Journal of Banking & Finance 39 (2014) 43–56

Contents lists available at ScienceDirect

Journal of Banking & Finance

journal homepage: www.elsevier.com/locate/jbf

Financial development and barriers to the cross-border diffusion of financial innovation

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ARTICLE INFO

Article history:
Received 18 June 2013
Accepted 27 October 2013
Available online 7 November 2013

JEL classification:
G15
O50
O16

Keywords:
Financial development
Genetic distance to the frontier
Financial innovation

ABSTRACT

This paper explores the determinants of financial development by focusing on the role played by barriers to the diffusion of financial technology. These barriers are measured using human genetic distance from the technology frontier. The results based on cross-sectional data for 123 countries suggest that genetic distance to the global frontier has an economically and statistically significant effect on financial development, in that countries that are genetically far from the technology leader tend to have lower levels of financial development. Genetic distance is found to have the largest effect, even after controlling for other determinants of financial development established in the literature. These findings indicate that cultural barriers to the diffusion of financial technology across borders impact financial development by influencing the follower countries' ability to adopt and adapt innovations from the frontier.

1. Introduction

There is now a widespread consensus in the literature recognizing the important role of financial development as a source of economic growth (see, e.g., King and Levine, 1993; Demetriades and Hussein, 1996; Levine, 1997; Rajan and Zingales, 1998; Beck et al., 2000; Demetriades and Andrianova, 2004; Ang and McKibbin, 2007; Ang, 2011; Andrianova et al., 2012; Madsen and Ang, 2013). The preponderance of evidence suggesting the beneficial role of financial development has shifted the focus of research towards answering the question of why some countries have well-functioning financial systems whereas others do not.

Several explanations have been proposed. The prominent law and finance theory of La Porta et al. (1997, 1998) stresses the importance of the legal tradition of a country in shaping the subsequent development of its financial system. Other influential works offer alternative perspectives, underlining the importance of endowments (Acemoglu et al., 2001; Beck et al., 2003), financial and trade openness (Rajan and Zingales, 1998; Baltagi et al., 2009) or culture (Stulz and Williamson, 2003). However, despite the above contributions, one potential factor underlying differences in the level of financial development across nations – barriers to the diffusion of financial innovation – has thus far not been considered in the literature.

Major innovations in the financial sector often take place in technologically sophisticated countries such as the United States. These inventions, such as cash dispensing automatic teller machines (ATMs), electronic payment mechanisms, on-line trading of securities, internet banking, and electronic record-keeping of credit scores, have significantly improved the functioning of financial systems in the frontier countries. A pertinent question is why these innovations do not flow easily to financially backward countries. One plausible source of this impediment is the existence of significant cultural barriers between the frontier and the followers. These development barriers, which can be captured by the genetic distance between countries according to Spolaore and Wacziarg (2009), prevent the free flow of financial innovations through imposing costs on imitation and adaptation.

Against this backdrop the purpose of this paper is to shed some light on how barriers to the diffusion of financial technology affect financial system deepening. We argue that genealogical distance works as a barrier to the diffusion of financial innovations across populations and countries. The underlying premise of this proposition is that populations that are genetically more distant tend to

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http://dx.doi.org/10.1016/j.jbankfin.2013.10.011

differ more in a variety of characteristics that are transmitted inter-generationally, such as language, appearance, norms, values, customs, beliefs, and habits. Differences in these traits between populations hinder the exchange of ideas and reduce opportunities for learning, imitating and adopting, thereby serving as barriers to the diffusion of innovations in financial products and services from the frontiers to the laggard countries.

Conversely, a country with a population genealogically similar to the financial technology leader is able to facilitate the diffusions more effectively since they share similar traits and characteristics, which enables the transfer of financial technology and the diffusion of financial knowledge to take place easily. Such a country is also more likely to act in similar ways in its formulation of financial sector policies and the introduction of financial reforms, and hence is less likely to experience financial backwardness.

We use human genetic distance data compiled by Spolaore and Wacziarg (2009), who provide a summary measure of the degree of genealogical relatedness between populations over time, to investigate how development barriers due to genetic distance relative to the frontier influences variations in the levels of financial development across the globe. Although human genetic distance is not commonly studied in the social sciences, several recent papers have pointed out its important role in predicting economic outcomes.

In particular, the seminal work of Spolaore and Wacziarg (2009) shows that genetic distance between populations is strongly correlated with differences in per capita income across countries. They argue that genetic distance between populations captures the divergence in a wide range of traits and characteristics transmitted across them, and interpret the effects of this distance as barriers to the diffusion of economic development from the world technological frontier, since differences in these traits hinder the flow of ideas, goods, and technologies across populations, which curbs development.

Besides, a related work by Guiso et al. (2009) demonstrates that genetic distance between European populations lowers bilateral trust, which in turn leads to less economic exchanges, such as trade, portfolio investment and direct investments, between countries. Giuliano et al. (2006), however, show that the effect of genetic distance between European populations on trade volume disappears once geographic factors are properly controlled for. Our work is closely related to the above studies. However, unlike them, we study how genetic distance explains differences in the levels of financial development, rather than income or trade flows, across countries.

Using data for 123 countries, our results indicate that genetic distance to the frontier (i.e., the United States) has an economically large and statistically significant effect on differences in the levels of financial development across countries, supporting the notion that diffusion barriers due to genetic distance reduce financial development. The results are remarkably consistent when we control for the effects of creditor rights, trade openness, financial openness, legal origins, geographic factors, and religions. These findings are also robust to the use of alternative measures of financial development and genetic distance, the choice of technological frontier, and the inclusion of ethnic fractionalization, institutional quality, social capital and continent-fixed effects in the specification. Similarly, excluding the OECD or Neo-Europes does not eliminate the significant effect of genetic distance to the frontier on financial development.

