Genetic Distance, Trade, and the Diffusion of Development

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Abstract

The determinants of countries' long-term income differences feature prominently in the literature. Spolaore and Wacziarg (The diffusion of development, The Quarterly Journal of Economics 2009; 124: 469-529) argue that cultural differences, measured by countries' genetic distance, are an important barrier to the diffusion of development from the world's technological frontier. We revisit their findings in three ways. First, we successfully reproduce their results and confirm the robustness of their baseline findings. Second, we estimate their models for different time periods and find that the impact of genetic distance on income differences did not significantly change over time. Finally, we explore one of the underlying mechanisms of technology adoption and show that bilateral trade is one channel through which cultural differences retard the diffusion of development.

Keywords: Genetic Distance; Culture; Bilateral Trade; Diffusion of Development

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1 Introduction

What explains countries' economic performances and the long-term differences in per capita income is one of the most fascinating and difficult questions in economics. For instance, Barro (1991, 1996) convincingly argues that economic growth is enhanced by a number of factors such as higher human capital, physical investment, rule of law and political stability. The influence of human capital on development has since attracted a lot of attention (Bils & Klenow, 2000), and several studies have explored how the composition of the population, particularly in terms of ethnic heterogeneity, helps explain cross-country differences in growth rates (e.g., Easterly & Levine, 1997; Ottaviano & Peri, 2006; Bove & Elia, 2017). Establishing the very direction of the impact of diversity on growth is not straightforward. Cultural diversity can erode trust among individuals and social cohesion within societies at large. At the same time, however, a wider spectrum of traits can nurture technological innovation, the diffusion of new ideas, and thus the production of a greater variety of goods and services (Alesina & Ferrara, 2005). Given the theoretical ambiguities around the issues of cultural differences, technology diffusion and development, perhaps it comes as no surprise that it has been very hard to detect empirically a robust association between culture and development.[1] The seminal paper by Spolaore & Wacziarg (2009) directly tackles the question of what hampers the diffusion of technological and institutional innovations across societies. They employ genetic distance to capture a wide array of cultural traits transmitted intergenerationally within populations over the long run. They find that important differences in societal norms, customs, and habits, proxied by genetic distance, act as barriers to the diffusion of development from the frontier country.[2]

We revisit Spolaore and Wacziarg's (2009) findings in three ways. First, we successfully reproduce their results in a narrow sense. Second, we check the robustness of their main findings in a wide sense by adding a battery of classical gravity equation impediments to economic interaction and exchange. Moreover, we estimate the baseline model for different time periods, and find that the substantive impact of genetic distance on income differences has not significantly increased or decreased over time. Third, Spolaore & Wacziarg (2009, p.523) note that although their anal-

[1] Ashraf & Galor (2013) find that genetic diversity within a society has an inverse u-shaped relationship with income per capita, reflecting the trade-off between the beneficial and the detrimental effects of diversity on productivity.

[2] More recently, Spolaore & Wacziarg (2016) use new information on human microsatellite variation and confirm that relative ancestral distance from the technological frontier had a statistically and economically significant effect on income differences.

ysis "provides a general macroeconomic framework [...], the study of the specific microeconomic mechanisms through which the effects operate is left for future research." As a first step in this direction, we provide some evidence on the underlying mechanisms of technology adoption (and barriers to such adoptions). We show that, by reducing the substantive effect of genetic distance on income differences by almost 30%, lower bilateral trade due to genetic distance is one of the channels through which cultural differences retard technology adoption from the frontier, and hence, the diffusion of development.

2 Data and Empirical strategy

The variable of interest is genetic distance, a measure of distance to the most recent common ancestors of two populations, i.e. their degree of genealogical relatedness, or equivalently, the length of time since two populations split apart (Spolaore & Wacziarg, 2009).[3] As in Spolaore & Wacziarg (2009), to better determine the expected genetic distance between two randomly selected individuals, we use data on genetic distance weighted by the share of population belonging to each distinct ancestral group in each country, rather than genetic distance based on dominant groups only. By measuring the time since two populations shared common ancestors, genetic distance provides an ideal summary of differences in slowly changing genealogically transmitted characteristics, including habits and customs (Spolaore & Wacziarg, 2009, p. 523).

