this topic.

2. Data

To facilitate a direct comparison between the results in this study and those of Gallup et al. (1999), their original dataset for the economic, social, policy and geographical variables was used. All but the geographical variables are from established, widely available sources[2]. The physical geography and malaria index variables are contributions of Gallup et al. (1999)[3].

2 See Appendix A for a description of the variables and the sources as well as Gallup et al (1999).

3 Detailed explanations regarding the calculations of these variables are contained in the appendix to Gallup et al (1999).

The variables relating to temperature and rainfall are direct contributions of this paper.The variables were calculated based on a data set compiled by the National Climatic Data Center (NCDC) (1997). The data set contains information on worldwide temperatures and precipitation for at least one location in each country throughout the world, whenever possible. For large countries the stations are selected to provide comprehensive geographical coverage[4]. The data are presented as an annual average calculated over a record length ranging from 3-105 years, averaging about 30 years for most countries. The temperature data consists of values of average daily temperature in January, April, July and October, as well as extreme maximum and extreme minimum temperatures, all in Fahrenheit. The precipitation data consists of average precipitation in each month as well as an annual total, all in inches. Dell et al. (2014) summarise the various data sets commonly used in the climate and economic analyses. Out of the two methods suggested for aggregating the data, spatially or using population weights, this study uses the former. From the raw data set, country averages for total annual rainfall, mean temperature and the difference between the extreme maximum and minimum temperatures[5] were computed. A table listing the values of these variables for each country used in the study is provided in Appendix C.

3. Results

The linkage between climate and development is investigated both on levels and growth rates of GDP per capita. It begins by estimating an equation of the form $Y_{it} = \alpha_0 + \beta Z_i + \lambda W_i + \gamma X_i + \varepsilon_i$

where Y_{it} is GDP per capita for country i at time t, Z_i is a vector of geography variables created by Gallup et al (1999), W_i is a vector of social and political variables which have been shown to influence GDP and X_i is a vector of our climate variables. The estimation is carried out using standard OLS on this specification of the equation (Table 1) and on the log of levels of GDP per capita (Table 2). Table 3 replaces GDP per capita with the growth rate of GDP/capita from 1965-90 as the dependent variable and adds a measure for initial GDP/capita in 1965 to the vector of independent variables.

Table 1: Dependent Variable GDP Per Capita 1990

Variable	(1) GDP90	(2) GDP90	(3) GDP90	(4) GDP90
Tropicar	-2299.33*	-802.53		
	(3.58)	(0.91)		
Pop100km	1038.74	974.877	-487.98	48.66
	(1.44)	(1.18)	(0.62)	(0.06)
Open6590	4648.09*	3695.15*	2665.83*	2668.38*
	(5.42)	(4.01)	(3.28)	(3.4)
Instit	1532.3*	1618.699*	1222.16*	1216.88*
	(9.02)	(8.44)	(6.71)	(6.93)
Lifex65			154.19*	149.13*
			(4.35)	(4.35)
School			1202.32*	1123.88**
			(2.7)	(2.61)
Meantemp		-88.09**	-49.53***	5.06
		(2.2)	(1.68)	(0.14)
Extempdiff				36.99**
				(2.42)
Constant	-3562.49*	1479.5	-7726.22**	-13854.96*
	(3.2)	(0.5)	(2.44)	(3.49)
Number of Observations	97	81	73	73
R^2	0.8674	0.8760	0.9143	0.9214

Note:
Numbers in parentheses are absolute values of t-statistics.
* Denotes significance at 1% level.
** Denotes significance at 5% level.
***Denotes significance at 10% level.

[4] For more details on the coverage of the data and the sources used, see the NCDC (1997) document.
[5] See Appendix A for details on how these values were computed.

Table 2: Dependent Variable Log of GDP Per Capita 1990

Variable	(5) LGDP90	(6) LGDP90	(7) LGDP90	(8) LGDP90
Tropicar	-0.417**	-0.21***		
	(2.17)	(1.81)		
Pop100km	0.724*	0.21***	0.267**	0.245**
	(4.04)	(1.87)	(2.33)	(2.18)
Open6590	0.588*	0.355*	0.34*	0.3*
	(2.94)	(3.06)	(3.00)	(2.7)
Instit	0.19*	0.109	0.11*	0.117*
	(4.57)	(4.34)*	(4.57)	(4.84)
Meantemp	-0.0166*	-0.004		
	(1.92)	(0.74)		
LnLifex		2.45*	2.53*	2.67*
		(8.26)	(8.86)	(9.17)
LnSchool		0.113**	0.117**	0.114**
		(2.44)	(2.58)	(2.55)
Extempdiff			0.005*	0.004***
			(2.98)	(1.79)
AvRain				-0.114**
				(2.39)
Rain2				0.000087**
				(2.5)
Constant	(7.84)*	-2.05	3.1*	-3.31*
	(12.27)	(1.62)	(2.81)	(2.86)
Number of observations	81	73	73	73
R^2	0.8065	0.9385	0.9392	0.9446

