The Diffusion of Development: Along Genetic or Geographic Lines?

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ABSTRACT

Why are some peoples still poor? Recent research suggests that some societies may be poor due to their genetic endowments, which have been found to be a significant predictor of development even after controlling for an ostensibly exhaustive list of geographic and cultural variables. We find, by contrast, that the correlation of genetic distance from the US and GDP per capita disappears with the addition of controls for climatic distance including distance from the equator and a dummy for sub-Saharan Africa.

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1. INTRODUCTION

Why are some peoples still poor? Economists have begun to investigate the role of genetics in the wealth of nations. One prominent example is Spolaore and Wacziarg (2009) — henceforth SW — which argues that the revolution in technological innovation which began in Lancashire cotton textiles circa 1760 spiraled outwards first to immediate locales, then to the whole of Britain, soon to the entire English-speaking world, and finally to other culturally and *genetically* similar peoples of the world.[1] Today, with the United States at the forefront of the world technological hierarchy, SW find that distance to the United States, measured geographically, culturally, and genetically, is a determinant of a society's level of technology and development.

The authors argue that the significance of their genetic distance variable, a measure based on the time elapsed since two societies existed as a single panmictic population developed by Cavalli-Sforza *et al.* (1994), does not imply any direct influence of specific genes on income. Instead they argue that genetic distance proxies a divergence in traits "biologically and/or culturally" which affect the diffusion of technology. SW report that genetic distance "has a statistically and economically significant effect on income differences across countries, even controlling for measures of geographical distance, climatic differences, transportation costs, and measures of historical, religious, and linguistic distance."[2] Were the impact of genetic distance on development robust to geographic and cultural controls, this would be evidence in favor of a direct impact of genetic endowments on per capita income, and would be an interesting and important result, in addition to being provocative. It would also be surprising given that genetic distance from the US, the variable used in the paper, appears to be a simple function of geography (see the world map in Figure 1 and the correlation matrix in Table 3).

[Insert Figure 1]

While the authors deserve credit for introducing a politically incorrect variable into the development discourse, we find that their evidence offered in support of the theory that genetic distance predicts GDP per capita is sensitive to geographic controls, including latitude and a dummy variable for sub-Saharan Africa. Our findings are consistent with the theory that the technologies developed during the Industrial Revolution diffused first to other temperate regions of the world, where European agricultural technology could be deployed and where the disease environment was most favorable to European people and their institutions, technology, seeds, animals and even germs. This is the theory developed by a long line of scholars, including Crosby (1972), Kamarck (1976), Diamond (1992), Sachs (2001), and Gallup, Mellinger, and

[1] Two other examples are Spolaore and Wacziarg (2011), who use the same genetic data and make a similar argument with technology adoption, and Ashraf and Galor (2008), who look at ethnic diversity.
[2] Spolaore and Wacziarg (2009), p. 469.

Sachs (1999), who all stress the importance of climatic similarity for the diffusion of various technologies.[3] In a world with trade costs, where the stability of GDP per capita rankings across decades implies that history matters, and where Malthusian forces have certainly been a strong historically and are debatably still at play in some developing countries (see Clark, 2008), the nature of agricultural technology diffusion and the historical disease environment will necessarily carry outsized importance for development. And regardless of the mechanism, it has long been known that countries near the equator tend to be less developed. SW themselves argue for the inclusion of latitude as a control and express legitimate concern that sub-Saharan Africa may be driving their results, yet struggle to implement these controls in a suitable manner.[4]

In related research, Giuliano, Spilimbergo, and Tonon (2006) find that genetic distance does not explain trade flows or GDP differentials within Europe after controlling for various geographic measures. Angeles (2011) shows that SW's genetic distance proxy is sensitive to the inclusion of 12 additional linguistic, religious, colonial, geographic and another genetic control (percentage of population with European ancestry, not counting mestizos). While these papers also argue against a role of genetics in economic development, the former only applied to the relatively homogenous gene pool of Europe while the latter replaces one genetic variable with another.

2. EMPIRICS

In column (1) in Table 1, we have reproduced the baseline result from SW's Table 1, finding that "genetic distance to the US," measured as the amount of time elapsed since the populations in these countries separated, is a significant predictor of income per capita even after controlling for various measures of physical distance. Yet, column (1) does not contain any variables which denote differences in climatic endowments. "Absolute difference in latitude" from the US is included, but "absolute difference in absolute latitude"—distance from the equator—is not. The reason why the latter is the appropriate control should be clear: although the Southern Cone countries, South Africa, and Australasia all have very large absolute differences in latitudes with the US, they have similar climates owing to their similar *absolute latitudes* with Europe and the United States.