Information on GDP per capita comes from the Penn World Tables (PWT), version 7.1.7.[4] Trade data are from UN ComTrade dataset that includes aggregate yearly trade flows across dyads. With the exception of Table 2, our analyses are for the year 2000.

We start off by replicating the main results of Spolaore & Wacziarg (2009), and present regressions of income differences on relative genetic distance from the technological frontier, the US. We estimate the following regression:

$$|LogY_i - LogY_j| = \gamma GeneticDistance_{ij,US} + \alpha_k \tau_{kij} + \epsilon_{ij}$$

[3]This measure of genetic distance, also called F_{ST} distance, is constructed using information on 128 alleles related to 45 selectively neutral genes. It includes alleles coding for blood groups, immunoglobulin, hemoglobin, enzymes and lymphocyte antigens. We refer the interested reader to Spolaore & Wacziarg (2009) for a more comprehensive overview and a formal definition of genetic distance. See also Cavalli-Sforza *et al.* (1994).

[4]Spolaore & Wacziarg (2009) use income numbers from the Penn World Tables and from the World Bank (both for the year 1995) and find that this makes little difference in the results.

where $|LogY_i - LogY_j|$ is the absolute per capita income difference between all pairs of countries for the year 2000; $GeneticDistance_{ij,US}$ is the absolute difference in genetic distance of countries i and j from the US, i.e. genetic distance relative to the US ($|GeneticDistance_{US,i} - GeneticDistance_{US,j}|$); τ_{kij} represents the k bilateral controls other than genetic distance; and ϵ_{ij} is the error term.

3 Results

In Table 1 we first present a univariate regression of income differences on genetic distance, and then, we gradually add various measures of geographic isolation, physical barriers and environmental factors. In the baseline model of column (2), we control for geodesic distance and contiguity. Subsequently, we test the robustness of the results to additional geographic factors such as latitudinal and longitudinal distances as well as the number of islands and landlocked countries in the pair. We also use an array of measures of climatic similarity, as climate may also act as a barrier to the diffusion of development, see column (5). Moreover, given the potential endogeneity of genetic distance with respect to income differences, in column (4), we use Spolaore and Wacziarg's (2009) data on genetic distance in 1500 as an instrument for current genetic distance. Finally, in columns (6) and (7), we check whether the effect of genetic distance is robust to the inclusion of other markers of identity (and thus cultural similarities), in particular religious and linguistic distance relative to the US, and a shared colonial history. Results from columns (1) to (7) suggest that, conditional on various controls, a one-unit change in genetic distance is associate with an expected increase in income differences of 7 to 13 units (where income is log-transformed). Overall, the results of this narrow replication exercise confirm the signs and the magnitudes of the estimated coefficients reported in Spolaore and Wacziarg's (2009) original study.[5]

As a second step, we ask whether the coefficient of interest, γ, is stable across various time periods. In Table 2, we reproduce the baseline model of column (2) of Table 1 for different years from 1950 to 2005. One might expect an accelerated speed of technological progress in more recent times. If genetic distance acts as a barrier to technology adoption from the technological frontier, then the greater is the technological difference between the frontier and the laggards, the

[5]For example, the coefficient of genetic distance in column (1) is 7.18, which is very close to 6.36 in the same model of Spolaore & Wacziarg (2009). The small differences throughout the specifications are due to the choice of the reference year (we use 2000, they use 1995), and therefore a different sample size. However, when we use the same year (column (6) of Table 2), we get virtually the same coefficient.

larger is going to be the impeding effect of genetic distance. Since a potential concern is that our dependent variable, income differences, varies greatly over several decades, whereas genetic distance is time invariant, we follow Spolaore & Wacziarg (2009) and report the standardized beta coefficients on genetic distance (in square brackets).[6] Spolaore & Wacziarg (2009) find a slight decrease in the effect of genetic distance in recent times (although they use variation in income only for 1960 and 1995). Yet, on the one hand, the top panel in Table 2 suggests that the standardized effect does not rise monotonically, moving from 15% in 1950 to 26% in 1965, then stabilizing around 26% until 2005. Perhaps more importantly, however, the magnitudes of the corresponding standard errors suggest that the coefficients are never statistically different from one another; in other words, there is no statistically significant change in the positive impact of genetic distance over time. On the other hand, given the lack of data on some of the variables for earlier periods, resulting in an increasing number of observations over decades, in the bottom panel of Table 2 we rely on a common sample, using the 1950 countries only. Despite a non-monotonic increase over time, the size of the standard errors suggest again that the effect of genetic distance on income differences does not significantly evolve over time when we use the same number of countries.