Note:
Numbers in parentheses are absolute values of t-statistics.
* Denotes significance at 1% level.
** Denotes significance at 5% level.
***Denotes significance at 10% level

Table 3: Dependent Variable Growth Rate of GDP Per Capita 1965-90

Variable	(9) GDPG6590	(10) GDPG6590	(11) GDPG6590	(12) GDPG6590
Tropicar	-0.904*	-1.25*	-0.904**	
	(2.74)	(3.22)	(2.31)	
LGDP65	-2.44*	-2.24*	-2.32*	-2.38*
	(9.44)	(8.5)	(9.16)	(9.43)
Pop100km	0.998*	0.817**	0.69***	0.93*
	(2.73)	(2.16)	(1.9)	(2.45)
Open6590	1.84*	1.985*	1.88*	1.77*
	(4.62)	(5.02)	(4.96)	(4.72)
Instit	0.248*	0.24*	0.36*	0.375*
	(2.73)	(2.66)	(3.72)	(3.94)
LnLifex	5.5*	5.31*	3.82*	4.07*
	(4.91)	(4.86)	(3.24)	(3.45)
LnSchool	0.242	0.267***	0.185	0.19
	(1.49)	(1.69)	(1.2)	(1.24)
Meantemp		0.031***	0.35**	0.04**
		(1.78)	(2.1)	(2.25)
Malaria Index			-1.44**	-1.55*
			(2.71)	(3.0)
ExTempDiff				0.018**
				(2.4)
Constant	-3.76	-6.29	-0.37	-3.06
	(0.92)	(1.49)	(0.08)	(0.65)
Number of observations	75	73	73	73
R^2	0.7514	0.7594	0.7845	0.7859

Note:
Numbers in parentheses are absolute values of t-statistics.
* Denotes significance at 1% level.
** Denotes significance at 5% level.
***Denotes significance at 10% level.

4. Analysis of Findings

The first regression in Table 1 replicates Gallup et al's (1999) study. It shows that the variable 'tropicar' which represents the percentage of land area in the geographic tropics, is negatively associated with that country's GDP per capita.

Regression 2 adds the climate variable calculated in this paper 'meantemp' which measures the mean temperature for a country. 'Tropicar' then loses significance, probably due to multi-collinearity, and in subsequent regressions it is left out. The other variables enter as expected; 'pop100km' is the proportion of a country's population within 100 km of the coast, 'open6590' is the Sachs-Warner index of openness and measures the proportion of time between 1965-90 that a country was open to international trade, while 'instit' measures the quality of public institutions in the country. These three variables are all positively related to per capita income as expected and demonstrated in earlier studies.

The main result that this study highlights is that mean temperature is a significant determinant of GDP per capita and is negatively related to output, indicating that warmer temperatures have detrimental effects on output. This is not the same as stating that tropical countries have lower per capita income (the main finding of the Gallup et al (1999) study) since being tropical includes a variety of features pertaining to climate, vegetation, soil etc. At the very least it singles out temperature as an important determinant of the 'tropical' characteristic. Moreover, this finding holds while correcting for the effect of institutions, something that has not been found in earlier studies.

The reasons for this phenomenon and the channels through which heat can affect economic activity have been discussed earlier in this paper. They include the impact of infectious diseases and hence life expectancy which may influence labor productivity in manufacturing and services. The same factors could also affect crop yields and labor productivity in agriculture, which together could influence agricultural output and productivity.

To test the robustness of the temperature variable, regression 3 adds two more variables which could impact income, a human development indicator and a measure of human capital. The two variables are 'lifex65', which measures life expectancy in 1965 and 'school', which measure years of secondary schooling in 1965. Both enter as expected and the temperature variable remains negative and significant ('tropicar' is dropped since it lost significance due its correlation with 'meantemp').

Regression 4 adds another variable 'extempdiff' which measures the country average difference in extreme maximum and minimum temperatures.