[Insert Table 1]

[3] For example, Crosby (1972) notes that European people, plants, animals, and germs all colonized areas of the world with climates most similar to Europe (which he terms "Neo-Europes"), while Diamond (1992) argues that both diseases and agricultural technology spreads more easily east-to-west, helping to give the natives of the relatively large Eurasian landmass an advantage over more isolated areas (Africa or Australasia) and over those living in continents with a north-to-south axis such as the Americas. Kamarck (1976) discusses the extreme difficulty of transplanting agricultural technologies from temperate regions to the tropics.

[4] Spolaore and Wacziarg (2009), p. 501.

Figure 2.A displays the nonlinear relationship between income and absolute difference in latitude with the US, while the strong relationship between income and distance from the equator is readily apparent in Figure 2.B. SW themselves write that latitude could affect income directly, or via technology diffusion, and so is a relevant control, yet they do not include distance from the equator as a control in their primary results in Table 1.

[Insert Figure 2]

It might be that "genetic distance" explains why it is that sub-Saharan Africa is poor or why latitude is so highly correlated with development—that Europeans settled in areas with climates similar to Europe, and these places are now developed owing to their European institutional endowment, superior genes, or human capital. In column (2) of Table 1, however, when we include distance from the equator and a dummy for the 41 sub-Saharan African nations in our sample—the very first specification we tried—the coefficient on genetic distance falls substantially, rendering the results insignificant.

SW presciently express concern that sub-Saharan Africa may be driving their results, but instead of including it as a control, as is standard in the cross-country growth literature, including Barro (1991), Sala-i-Martin (1997) and Lorentzen, McMillan, and Wacziarg (2008), SW merely report that their results are robust to excluding sub-Saharan Africa countries in their regressions.[5] Yet, several rich East-Asian nations, such as Japan, Hong Kong, and Singapore, are more distant from the US genetically than many poor sub-Saharan Africa countries, such as Somalia, Ethiopia, and Madagascar (see Figure 3.A). A preferable approach to excluding the sub-Saharan Africa countries, which on net constitute counterexamples, is to include a dummy for sub-Saharan Africa.

[Insert Figure 3]

There are other arguments why a sub-Saharan Africa dummy should be included. Historically, the Sahara desert, the largest in the world, provided a significant barrier to trade and the diffusion of technology between sub-Saharan Africa and the Mediterranean.[6] Sub-Saharan Africa also has a unique ecological endowment, which includes having no native domesticable grains or large mammals (Diamond, 1992) and the most challenging disease environment of any continent (Gallup *et al.*, 1999), which Lorentzen *et al*. (2008) documents is still the case. The entire region shares various geographic, institutional and cultural traits of which we are only controlling for a small subset. Thus to argue that the impact of genetic distance on income per

[5] Spolaore and Wacziarg (2009), p. 501.

[6] There is a famous sign in Zagora, Morocco, which says it takes 52 days to get to Timbuktu by camel. Whether or not this is accurate, the width from the Mediterranean to sub-Saharan Africa is between 800 and 1,200 miles (Encyclopedia Brittanica).

capita is robust to controlling for both geography and culture, one should naturally include dummies for large geographic regions, as SW also argue.

As distance from the equator is an imperfect proxy for climate, when we include a more precise climatic variable, the percentage of each country's land area in the tropics or sub-tropics in column (3), the point estimate falls even further. In column (4), we show that that controlling for the tropics and sub-Saharan Africa alone eliminates the result.

The regression results in column (5) demonstrate that the impact of genetic distance on income is also not robust to controls for Europe and sub-Saharan Africa. In Figure 3.B, it can be seen that there is no statistically significant correlation between GDP per capita and genetic distance to the US outside of sub-Saharan Africa and Europe, and Figure 3.A shows that within both Asia and sub-Saharan Africa income and genetic distance are positively correlated. Finally, in column (6), when we expand the sample to include 20 additional countries for which we do not have complete data, and just include continent controls for Europe, sub-Saharan Africa, and contiguity (effectively a North America dummy), we again find no statistically significant relationship.[7]

SW also argue that if genetic distance to the US predicts income levels, then the income differential between any two countries should be a function of their relative genetic distance to the US. Thus, SW offer evidence (baseline controls in Table IV) that relative genetic distance to the US is correlated with income differences generally. To show this, the authors difference GDP per capita at the dyadic pair level for each combination of 137 (144 in our sample) countries, manufacturing 9,316 highly dependent data points (10,296 in our slightly larger sample), and use this as the dependent variable with the regressor of interest now being relative genetic distance to the US. It should be noted that the theory that relative genetic distance to the US predicts income differentials relies on there being a cross-country relationship between genetic distance to the US and income. We include our Table 2 in the interest of being thorough.