Building on Table 2, Table 3 adds dyadic trade controls that are standard in gravity equations *à la* Anderson & van Wincoop (2003). In particular, we take into consideration institutional and historical links across countries. To that end, we control for common official language, isolating the impact of genetic distance from simple communication costs; same legal origin, which can lower transaction costs due to legal and regulatory systems and improve mutual trust (Guiso *et al.* , 2009); and the existence of a colonial relationship. We additionally account for a host of economic factors such as free trade agreements (FTA), GATT/WTO membership, common currency and generalized system of preferences agreements (GSP).[7] Finally, we account for the so-called "multilateral resistance terms" by including monodic country fixed effects, whose exclusion biases estimates in gravity models of trade (Anderson & van Wincoop, 2003). Controlling for monodic country fixed effects is a quite "demanding" test for the model, as fixed effects soak up the explanatory power of many variables by explicitly taking into account country-specific characteristics such as

[6]This should provide a more relevant metric of changes in the explanatory power of genetic distance. We thank an anonymous referee for suggesting the inclusion of these estimates.

[7]Control variables can be accessed on CEPII's or Thierry Mayer's webpage. `http://econ.sciences-po.fr/node/131.`

the quality of the institutions or the level of human capital. Furthermore, we combine fixed effects with two-way clustered standard errors, which should make it harder for a number of variables to appear either substantively or statistically significant. Despite the very demanding specification, adding country fixed effects and dyadic trade controls does not alter the results (with a lower bound estimate of the genetic distance coefficient of 6.0). The reported results further corroborate Spolaore and Wacziarg's (2009) original findings in terms of the estimated sign, magnitude, and statistical significance.

In Table 4, we evaluate the idea that the effect of genetic distance on income differences works through barriers to technology adoption from the technological frontier, the US. We argue that genetic distance delays the diffusion of development partly by reducing trade, and hence, bilateral exchange and interaction with the technological frontier, the US.[8] Lower bilateral exchange with the US, due to genetic differences, will then retard the adoption and the diffusion of technology, and as a result, will lead to greater income differences.

To make our point, we need to estimate a number of auxiliary models. In column (1) of Table 4, we first show how genetic distance from the technological frontier, the US, affects a county's bilateral trade with the same technological frontier, the US. Cultural distance seems to have a substantive influence on bilateral trade. A one percentage point increase in genetic distance leads to a 21% decrease in imports from the US. Furthermore, column (2) of Table 4 shows that genetic distance of country j from the US lowers its income per capita (in line with Table 1 of Spolaore & Wacziarg (2009)). At the same time, as expected, we observe in column (3) that more trade with the US is associated with higher income. Column (4) combines columns (2) and (3) to show that when we include both genetic distance and trade with the US in an income regression, the effect of genetic distance from the US on income is reduced by 25% compared to column (2).

Column (5), on the other hand, shows that relative trade of countries with respect to the US increases with their genetic distance relative to the US. For example, country i that is genetically close to the US will trade more with the US than does country j that is genetically distant from the US. Hence, both their genetic distance relative to the US and their relative trade with the US will be large. Column (6) reports the effect of relative genetic distance on differences in income replicating column (8) of Table 3. Similarly, column (7) reports that larger relative trade with the

[8]For studies on the negative impact of cultural distance on trade, see Guiso *et al.* (2009), Felbermayr & Toubal (2010), Gokmen (2017).

US is associated with higher income differences. Relative genetic distance affects relative trade and income differences, while trade has an independent effect on income. Therefore, in column (8), by combining columns (6) and (7), we asses what part of the effect of relative genetic distance on income difference is intermediated through bilateral trade. When both relative genetic distance and relative trade with the US are included in the specification, the impact of relative genetic distance on income differences is mitigated by 29% compared to column (6).[9] In sum, these results from Table 4 suggest that a substantial part of the effect of genetic distance on the diffusion of development is mediated through its effect on trade and bilateral exchange.