The results indicate that countries with wider ranges in temperature extremes had higher income levels. There is a fairly strong negative correlation (coeff. = -0.78) between the mean temperature and the difference in extreme temperatures, indicating that colder countries are also more prone to extremes in climate.[6] A close look at the data shows that these countries have much lower extreme minimum temperatures and not as high extreme maximum temperatures as the warmer climates (not surprising). Hence, extreme cold apparently does not have as detrimental an effect on output as extreme heat.

Table 2 duplicates the above analyses but this time on the log of GDP per capita. This was done in order to facilitate a direct comparison with Gallup et al. (1999) who use the log level of these variables. Regression 5 produces the same results as regression 1 but regression 6 shows that the variable 'meantemp' is not robust to the addition of the human development and educational attainment indicators. Thus in regressions 7 and 8 the variable'extempdiff' replaces 'meantemp' and the variable 'tropicar' is dropped due to multicollinearity. As before 'extempdiff' is positive and significant.

In the last regression two variables for precipitation are also added. 'Avrain' is average annual total rainfall and 'avrain2' is the same variable squared.The specifications of these variables were designed to test for non-linearity in the data. The findings confirm that by itself precipitation is not significant but in conjunction with its squared term it has a powerful impact on the dependent variable. The direction of this relationship was a surprising finding since the level of precipitation appears to have a negative influence on output but in light of the fact that it is only significant when 'rain2' is included (which enters as a positive factor) perhaps this could be reinterpreted. It could be that at low levels of precipitation an increase in the amount of precipitation will not increase output and in fact could have a negative impact if it contributed to an increase in infectious diseases, parasites, fungi etc.

[6] This also explains why 'meantemp' now loses significance, again due to multicollinearity. See Appendix B for correlation coefficients.

Also the infrastructure of developing countries is susceptible to many factors and rainfall could easily disrupt many basic utilities such as energy, water and transportation (due to the conditions of roads). However at sufficiently high levels of precipitation the benefits accruing to agriculture may outweigh these factors and result in an overall positive impact on GDP per capita.

This interpretation is certainly open to debate. A better measure of precipitation would probably be the *variability* in rainfall. As Kamarck (1973)[7] points out *"Rainfall in the tropics is usually too much or too little. Average annual rainfall means little when one year may receive three times as much rain as the next, or when it does not rain evenly throughout a given season of the year but falls in torrents within brief periods*".

Hence a measure of the variation in rainfall might be a better indicator to test whether or not precipitation is a factor in affecting output.

Table 3 displays results for estimating a model where the dependent variable is the average annual growth rate of GDP per capita over the period 1965-90. We follow the literature in specifying the basic model in which growth is a function of initial levels of GDP per capita, initial human capital measured by the log of average years of secondary schooling, initial human development measured by the log of life expectancy at birth, openness of the economy to international trade and the quality of public institutions. To this model we add a physical geography variable measuring the percentage of the population that lives within 100 km of the coast as well as our climate variables.

Regression 9 tests for climate effects using Gallup et al's (1999) 'tropicar' variable which is negative and significant as before indicating that tropical countries have had lower rates of income growth. Regression 10 adds the temperature variable 'meantemp' which is also significant but surprisingly the effect this time is positive, indicating that warmer countries have had higher growth rates. This result is robust even when a control for malaria, a measure of the malaria index in 1966 that was highly significant and important in the Gallup et al (1999) study, is included as in regression 11.

Lastly, regression 12 tests for the effects of differences in temperature extremes on the dependent variable and the result is the same as before, i.e. positive and significant. However in this case 'tropicar' loses significance so it is eliminated from this specification of the model.

Overall the results in Table 3 prove to be somewhat conflicting, indicating that countries with wider ranges in extreme temperature (which are generally the more temperate countries) have grown faster in the specified period 1965-90, yet countries with higher mean temperatures have also grown faster. Reconciling these conflicting results merits further investigation since the two variables are highly negatively correlated (coeff. = -0.78) and will be one avenue for future research on this topic.

5. Conclusion

This study has provided additional evidence to suggest that climate, as defined specifically by temperature and rainfall, may have an important role in determining both the levels of output per capita and how fast a country grows. As suggested by Dell et al. (2014), since climatic and geographic variables are (largely) exogenously determined, reverse causation is unlikely to be of concern with these results. The puzzling nature of the link between climate and economic growth warrants further investigation and should serve as a springboard for more studies on this topic.