[Insert Table 2]

Column (1) in Table 2 benchmarks SW's Table IV results. While SW correctly stress the importance of including continent dummies in their analysis, they include only six regions (Asia, Africa, Europe, North America, Latin America, and Oceania) and did not separate sub-Saharan Africa from Mediterranean North Africa. They included a set of six dummies equal to one if both countries in a pair are on the same region and another set of dummies equal to one if one country belongs to a given region, and the other not. However, using just 12 dummies for six regional

[7] In the additional appendix (not for publication), and in regressions available for download on our academic homepage (http://dougcampbell.weebly.com/), we show additional robustness results using alternative measures of genetic distance, and a larger sampling of countries using fewer controls.

pairings with 21 combinations could be problematic. For example, the average absolute income difference between North America and Europe is likely smaller than the sum of the average absolute income difference between North America and all other countries plus the average absolute income difference between Europe and all other countries.

If instead we separate sub-Saharan Africa from the Mediterranean North African countries, and include a separate dummy for each regional pairing—*i.e.*, a dummy for North America paired with South America, and a separate dummy for South America paired with sub-Saharan Africa for 28 fixed effects total—then the impact of relative genetic distance shrinks and loses significance. However, including these dummies does not render the "Absolute difference in absolute latitude" or the "Absolute difference in % of land area in the tropics" variables insignificant in columns (4) and (5), while several of the other controls actually increase in significance.

[Insert Table 3]

3. CONCLUSION

The results presented above show that genetic distance loses the ability to explain income after the inclusion of geographic controls, including distance from the equator and a sub-Saharan Africa dummy. Our findings provide additional evidence for the importance of climatic endowment variables, if not the exact mechanism by which these variables impact development. Future research should continue in the spirit of Spolaore and Wacziarg (2009), introducing creative new variables with the potential to explain why some peoples are poor, and why climatic similarity has been such a strong force historically—but there is scant evidence that the answer to this mystery lies in our genetic differences.

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TABLE 1

Income Level Regressed on Various Geographic Measures, 1995

	(1) SW's Baseline Controls	(2) Add sub-Saharan Africa (SSA) dummy & Distance from equator	(3) Add (%) of Land Area in Tropics and Sub-Tropics	(4) Sparse Controls (SSA dummy & Climatic Control)	(5) Two Continent Controls Only	(6) Enlarged Sample, with Continent Controls
F_{ST} genetic distance to the US, weighted	-14.315***	-3.782	-1.617	-3.610	-3.530	-3.466
	(1.958)	(2.738)	(2.844)	(2.729)	(2.514)	(2.267)
Absolute difference in latitude from US	1.364**	1.218**	1.519***			
	(0.589)	(0.489)	(0.529)			
Absolute difference in longitude from US	0.801*	-0.024	0.339			
	(0.434)	(0.393)	(0.359)			
Geodesic distance from the US (1000s of km)	-0.159*	-0.038	-0.117*			
	(0.086)	(0.075)	(0.068)			
=1 for contiguity with the US	1.002***	0.695***	0.395			1.165***
	(0.173)	(0.168)	(0.255)			(0.330)
=1 if the country is an island	0.464	0.391	0.448*			
	(0.298)	(0.287)	(0.254)			
=1 if the country is landlocked	-0.234	-0.465**	-0.469**			
	(0.227)	(0.200)	(0.213)			
Sub-Saharan Africa dummy		-0.838***	-1.269***	-1.225***	-1.113***	-1.080***
		(0.234)	(0.248)	(0.270)	(0.246)	(0.234)
Distance from the Equator		0.031***				
		(0.010)				
% of land area in tropics and sub-tropics			-1.164***	-0.736***		
			(0.219)	(0.231)		
Europe dummy					0.992***	0.941***
					(0.198)	(0.195)
Observations	144	144	144	144	144	164
R^2	0.436	0.538	0.551	0.463	0.523	0.468

Notes: 1. Robust Standard errors in parentheses; *significant at 10%; **significant at 5%; ***significant at 1%.