A fair criticism would be to point out the endogeneity problems plaguing the trade to income differences dynamics. Although we mitigate the issue of endogeneity stemming from the likely omission of important co-determinants of trade and income differences with country i and j fixed effects, the coefficient of trade might be contaminated by other unobserved factors and from causality running both ways. Yet, finding a suitable exogenous instrument for trade is challenging. The remoteness variable is often used in the international trade literature as an instrument for trade, yet a country with low remoteness has many close and large alternative sources of goods and this could in turn directly affect its level of development. Virtually all factors affecting bilateral trade, including geographic distance or the presence of a common language, are also likely to violate the exclusion restrictions. As such, this result must be interpreted with caution.

4 Conclusions

The level of economic development varies enormously across countries, and a number of economic studies have pursued the question of what factors determine the large observed income differences. This paper successfully reproduces the main findings of Spolaore & Wacziarg (2009): genetic distance bears a statistically significant relation to income differences, and as such it captures the important barriers to the diffusion of technology. We further show that the substantive effect of genetic distance on income differences has not significantly changed over time. Finally, as there

[9] It is easy to check that multiplying the coefficient of genetic distance on trade in column (5) by the coefficient of trade on income differences in column (7) gives approximately an idea of the size of the impact of genetic distance on income differences through its effect on trade. In fact, the product of the two coefficients, 1.85, is roughly equal to the amount of change in the coefficient of genetic distance when we move from column (6) to column (8) and explicitly include trade in the equation for income differences. The two magnitudes are similar, which suggests that trade is indeed capturing about one-third of the effect of genetic distance on income. We thank an anonymous reviewer for highlighting this.

are no empirical works directly exploring the specific underlying mechanisms, we offer a first step in this direction and show that bilateral trade is potentially an important channel linking cultural distance to the diffusion of development.

Table 1: Genetic Distance Relative to the US and Income Differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Genetic Distance Relative to the US, Weighted	7.186***	6.819***	8.547***	12.892***	8.959***	8.638***	8.604***
	(1.113	(1.148)	(1.427)	(0.570)	(1.368)	(1.459)	(1.463)
Log Distance		✓	✓	✓	✓	✓	✓
Contiguity		✓	✓	✓	✓	✓	✓
Absolute Difference in Latitude			✓	✓	✓	✓	✓
Absolute Difference in Longitude			✓	✓	✓	✓	✓
Number of Islands			✓	✓	✓	✓	✓
Number of Landlocked Countries			✓	✓	✓	✓	✓
Log Absolute Difference in Elevation			✓	✓	✓	✓	✓
Log Absolute Difference in Distance to Coast			✓	✓	✓	✓	✓
Abs. Dif. in Polar Land Percentage					✓		
Abs. Dif. in Boreal Land Percentage					✓		
Abs. Dif. in Temperate Desert Percentage					✓		
Abs. Dif. in Tropical Desert Percentage					✓		
Abs. Dif. in Dry Land Percentage					✓		
Abs. Dif. in Wet Land Percentage					✓		
Abs. Dif. in Subtropical Land Percentage					✓		
Abs. Dif. in Tropical Land Percentage					✓		
Religious Distance Relative to the US, Weighted						✓	✓
Linguistic Distance Relative to the US, Weighted						✓	✓
Colonial Link							✓
N	23944	23944	11693	11693	10492	10845	10845

Regressand: $|LogY_i - LogY_j|$: Absolute income per capita difference in 2000.

Genetic Distance Relative to the US: $|GeneticDistance_{US,i} - GeneticDistance_{US,j}|$.

In column (4), genetic distance is instrumented with genetic distance in 1500.

Two-way clustered standard errors are in parentheses.

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 2: Genetic Distance Relative to the US and Income Differences over Time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	1950	1955	1965	1975	1985	1995	2005
Genetic Distance Relative to the US, Weighted	3.903**	4.187**	5.519***	6.391***	6.381***	6.927***	7.952***
	(1.990)	(1.981)	(0.936)	(0.992)	(0.972)	(1.149)	(1.235)
	[0.144]	[0.147]	[0.264]	[0.261]	[0.259]	[0.237]	[0.266]
N	3780	4420	14012	16714	19370	23328	22720
Fixing the sample to 1950 countries only:							
Genetic Distance Relative to the US, Weighted	3.903**	4.692**	7.043**	8.959***	7.024**	9.820**	10.187***
	(1.990)	(2.170)	(2.733)	(3.166)	(2.741)	(3.804)	(3.732)
	[0.144]	[0.164]	[0.227]	[0.266]	[0.216]	[0.240]	[0.248]
N	3780	3785	3833	3842	3850	3507	3622
Log Distance	✓	✓	✓	✓	✓	✓	✓
Contiguity	✓	✓	✓	✓	✓	✓	✓

Regressand: $|LogY_i - LogY_j|$: Absolute income per capita difference in specified years.