It is possible that the measurement of some variables such as political and institutional factors might influence the results based on the construction of those variables. To avoid the possible effects of such differences, an alternative approach might be to study income differentials within a country, such as the United States, and test to see whether climate has played a role in regional economic growth.

[7] See Kamarck (1973), "The Tropics and Economic Development", p. 15-16.

The increased availability of data on global weather has led to an increase in the use of GIS (geographical information systems) software and data sets in investigating weather-related phenomena as evidenced by recent research in the area. GIS has the advantage of being potentially more accurate since it corresponds to the particular surface area being analyzed instead of a countrywide average. This would be particularly helpful if one were to study differences in output and climate within a certain region or country, for instance Brazil.

As a final note, it should be stated that the purpose of studies such as this are not to suggest that geography *alone* is responsible for determining the economic outcome of a country, a concept that has come to be known as 'geographical determinism'. Instead, the intent is to draw attention to the fact that geography and climate do matter and *how* they matter is an area worthy of further investigation.

If a particular technology or policy prescription works in a certain environment because of the right conditions, then adapting it to work in a different one where conditions are substantially altered would certainly require a commitment to R&D that may be beyond the scope of poorer countries but could be pursued in the developed world. In addition, policy or development might increasingly be tailored to regional conditions, even in more developed countries.

Appendix A

Description of variables used in the data set

The following variables were part of the data set created by Gallup et al (1999).

Refer to Gallup et al (1999) for details on the construction of these variables and the original sources used.

Tropicar – the proportion of a country's land area within the geographic tropics.
Pop100km – the proportion of a country's population in 1994 within 100 km of a coast or an ocean-navigable river.
Open6590 – the proportion of years between 65-90 inclusive that a country was open to trade. Also known as the Sachs-Warner index of openness.
Instit – the quality of public institutions averaged over five indicators.
Lifex65 – the life expectancy at birth in 1965. From the United Nations (1965).
School – number of years of secondary schooling for the population in 1965. From Barro and Lee (1993).
GDP65 – purchasing power parity (PPP) adjusted Gross Domestic Product (GDP) per capita in 1965. From the Penn World Tables 5.6 (Summers and Heston (1994)).
GDPG6590 – PPP adjusted growth rates of GDP per capita from 1965-90. From the Penn World Tables 5.6 (Summers and Heston (1994)).
Malaria – the malaria index in 1966 based on a digitized map of the extent of malaria and the proportion of falciparum malaria from the World Health Organization (WHO (1967)).

The following climate variables were calculated by the author, based on data published by the National Climatic Data Center (NCDC (1997)):

Meantemp – average temperature for a country in Fahrenheit. The raw data set lists average maximum and minimum monthly temperatures over a certain time period (which varies from station to station) for the months of January, April, July and October. These values are listed for every station for which observations are available for the particular country. We first calculated the mean monthly temperature by taking the mean of the maximum and minimum. Next we averaged over all four months and finally over all the stations in the country to come up with the country wide average.

Extempdiff – the difference between the average extreme maximum and average extreme minimum temperature for a country, in Fahrenheit. Values for extreme maximum temperatures and extreme minimum temperature over a certain time period at a particular station are listed for every station in the country. Hence we first calculated the average of each extreme for the country as a whole by averaging over all the stations for that country. Next we simply subtracted to get the difference between the two average extremes.

Avrain – total annual rainfall in inches for the country. The raw data set lists total annual rainfall for each station averaged over a particular time period. We simply took the average of all the stations for a particular country.

Rain2 – the value of avrain squared.

Appendix B

Table 4: Summary Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Tropicar	150	.486682	.477491	0	1
pop100km	150	.4321408	.365913	0	1
open6590	140	.2494505	.3972599	0	1
Instit	98	5.682976	2.257114	2.27083	9.98437
lifex65	150	56.20533	12.06608	33.5	74.1
School	94	.6871422	.7107662	.008	3.508
Lnlifex	150	4.004725	.2245914	3.511545	4.305416
Lnschool	94	.9521193	1.223017	4.828314	1.255046
lgdp65	108	7.415965	.9565491	5.676754	9.362031
Meantemp	90	68.00389	12.16321	33.83	83.42
Extempdiff	90	68.61944	26.10794	25.15	138.51
Avrain	90	46.24533	29.31616	4.05	137.6
rain2	90	2988.519	3707.861	16.4025	18933.76
Malaria	144	.3200206	.4241056	0	1