The rest of the paper is organized as follows. Section 2 briefly reviews the related literature. Section 3 discusses the data and sets out the empirical strategies. The estimates are presented and discussed in Section 4. Section 5 provides some robustness checks. Section 6 tests whether the effect of cultural diffusion barriers on income works through financial development, and the last section concludes.

2. Related literature

The growing consensus that financial development promotes growth has spawned an expanding body of research that examines its determinants. The existing literature has highlighted several factors that might account for the differences in the level of financial development across countries.

One influential strand emphasizes legal systems, particularly the legal and regulatory frameworks involving property rights protection, contract enforcement, and creditor rights, as an important determinant of financial development. For example, the Law and Finance view articulated by La Porta et al. (1997, 1998) stresses that the legal origin of a country is a good predictor of how efficient the legal system is in protecting investor rights and enforcing contracts. Focusing on the differences between the most influential legal traditions, they find that countries with the British common law origin emphasize freedom of contract and provide the highest levels of investor protection, hence achieving higher levels of financial development than countries with French, German or Scandinavian civil law origins. Djankov et al. (2007) further demonstrate that legal creditor rights and information-sharing institutions are important determinants of financial development. When lenders can more easily enforce repayment, seize collateral, gain control over firms, and have better access to information about potential borrowers, they will be more willing to extend credit.

Some proponents of the endowment theory stress the important role of geography and the disease environment in shaping institutional development. The underlying premise of this hypothesis is that countries located closer to the equator have a more tropical climate where a high prevalence of pests and disease hinders production. The lack of economies of scale in agriculture prevents specialization, and hence retards innovation and institutional and economic development (Gallup et al., 1999). Acemoglu et al. (2001) extend this argument by proposing that tropical endowments represented an inhospitable disease environment for European settlers, who therefore focused on extracting resources from colonies and, this led to the development of extractive institutions. Furthermore, Beck et al. (2003) argue that under an extractive environment, colonizers focused on establishing institutions in favor of small elite groups rather than private investors, which dampened property rights protection and contract enforcement, subsequently retarding financial development.

Openness is another important dimension relevant to the shaping of financial development that is often highlighted in the literature. The influential work of Rajan and Zingales (2003) proposes that the incumbent interest groups frequently stand to oppose the policies that would foster financial deepening so as to prevent their rents from being eroded due to greater competition. The strength of the interest groups, however, will be lower the more open the economy is to trade and capital flows. This follows from the fact that new opportunities created by openness may generate enough profits to overcome the loss of rents resulting from increased competition and the loss of incumbency. Hence, their theory suggests that the simultaneous opening of both trade and capital accounts holds the key to successful financial development. Herger et al. (2008) and Baltagi et al. (2009) test this hypothesis and find some supporting evidence.

Differences in the levels of financial development may also be due to cultural diversity, according to Stulz and Williamson (2003). This view proposes that, unlike Protestantism, Catholic and Muslim religions tend to produce relatively centralized hierarchical and authoritative governments with powerful religious bonds that affect the efficiency and development of financial markets through stringent regulations (Putnam, 1993; Landes, 1999). Stulz and Williamson (2003) show that a country's principal religion plays a significant role in explaining the differences in investors' rights across countries, more so than the origin of a country's legal system. In particular, they find that investor protection is stronger in countries where the main religion is Protestant rather than Catholic. Herger et al. (2008), however, find only limited evidence that religious beliefs directly impede the development of financial systems. Our empirical specification will take into consideration the various hypotheses outlined above while estimating the effect of cultural barriers across borders on financial development.

3. Empirical strategies and data

3.1. Empirical specification

Following standard practice in the literature, Eq. (1) is specified to investigate the influence of genetic distance to the frontier on subsequent financial development across countries.

$$FD_i = \beta_1 + \beta_2 GD_i + \beta_3 X_i + \varepsilon_i \quad (1)$$

where FD_i is an indicator of financial sector development for country i; GD_i is the measure of genetic distance of country i with respect to the global technological frontier, i.e., the United States; X_i represents the vector of control variables which affect the level of financial development of country i, including creditor rights protection, trade openness, financial openness, legal origin, and geographic and cultural factors, as suggested by the discussions above; and ε_i is the random error term. We are mainly interested in testing whether the coefficient of GD_i, i.e., β_2, is statistically and economically significant.

Eq. (1) will be estimated using the least squares estimator with heteroskedasticity robust standard errors for 123 countries. However, identification of the model will not be achieved if financial development is endogenous with respect to genetic distance to the frontier. For that reason, Eq. (1) will also be estimated using an instrumental variable method described in the next section. The measures of financial development are expressed as an average over the period 2000–2010. Some of the control variables, including creditor rights, trade openness and financial openness, are measured in their 2000 values to minimize potential reverse causality problems.

3.2. Data

Financial development will be measured mainly by using the ratio of private credit to GDP (see, e.g., Arestis and Demetriades, 1997; Ang and McKibbin, 2007; Baltagi et al., 2009; Ang, 2010). Private credit is defined as the value of credit provided by financial intermediaries to the private sector. It excludes credit issued to the public sector and credit issued by the central and development banks. As a robustness check, we also consider the ratio of domestic credit (comprising credit to both the private and public sectors) to GDP, stock market capitalization, total value of stock market trade, and stock market turnover ratios as alternative financial development indicators. Stock market capitalization is defined as the stock market value of listed companies as a share of GDP. The total value traded is the ratio of the trade volume of domestic shares to GDP. The turnover ratio is defined as the ratio of the trade volume of domestic shares to stock market capitalization. The data are obtained from the World Bank's World Development Indicators (2012) online database and the Financial Development and Structure Database of Beck et al. (2010). All indicators are averaged over the period 2000–2010. The regressions involving stock market measures contain a smaller number of observations due to the unavailability of data for some countries.