2. Genetic distance data from Cavalli-Sforza et al. (1994) via SW (2009). Geographic data is from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), Tropics variable from Gallup, Mellinger, and Sachs available at http://www.ciesin.columbia.edu/eidata/, and GDP data is from the World Bank's WDI.

3. The genetic variable (Weighted Fst distance) is the time elapsed between two populations on average.

TABLE 2

Paired World Income Difference Regression (Two-way Clustering)

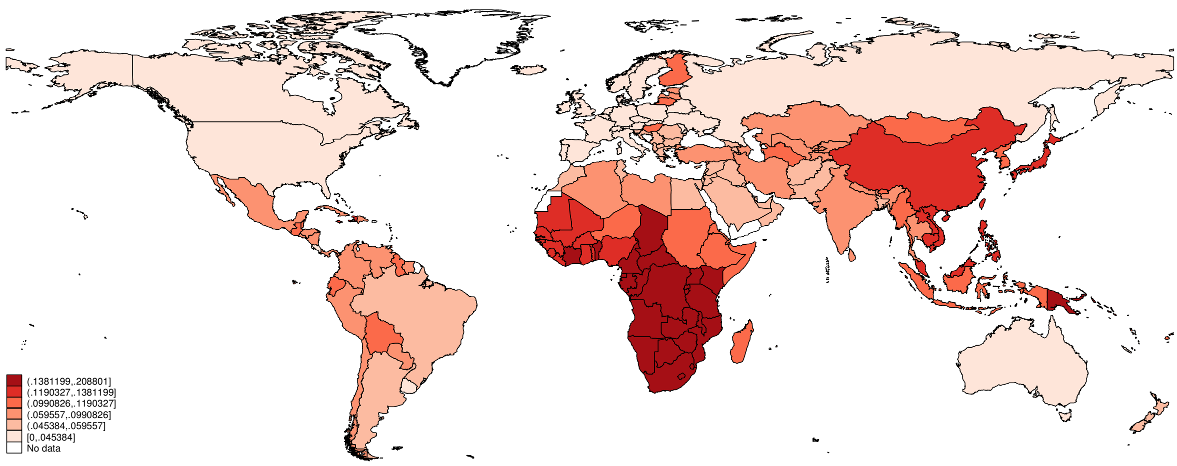
	(1)	(2)	(3)	(4)	(5)
	Replication SW's column 5 in Table IV	6 regions based on SW (Asia, Africa, Europe, N. America, S. America, Oceania)	7 regions with sub-Saharan Africa and Middle East& North Africa	Adding Abs. Difference in Abs. Latitude	Adding Abs. Difference in % of Area in Tropics and Sub-Tropics
	SW's Regional Dummy	Region-by-Region Fixed Effects			
F_{ST} genetic distance relative to the US, weighted	4.414*** (1.229)	3.986*** (1.222)	0.999 (1.141)	0.648 (1.136)	0.659 (1.13)
Absolute difference in latitude	-0.23 (0.228)	-0.117 (0.259)	-0.033 (0.259)	-0.462* (0.28)	-0.095 (0.262)
Absolute difference in longitude	0.163 (0.140)	0.322 (0.20)	0.465** (0.203)	0.229 (0.189)	0.409** (0.193)
Geodesic distance (1000s of km)	-0.015 (0.02)	-0.035 (0.027)	-0.042 (0.027)	-0.011 (0.025)	-0.037 (0.026)
=1 for contiguity	-0.341*** (0.074)	-0.360*** (0.076)	-0.350*** (0.071)	-0.306*** (0.068)	-0.330*** (0.069)
=1 for either country is landlocked (0 for both landlocked)	0.133* (0.07)	0.129* (0.069)	0.127* (0.065)	0.140** (0.063)	0.133** (0.064)
=1 for either country is island (0 for both are islands)	0.149* (0.087)	0.148* (0.084)	0.171** (0.083)	0.165** (0.082)	0.161* (0.085)
Absolute difference in absolute Latitude				0.010*** (0.004)	
Absolute difference in % of land area in tropics and subtropics					0.183** (0.089)
Observations	10,296	10,296	10,296	10,296	10,296

Notes: 1. Two-way clustered standard errors in parentheses (Cameron *et al.* 2011).
*significant at 10%; ** significant at 5%; *** significant at 1%.
2. All data are from the same sources as in Table 1.
3. Column (2) contains 21 region-by-region fixed effects and columns (3)-(5) include 28.