Genetic Distance Relative to the US: $|GeneticDistance_{US,i} - GeneticDistance_{US,j}|$.

Standardized beta coefficients are in brackets.

Two-way clustered standard errors are in parentheses.

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 3: Genetic Distance Relative to the US and Income Differences, Adding Dyadic Trade Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Genetic Distance Relative to the US, Weighted	6.812***	6.794***	6.744***	6.392***	6.275***	6.253***	6.004***	6.000***
	(1.148)	(1.150)	(1.148)	(1.127)	(1.127)	(1.123)	(1.107)	(1.286)
Log Distance	✓	✓	✓	✓	✓	✓	✓	✓
Contiguity	✓	✓	✓	✓	✓	✓	✓	✓
Common Official Language	✓	✓	✓	✓	✓	✓	✓	✓
Common Legal Origin		✓	✓	✓	✓	✓	✓	✓
Colonial Link			✓	✓	✓	✓	✓	✓
Free Trade Agreements				✓	✓	✓	✓	✓
GATT/WTO Membership					✓	✓	✓	✓
Common Currency						✓	✓	✓
Generalized System of Preferences							✓	✓
Country *i* FE								✓
Country *j* FE								✓
N	23944	23944	23944	23798	23798	23798	23798	23798

Regressand: $|LogY_i - LogY_j|$: Absolute income per capita difference in 2000.

Genetic Distance Relative to the US: $|GeneticDistance_{US,i} - GeneticDistance_{US,j}|$.

Two-way clustered standard errors are in parentheses.

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 4: Genetic Distance, Trade and Income Differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$LogImports_{US,j}$	$LogY_j$	$LogY_j$	$LogY_j$	$\lvert LogImports_{US,i} - LogImports_{US,j}\rvert$	$\lvert LogY_i - LogY_j\rvert$	$\lvert LogY_i - LogY_j\rvert$	$\lvert LogY_i - LogY_j\rvert$
Genetic Distance from the US, Weighted	-21.947***	-17.096***		-12.773***				
	(4.252)	(2.474)		(2.377)				
$LogImports_{US,j}$			0.273***	0.196***				
			(0.035)	(0.035)				
Genetic Distance Relative to the US, Weighted					9.651***	6.000***		4.277***
					(1.978)	(1.286)		(1.162)
$\lvert LogImports_{US,i} - LogImports_{US,j}\rvert$							0.192***	0.178***
							(0.027)	(0.026)
Log Distance	✓	✓	✓	✓	✓	✓	✓	✓
Contiguity	✓	✓	✓	✓	✓	✓	✓	✓
Common Official Language	✓	✓	✓	✓	✓	✓	✓	✓
Common Legal Origin	✓	✓	✓	✓	✓	✓	✓	✓
Colonial Link	✓	✓	✓	✓	✓	✓	✓	✓
Free Trade Agreements	✓	✓	✓	✓	✓	✓	✓	✓
GATT/WTO Membership	✓	✓	✓	✓	✓	✓	✓	✓
Common Currency	✓	✓	✓	✓	✓	✓	✓	✓
Generalized System of Preferences	✓	✓	✓	✓	✓	✓	✓	✓
Country i FE					✓	✓	✓	✓
Country j FE					✓	✓	✓	✓
N	164	164	164	164	23798	23798	23798	23798

$LogY_j$: Log Income per capita. $|LogY_i - LogY_j|$: Absolute income per capita difference.

Genetic Distance from the US: $GeneticDistance_{US,j}$. Genetic Distance Relative to the US: $|GeneticDistance_{US,i} - GeneticDistance_{US,j}|$.

Robust standard errors and two-way clustered standard errors (in columns (5)-(8)) are given in parentheses.

$*p < 0.10, **p < 0.05, ***p < 0.01$

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