Human genetic distance will be measured using the fixation index, which reflects the degree of genealogical relatedness between two populations using allelic frequencies of a set of genes in different populations. By construction, the index takes a value between 0

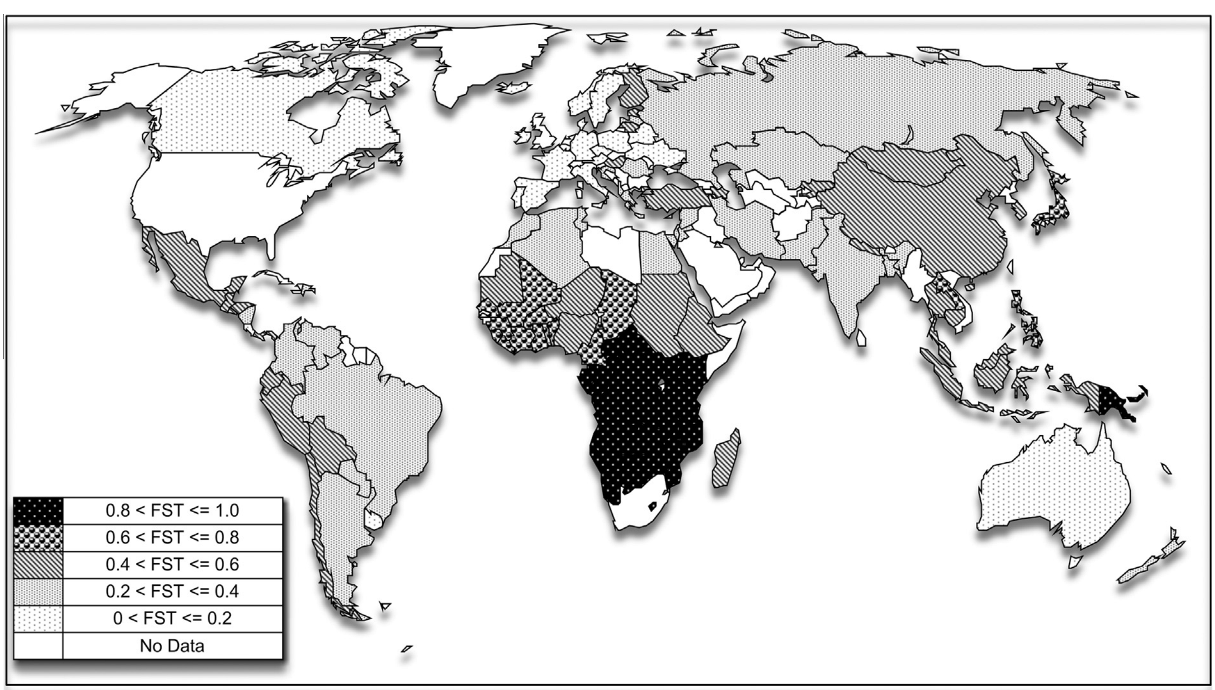

Fig. 1. Distribution of genetic distance to the frontier for 123 countries. *Notes*: The F_{ST} genetic distance estimates of Spolaore and Wacziarg (2009) are rescaled to take values between 0 and 1 using the maximum distance value in our sample.

and 1 where 0 indicates that the two populations are genetically identical and 1 indicates that they are completely different. Thus, a higher value indicates greater genetic differences between populations or a longer separation time between populations.

This measure is based on the notion that differences in gene distributions between populations across a range of neutral genes reflect the time that has passed since two populations shared common ancestors. Since a large number of human traits and characteristics, e.g., habits, cultures, customs, norms, beliefs, and values, are transmitted with variations across generations over time, genetic distance captures the overall divergence in such intergenerationally transmitted characteristics across populations. Consequently, genetic distance provides an overall measure of the differences in traits and characteristics across populations. As the amount of time that two populations have separated increases, differences in traits and characteristics, which hinder the free flows and adaptation of financial innovations, also increase. This measure therefore captures the development barriers to diffusion (Spolaore and Wacziarg, 2009).

The data are obtained from Spolaore and Wacziarg (2009). They match the genetic distance data at the population level to countries using country level data on ethnic composition. In our empirical analysis, genetic distance to the global technological frontier is defined as the genealogical (fixation index, F_{ST}) distance between the populations of country i and the United States (the global technological frontier). In our sample, the smallest distance is 0.031, between Belgium (and Ireland) and the United States whereas the largest gap (0.209) is between the same frontier and the Congo Republic (and the Congo Democratic Republic). The variable is rescaled to take a value between 0 and 1 so that their respective values are 0.151 and 1.000. The global mean value in our sample is 0.464. Appendix B provides details on the definition of F_{ST} and illustrates how this measure is constructed.

Fig. 1 shows the distribution of this measure across the globe. It is evident that F_{ST} shows great disparity across countries. Averaged genetic distance relative to the global frontier for America (0.396), Asia (0.421) and Oceania (0.440) is almost double that of Europe (0.225). The gap between Africa and the global leader is nearly three times that of Europe. Interestingly, the African countries are also those that have the most underdeveloped financial systems whereas European countries tend to have the highest levels of financial development in the world. In the empirical section we will test whether there is a robust relationship between these two variables.

Our measure of genetic distance to the United States bears a negative correlation coefficient of 0.53 with financial development (measured by the ratio of private credit to GDP). Fig. 2 plots the average level of financial development over the period 2000–2010 against the measure of genetic distance to the United States. Consistent with the interpretation of genetic distance being related to barriers to the international diffusion of financial innovation, the scatter diagram shows a clear negative relationship between these variables. Graphical inspection also suggests that Cyprus and Japan are outliers. Excluding these countries in the regressions, however, does not affect the main findings in the paper. Summary statistics, definitions of variables, and sources of data are given in Appendix A.