TABLE 3

Correlation between Key Variables

	Log GDP per capita	*F*st Genetic Distance to the US, weighted	Sub-Saharan Africa dummy	Distance from Equator	% of land area in tropics and subtropics	Europe dummy
Log GDP per capita	1					
*F*st genetic distance to the US, weighted	-0.6107	1				
Sub-Saharan Africa dummy	-0.6132	0.7693	1			
Distance from Equator	0.5639	-0.6623	-0.5378	1		
% of land area in tropics and subtropics	-0.4579	0.556	0.3076	-0.7723	1	
Europe dummy	0.539	-0.5192	-0.3575	0.7169	-0.4975	1



(Darker countries are genetically relatively more distant.)

Fig. 1. Chloropleth Map: Weighted Genetic Fst Distance from the US

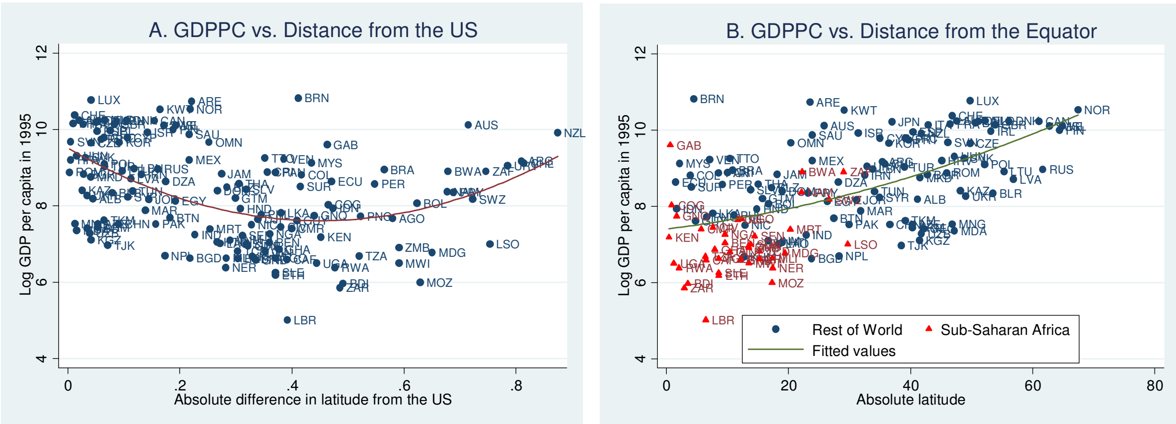


Fig. 2. Latitudinal Distance from the US vs. Distance from the Equator

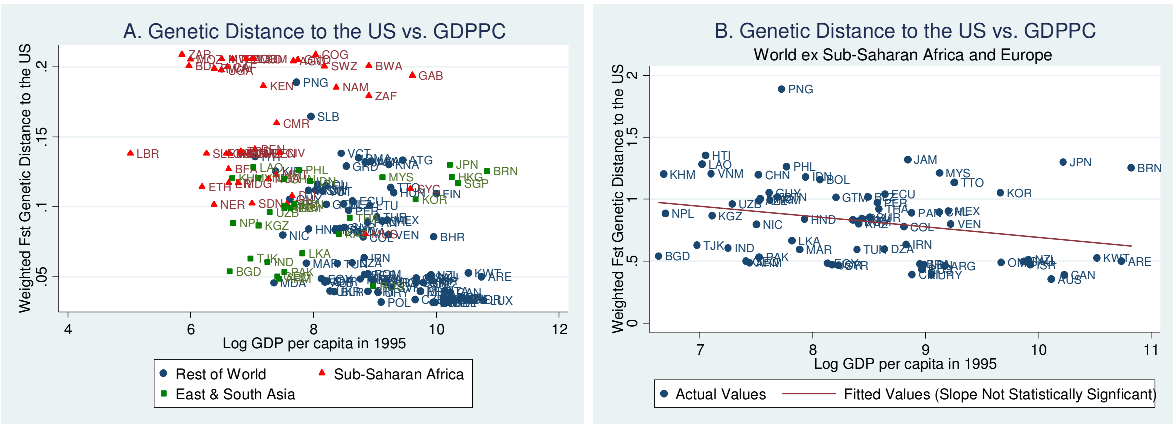


Fig. 3. Genetic Distance to the US vs. Income per capita