Table 5: Correlations for Climate Variables and Malaria Index

	Tropicar	Meantemp	Extemp diff	AvRain	Rain2	Malaria
Tropicar	**1.0000**					
Meantemp	**0.7790**	**1.0000**				
ExTempDiff	**-0.8515**	**-0.7855**	**1.0000**			
AvRain	**0.5615**	**0.4782**	**-0.6599**	**1.0000**		
Rain2	**0.4935**	**0.4643**	**-0.5989**	**0.9601**	**1.0000**	
Malaria	**0.6420**	**0.5741**	**-0.5154**	**0.2945**	**0.2591**	**1.0000**

Appendix C

Climate Values for Countries in Dataset

Country	Rain (inches)	Meantmp (Fahrenheit)	Extempdiff (Fahrenheit)
Argentina	19.84	58.56	91.72
Australia	26.38	69.25	80.62
Austria	29.7	48.44	112.5
Benin	52.4	77.75	30
Burkina Faso	40.8	81.5	69.5
Bangladesh	73.9	78.63	65
Bulgaria	22.3	53.44	117.5
Bolivia	29.67	58.56	62
Brazil	61.98	75.33	57.09
CAF	58.3	80.01	47.5
Canada	27.74	33.83	138.51
Switzerland	37.7	49.13	105.66
Chile	54.81	53.39	60.55
China	38.39	56.01	105.17
Cameroon	59.2	73.63	47.5
Congo	54.9	77.92	41.33
Colombia	102.38	70.78	25.15
Costa Rica	70.8	68.75	43
Germany	27.3	47.55	107.28
Denmark	24.95	46.44	96.5
Dominican R.	55.8	77.88	39
Algeria	9.86	70.36	91
Ecuador	38.74	64.75	52.97
Egypt	4.05	73.63	82
Spain	17.92	60.15	87
Finland	22.67	37.33	120

Country	Rain (inches)	Meantemp (Fahrenheit)	Extempdiff (Fahrenheit)
France	29.4	53.91	96.7
Gabon	80.4	77.88	34
UK	31.97	51.58	78.89
Ghana	41.85	78.69	45
Guinea	117	79.88	46.5
Gambia	51	78	61
GuineaBissau	85.9	79.75	47
Greece	20.63	64.57	84.25
Guatemala	51.8	67.5	49
Hong Kong	85.1	72.63	65
Honduras	96.1	78.25	38
Indonesia	111.93	80.39	30.43
India	87.82	75.57	68.92
Ireland	35.83	49.88	74.33
Iran	10.38	61.55	112
Israel	22.33	67.21	78

Italy	29.03	61.07	81.38
Jamaica	31.5	79.25	41
Jordan	10.9	63.38	88
Japan	57.76	54.33	89.4
Kenya	42.5	71.82	40.5
Korea,Rep	51.4	54.57	100.5
Sri Lanka	92.3	80.5	40
Morocco	17.3	64.63	84
Madagascar	35.2	73.67	53.66
Mexico	31.19	73.77	63.07
Mali	19.1	83.42	78.33
Mozambique	39.07	76.12	71.66
Mauritania	6.87	82.04	74
Mauritius	50.6	74	45
Malawi	45.6	73	51
Malaysia	124.5	81.09	32.67
Namibia	9.75	68.13	77
Nigeria	54.8	79.72	53.75
Norway	42.23	41.29	99.33
New Zealand	39.63	54.44	65.5
Pakistan	17.13	75.63	88.33
Panama	100	80.44	32.5
Peru	13.42	64.19	51.8
Philippines	79.8	80.75	37.5
P. NewGuinea	88.6	81.08	35
Portugal	33.03	58.5	82
Paraguay	46.2	75.63	76
Senegal	25.8	79.69	61
Singapore	95	80.75	31
SierraLeone	137.6	79.5	36
El Salvador	70	76.75	60
Sweden	22.63	39.45	114.57
Syria	10.1	65.04	99.34
Chad	22.4	82.58	73.67
Togo	31	77.88	36
Thailand	57.8	80.75	54
Trin. & Tob.	64.2	79.25	49
Tunisia	11.6	65.69	91.5
Turkey	24.06	56.24	99.86
Taiwan	71.6	73.38	62.5
Uganda	53.45	72.81	47
Uruguay	43	63.38	83.5
U.S.A.	30.21	56.12	120.99
Venezuela	46.86	74.8	41.4
SouthAfrica	18.94	63	75.14
Zambia	40.9	70.08	62.33
Zimbabwe	28	66.38	67

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