4. Estimation results

4.1. OLS estimates

Table 1 presents the results of regressing Eq. (1). Column (1) presents the estimates of a univariate regression where the private credit ratio is regressed only on genetic distance to the United States. It is evident that these two variables show a very strong negative correlation. The coefficient of *GD* is found to be −0.994, which is very precisely estimated at the 1% significance level. This estimate suggests that countries that are genetically far from the United States tend to have substantially lower levels of financial development. Along with this, the R^2 statistic also indicates that *GD* alone is able to explain 29% of the total variation in financial development across countries.

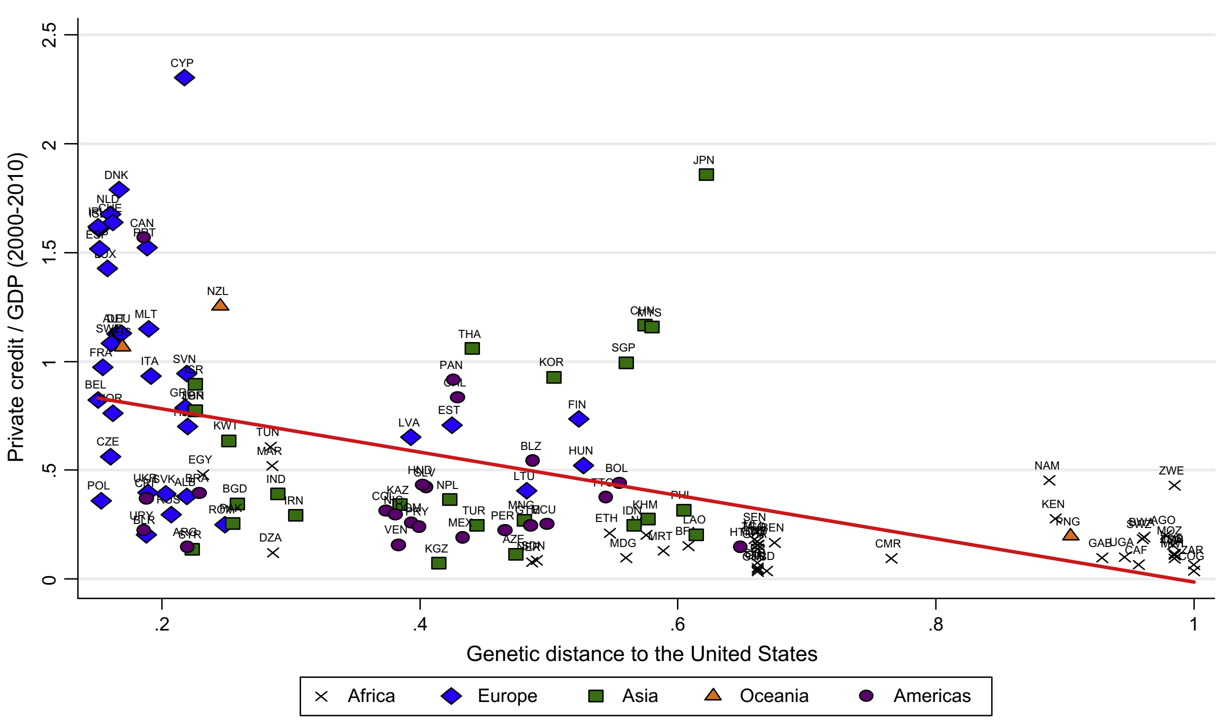

Fig. 2. Financial development and genetic distance to the frontier. *Source*: See description in the text.

Table 1
OLS estimates of the impact of genetic distance to the frontier.

Dep. var. = private credit/GDP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
F_{ST} gen. dist. to the US, weighted	−0.994***	−0.942***	−0.911***	−0.982***	−0.582***	−1.082***	−0.818***	−0.440***
	(−7.62)	(−7.31)	(−8.01)	(−6.23)	(−4.07)	(−8.98)	(−4.85)	(−4.85)
Creditor Rights		0.082***					0.037	0.084
		(3.04)					(1.52)	(1.52)
Trade Openness			0.207*				0.102	0.105
			(1.91)				(0.69)	(0.69)
Financial Openness			0.119**				0.094*	0.363*
			(2.46)				(1.72)	(1.72)
Trade Openness × Financial Openness			−0.024				−0.014	−0.109
			(−1.05)				(−0.48)	(−0.48)
French Legal Origin				−0.296***			−0.148*	−0.151*
				(−3.11)			(−1.80)	(−1.80)
German Legal Origin				0.063			0.042	0.029
				(0.36)			(0.24)	(0.24)
Scandinavian Legal Origin				0.298			0.182	0.074
				(1.44)			(0.61)	(0.61)
Latitude					0.731**		−0.226	−0.092
					(2.35)		(−0.73)	(−0.73)
Tropics					−0.058		−0.237**	−0.208**
					(−0.49)		(−2.44)	(−2.44)
Fraction Catholic						−0.602***	−0.126	−0.095
						(−3.48)	(−0.48)	(−0.48)
Fraction Muslim						−0.874***	−0.418*	−0.282*
						(−5.76)	(−1.76)	(−1.76)
Fraction Other Religion						−0.460**	−0.108	−0.068
						(−2.08)	(−0.36)	(−0.36)
Constant	0.981***	0.810***	0.580***	1.126***	0.589***	1.559***	0.984***	–
	(11.4)	(8.17)	(4.63)	(7.49)	(3.46)	(9.06)	(3.69)	
R^2	0.29	0.32	0.46	0.42	0.35	0.43	0.59	0.59
Observations	123	123	123	123	123	123	123	123

Notes: The dependent variable is private credit to GDP, averaged over the period 2000–2010. Figures in parentheses are *t*-statistics. Robust standard errors are used. Column (8) reports the standardized beta coefficients for the estimates in column (7).
* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

Columns (2–6), individually add the control variables guided by various propositions put forward in the financial development literature. The last two columns add all controls simultaneously. This allows us to gauge the relative importance of genetic distance to the frontier in explaining changes in the levels of financial development while allowing for the effects of other variables which have been found to be influential in the literature.

Column (2) presents the specification that includes creditor rights protection as an additional regressor. Consistent with the findings of Djankov et al. (2007), the results show that a higher level of creditor protection is associated with the presence of deeper financial systems. Such an effect is found to be highly significant. While controlling for the effect of creditor rights protection reduces the size of the coefficient of *GD* marginally, it remains highly significant with the expected sign.

Column (3) includes measures of trade openness (the sum of exports and imports as a share of GDP), financial openness (the sum of foreign assets and liabilities as a share of GDP) and their interaction to test the Rajan-Zingales hypothesis. Except for the interaction term, these variables are found to have some significant individual effects on financial development. Our results are consistent with Baltagi et al. (2009), who find only partial support for this proposition. Importantly, these considerations do not affect our previous findings regarding the effect of *GD* in any significant manner.

Column (4) introduces dummy variables for French, German and Scandinavian legal origin countries in the regression with those with British legal origin as the omitted group, to test the validity of the law and finance theory of La Porta et al. (1997, 1998). Column (5) includes latitude and a climate variable to control for the effect of geographic endowments (Gallup et al., 1999; Acemoglu et al., 2001; Beck et al., 2003). Column (6) adds several religious composition variables, including the shares of Catholics, Muslims or other religions in the populations (Protestantism is the omitted category) as proxies for culture, due to Stulz and Williamson (2003). In all cases, the effect of genetic distance to the frontier remains highly significant at the 1% level.

Column (7) presents a specification that includes the full set of controls, allowing the effects of genetic distance and all other potential determinants of financial development to be jointly estimated. This consideration reduces the estimated effect of genetic distance to the frontier slightly compared to the specification that has no control variables in the first column, but the sign and significance of the coefficient of *GD* do not vary, suggesting that the results from the previous columns are not driven by omitted variable bias. Among the control variables, only financial openness, French legal origin, tropics and the share of Muslim population enter significantly with their expected signs. Additionally, with all control variables included simultaneously, the estimated model now explains 59% of the cross-country variation in financial development.

To facilitate comparisons of the quantitative effect across regressors, column (8) reports the beta coefficients for the estimates in column (7). These coefficients are obtained by first standardizing all variables to have a mean of 0 and a standard deviation of 1. The estimates show that a one standard deviation increase in genetic distance to the frontier lowers the level of financial development by about 0.44 units of a standard deviation. Interestingly, this beta coefficient of *GD* is the highest among all regressors considered, implying that *GD* is the most economically significant determinant of financial development. We interpret these findings as evidence that cultural barriers to the international diffusion of financial innovation from the technological frontier can impose significant impediments to the development of financial systems.

4.2. Endogeneity and instrumental variable estimates

Spolaore and Wacziarg (2009) highlight that the likelihood of measurement errors in the genetic distance measure, which arise from errors in matching genetic groups to current populations and to countries, can lead to attenuation bias in the OLS coefficient of genetic distance. To address this issue, we follow their approach and instrument the current genetic distance using F_{ST} genetic distance to the English population as of 1500. Spolaore and Wacziarg (2009) explain that the matching of populations to countries is much more straightforward for 1500 than for the current period because Cavalli-Sforza et al. (1996), who provide the original source of the genetic data, collected data for populations as they were in 1500 and this mitigates the problem of measurement errors. To the extent that genetic distance to the United Kingdom in 1500 affects financial development only through its effect on the current genetic distance measure, the former will be an appropriate instrument.

Table 2 presents the two-stage least square regression results. The top panel details the second-stage estimates whereas the bottom panel reports the associated first-stage regressions. In Panel B, we find a very strong first-stage relationship between current genetic distance to the United States and genetic distance to the English population as of 1500. In particular, the first-stage *F*-test statistic on the excluded instrument and the partial R^2 in all cases indicate that the instrument is strong and valid. Results from the endogeneity tests also indicate that genetic distance to the United States should be treated as endogenous, thus supporting the use of an instrumental variable approach here.

Results from the second-stage regressions in Panel A reinforce the OLS estimates reported in Table 1. The coefficients of genetic distance to the frontier are found to be highly significant at the 1% level and have the expected negative sign in all cases. The resulting coefficients of *GD* are noticeably larger (in absolute terms) than the OLS counterparts in Table 1, suggesting some evidence of measurement errors. The standardized effect of genetic distance to the frontier reported in column (8) is about 35% higher, and continues to show that *GD* has the largest economic impact on financial development among all regressors considered. Overall,

Table 2
Instrumental variable estimates.

Dep. var. = private credit/GDP	Panel A: Second-stage regressions							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
F_{ST} gen. dist. to the US, weighted	−1.142***	−1.093***	−0.990***	−1.122***	−0.728***	−1.234***	−1.107***	−0.595***
	(−7.07)	(−6.85)	(−7.77)	(−5.69)	(−3.45)	(−8.39)	(−4.67)	(−4.67)
Creditor Rights		0.076***					0.029	0.068
		(2.87)					(1.31)	(1.31)
Trade Openness			0.207*				0.118	0.122
			(1.94)				(0.84)	(0.84)
Financial Openness			0.118**				0.094*	0.361*
			(2.53)				(1.81)	(1.81)
Trade Openness × Financial Openness			−0.024				−0.017	−0.125
			(−1.09)				(−0.58)	(−0.58)
French Legal Origin				−0.318***			−0.152**	−0.155**
				(−3.33)			(−2.01)	(−2.01)
German Legal Origin				0.025			0.049	0.033
				(0.14)			(0.29)	(0.29)
Scandinavian Legal Origin				0.246			0.0641	0.026
				(1.19)			(0.23)	(0.23)
Latitude					0.621*		−0.483	−0.196
					(1.89)		(−1.42)	(−1.42)
Tropics					−0.048		−0.231**	−0.202**
					(−0.42)		(−2.56)	(−2.56)
Fraction Catholic						−0.632***	−0.336	−0.254
						(−3.70)	(−1.25)	(−1.25)
Fraction Muslim						−0.897***	−0.607**	−0.410**
						(−5.99)	(−2.50)	(−2.50)
Fraction Other Religion						−0.469**	−0.267	−0.168
						(−2.15)	(−0.90)	(−0.90)
Constant	1.049***	0.890***	0.619***	1.211***	0.686***	1.647***	1.367***	–
	(10.9)	(8.23)	(4.73)	(7.25)	(3.40)	(9.39)	(4.28)	
R^2	0.279	0.313	0.458	0.416	0.347	0.420	0.584	0.584
Dep. var. = F_{ST} gen. dist. to the US	Panel B: First-stage regressions							
F_{ST} gen. dist. to the UK, 1500 match	0.748***	0.745***	0.755***	0.749***	0.701***	0.747***	0.651***	0.772***
	(28.78)	(27.19)	(29.79)	(27.48)	(14.09)	(27.50)	(11.91)	(11.91)
F-test on Excluded Instrument	828.2	739.1	887.5	755.2	198.5	756.2	141.9	141.9
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Partial R^2	0.79	0.78	0.79	0.76	0.63	0.81	0.56	0.56
Endogeneity test	[0.064]	[0.057]	[0.249]	[0.090]	[0.300]	[0.023]	[0.079]	[0.079]
Observations	123	123	123	123	123	123	123	123

Notes: The dependent variable is private credit to GDP, averaged over the period 2000–2010. The instrument for genetic distance to the United States is genetic distance to the United Kingdom in 1500. Figures in round parentheses are *t*-statistics whereas those in square brackets are *p*-values. Robust standard errors are used. Column (8) reports the standardized beta coefficients for the estimates in column (7).

* Significance at 10% level.

** Significance at 5% level.

*** Significance at 1% level.

Table 3
Alternative measures of financial development.

Dep. var. = Y	OLS (1a)	2SLS (1b)	OLS (2a)	2SLS (2b)	OLS (3a)	2SLS (3b)	OLS (4a)	2SLS (4b)
	Y = domestic credit/ GDP		Y = stock market capitalization/ GDP		Y = stock market value traded/ GDP		Y = stock market turnover ratio	
F_{ST} genetic distance to the US, weighted	−1.027***	−1.307***	−0.760***	−0.898***	−0.639***	−0.739***	−0.607***	−0.905***
	(−4.16)	(−4.17)	(−2.77)	(−2.97)	(−3.04)	(−2.71)	(−2.76)	(−2.56)
R^2	0.53	0.52	0.35	0.35	0.42	0.41	0.34	0.33
Observations	123	123	99	99	96	96	96	96
F-test on Excluded	–	141.9	–	144.7	–	127.2	–	134.7
Instrument	–	[0.000]	–	[0.000]	–	[0.000]	–	[0.000]
Endogeneity Test	–	[0.131]	–	[0.418]	–	[0.586]	–	[0.160]
Standardized Beta	−0.474	−0.603	−0.452	−0.534	−0.392	−0.453	−0.287	−0.427

Notes: The dependent variables are the ratios of domestic credit/GDP, stock market capitalization/GDP, total value of stock traded/GDP and stock market turnover, all of which are averaged over the 2000–2010 period. A constant and all control variables (i.e., creditor rights, trade openness, financial openness, trade openness × financial openness, legal origins dummies, geographic variables and religion variables) used in Tables 1 and 2 are included in the estimations but the results are not reported to conserve space. For the 2SLS estimates, the instrument for genetic distance to the United States is genetic distance to the United Kingdom in 1500. Standardized beta refers to the beta coefficient of F_{ST} genetic distance to the frontier measure. Figures in round parentheses are t-statistics whereas those in square brackets are p-values. Robust standard errors are used.
* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

Table 4
Estimates based on alternative sample periods.

$Dep.\ var.$ = private credit/GDP	OLS (1a)	2SLS (1b)	OLS (2a)	2SLS (2b)	OLS (3a)	2SLS (3b)	OLS (4a)	2SLS (4b)
	(1) 1980–2010		(2) 1985–2010		(3) 1990–2010		(4) 1995–2010	
F_{ST} gen. dist. to the US, weighted	−0.605***	−0.808***	−0.648***	−0.859***	−0.702***	−0.930***	−0.774***	−1.042***
	(−4.27)	(−4.42)	(−4.27)	(−4.42)	(−4.36)	(−4.48)	(−4.59)	(−4.67)
R^2	0.555	0.546	0.557	0.549	0.558	0.550	0.567	0.558
Observations	123	123	123	123	123	123	123	123
F-test on Excluded Instrument	–	141.9	–	141.9	–	141.9	–	141.9
		[0.000]		[0.000]		[0.000]		[0.000]
Endogeneity Test	–	[0.085]	–	[0.092]	–	[0.091]	–	[0.067]
Standardized Beta	−0.446	−0.596	−0.446	−0.591	−0.447	−0.592	−0. 453	−0.611

Notes: The dependent variables are the ratios of private credit to GDP, averaged over various sample periods. A constant and all control variables (i.e., creditor rights, trade openness, financial openness, trade openness × financial openness, legal origins dummies, geographic variables and religion variables) used in Tables 1 and 2 are included in the estimations but the results are not reported to conserve space. For the 2SLS estimates, the instrument for genetic distance to the United States is genetic distance to the United Kingdom in 1500. Standardized beta refers to the beta coefficient of F_{ST} genetic distance to the frontier measure. Figures in round parentheses are t-statistics whereas those in square brackets are p-values. Robust standard errors are used.
* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

the 2SLS findings along with those reported previously suggest that genetic distance to the frontier has a statistically and economically significant effect in retarding financial development across countries.

5. Robustness checks

In this section, we perform several robustness checks on the baseline specification in column (7) of Tables 1 and 2. These checks include using alternative financial development indicators, considering different measures of genetic distance and technological frontier, adding other variables which can potentially proxy the effects of diffusion barriers, and using alternative samples.

5.1. Alternative indicators of financial development

While the ratio of private credit to GDP is most widely used in the literature, financial development can also be captured using the ratios of domestic credit/GDP, stock market capitalization/GDP, total value of stock traded/GDP and stock market turnover. The OLS and 2SLS estimates for regressing Eq. (1) using these alternative measures are reported in Table 3. Consistent with the benchmark results in column (7) of Tables 1 and 2, the coefficients of genetic distance to the frontier are found to have an economically large and significant influence in shaping current financial development in all cases. Sizes of the coefficients of GD are smaller when stock market-based measures are used, suggesting that diffusion barriers are perhaps more influential for banking sector development. Nevertheless, the qualitative aspect of these results suggests that the effect of GD on financial development is not sensitive to how the latter is measured.

5.2. Financial development covering alternative sample periods

In the previous analyses, we have used the average ratio of private credit to GDP over the period 2000–2010. Defining the average ratio over this particular period may seem ad hoc, and therefore it is necessary to check if the results are sensitive to alternative time periods. Consequently, we also consider the following periods: (1) 1980–2010; (2) 1985–2010; (3) 1990–2010; and (4) 1995–2010 to provide a robustness check. The estimates reported in Table 4 suggest that the qualitative aspect of our results is

Table 5
Estimates excluding the crisis period.

Dep. var. = *Y* (2000–2006)	OLS (1a) *Y* = private credit/GDP	2SLS (1b)	OLS (2a) *Y* = stock market capitalization/ GDP	2SLS (2b)	OLS (3a) *Y* = stock market value traded/ GDP	2SLS (3b)	OLS (4a) *Y* = stock market turnover ratio	2SLS (4b)
F_{ST} genetic distance to the US, weighted	−0.814***	−1.016***	−0.712**	−0.780**	−0.592***	−0.721***	−0.572**	−0.849**
	(−4.66)	(−4.32)	(−2.49)	(−2.55)	(−2.99)	(−2.70)	(−2.12)	(−1.96)
R^2	0.541	0.536	0.393	0.392	0.418	0.416	0.281	0.276
Observations	123	123	99	99	96	96	96	96
F-test on Excluded	–	141.9	–	144.7	–	127.2	–	134.7
Instrument	–	[0.000]	–	[0.000]	–	[0.000]	–	[0.000]
Endogeneity Test	–	[0.206]	–	[0.666]	–	[0.448]	–	[0.244]
Standardized Beta	−0.459	−0.573	−0.413	−0.453	−0.382	−0.465	−0.239	−0.355

Notes: The dependent variables are the ratios of private credit/GDP, stock market capitalization/GDP, total value of stock traded/GDP and stock market turnover, all of which are averaged over the 2000–2006 period. A constant and all control variables (i.e., creditor rights, trade openness, financial openness, trade openness × financial openness, legal origins dummies, geographic variables and religion variables) used in Tables 1 and 2 are included in the estimations but the results are not reported to conserve space. For the 2SLS estimates, the instrument for genetic distance to the United States is genetic distance to the United Kingdom in 1500. Standardized beta refers to the beta coefficient of F_{ST} genetic distance to the frontier measure. Figures in round parentheses are *t*-statistics whereas those in square brackets are *p*-values. Robust standard errors are used.
* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

Table 6
Controlling for other effects.

	Add Ethnic Fractionalization		Add Institutions		Add Social Capital		Add Income		Add Continents	
	(1a) OLS	(1b) 2SLS	(2a) OLS	(2b) 2SLS	(3a) OLS	(3b) 2SLS	(4a) OLS	(4b) 2SLS	(5a) OLS	(5b) 2SLS
F_{ST} genetic distance to the US, weighted	−0.751***	−1.022***	−0.406**	−0.734***	−0.722***	−0.840***	−0.358	−0.672**	−0.755***	−1.025***
	(−3.93)	(−4.03)	(−2.12)	(−2.95)	(−3.69)	(−3.03)	(−1.59)	(−2.12)	(−3.17)	(−3.86)
Ethnic Fractionalization	−0.325*	−0.288*								
	(−1.78)	(−1.72)								
Institutions			0.077***	0.068***						
			(5.29)	(4.46)						
Social Capital					0.817**	0.780**				
					(2.18)	(2.19)				
Logs GDP per capita (PPP)							0.204***	0.175***		
							(4.05)	(3.24)		
Africa									−0.127	−0.014
									(−0.63)	(−0.08)
Europe									−0.028	−0.034
									(−0.12)	(−0.17)
Asia									0.102	0.163
									(0.57)	(1.10)
America									−0.173	−0.166
									(−0.84)	(−0.95)
R^2	0.611	0.603	0.702	0.692	0.635	0.633	0.68	0.67	0.614	0.610
Observations	123	123	123	123	94	94	122	122	123	123
F-test on Excluded	–	127.7	–	100.9	–	114.7	–	80.2	–	159.1
Instrument		[0.000]		[0.000]		[0.000]		[0.000]		[0.000]
Endogeneity Test	–	[0.129]	–	[0.052]	–	[0.532]	–	[0.128]	–	[0.127]
Standardized Beta	−0.404	−0.550	−0.218	−0.395	−0.351	−0.409	−0.190	−0.355	−0.406	−0.551

Notes: The dependent variable is the ratio of private credit to GDP, averaged over the 2000–2010 period. A constant is included in the regressions but is not reported. Figures in parentheses are *t*-ratios based on heteroskedasticity-robust standard errors. Figures in square brackets are *p*-values. All control variables (i.e., creditor rights, trade openness, financial openness, trade openness × financial openness, legal origins dummies, geographic variables and religion variables) used in Tables 1 and 2 are included in the estimations but the results are not reported to conserve space. The instruments in all columns for the genetic distance to the US are the genetic distance to the English in 1500. Endogeneity tests the null hypothesis of the exogeneity of the instrumented variable. Standardized beta refers to the beta coefficients of F_{ST} genetic distance.
* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

insensitive to this consideration. In other words, the coefficients of *GD* remain positive and are very precisely estimated in all cases.

In addition, the default period covers the turbulent time of the global financial crisis of 2007–2009, which may bias our analysis. We therefore also try to exclude the crisis years by restricting the period to 2000–2006, while constructing the measures of financial development. The results reported in Table 5 regarding how *GD* affects or is correlated with the private credit ratio and the various stock market-based indicators remains unchanged, thus providing further credence to our findings.

5.3. Controlling for other effects

Table 6 reports the results after controlling for the effects of ethnic diversity, institutions, social capital, income levels, and continent specific unobserved heterogeneity. Columns (1a) and (1b)

Table 7
Other robustness checks.

	Exclude OECD		Exclude Neo-Europes		F_{ST} gen. dist. to the UK		F_{ST} gen. dist. to the G7		Nei gen. dist. to the US	
	(1a) OLS	(1b) 2SLS	(2a) OLS	(2b) 2SLS	(3a) OLS	(3b) 2SLS	(4a) OLS	(4b) 2SLS	(5a) OLS	(5b) 2SLS
F_{ST} gen. dist. to the US, weighted	−0.648***	−0.939***	−0.743***	−1.171***						
	(−3.70)	(−3.71)	(−4.20)	(−5.25)						
F_{ST} gen. dist. to the UK, weighted					−0.695***	−0.932***				
					(−5.08)	(−4.65)				
F_{ST} gen. dist. to the G7, weighted							−0.806***	−1.052***		
							(−5.73)	(−4.65)		
Nei gen. dist. to the US, weighted									−0.670***	−0.907***
									(−3.37)	(−3.43)
R^2	0.499	0.482	0.590	0.570	0.594	0.586	0.601	0.594	0.572	0.565
Observations	91	91	120	120	123	123	123	123	123	123
F-test on Excluded Instrument	–	118.8	–	183.5	–	149.2	–	151.5	–	98.65
		[0.000]		[0.000]		[0.000]		[0.000]		[0.000]
Endogeneity Test	–	[0.021]	–	[0.001]	–	[0.090]	–	[0.131]	–	[0.162]
Standardized Beta	−0.491	−0.711	−0.408	−0.644	−0.445	−0.596	−0.479	−0.625	−0.360	−0.488

Notes: The dependent variable is the ratio of private credit to GDP, averaged over the 2000–2010 period. A constant is included in the regressions but not reported. Figures in parentheses are *t*-ratios based on heteroskedasticity-robust standard errors. Figures in square brackets are *p*-values. All control variables (i.e., creditor rights, trade openness, financial openness, trade openness × financial openness, legal origins dummies, geographic variables and religion variables) used in Tables 1 and 2 are included in the estimations but the results are not reported to conserve space. The instruments in all columns for the genetic distance to the US are the genetic distance to the English in 1500. Endogeneity tests the null hypothesis of the exogeneity of the instrumented variable. Standardized beta refers to the beta coefficients of the genetic distance measures.
* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

show the results of including ethnic fractionalization as a control variable. This variable measures the probability that two randomly selected individuals from a country's population will belong to different ethnic groups (Alesina et al., 2003). Easterly and Levine (2003) and Beck et al. (2003) argue that greater ethnic diversity tends to retard financial development, given that in highly ethnically diverse societies the ruling elites are more likely to develop policies and institutions that are aimed at preserving their power and controlling rather than creating an open and competitive financial system. The OLS and 2SLS estimates show that ethnic fractionalization enters with a negative sign, and is statistically significant at the 10% level. This result suggests that greater ethnic diversity does indeed adversely affect financial development. However, the inclusion of the ethnic fractionalisation variable does not change our core finding that the effect of *GD* remains highly significant.

The next two columns allow for the effects of institutional quality, which is measured as the sum of the indices of voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption, along the line of Ang (2013b). The data are taken from Kaufmann et al. (2010). The theoretical model of Andrianova et al. (2008) shows that better institutions improve depositors' confidence in private banking institutions, which enhances financial development. In line with this proposition, the empirical results of Girma and Shortland (2008) show that financial development can be promoted by democracy. A more recent study by Ang (2013a) also finds considerable evidence to support the notion that the presence of early state institutions shapes subsequent development of the financial system. Including a measure of institutions allows us to examine whether the effect of genetic distance on financial development operates through the development of an institutional framework. For both the OLS and 2SLS estimates reported in columns (2a) and (2b), respectively, the institutional quality variable is found to have a positive and statistically significant effect at the 1% level, suggesting that better institutional quality facilitates financial development. While the inclusion of this institutional variable reduces the quantitative effect of genetic distance, qualitatively this effect remains statistically highly significant.

Columns (3a) and (3b) demonstrate the robustness of the results to the inclusion of a social capital variable. Social capital refers to the features of social organization, such as trust, norms, and networks, which can improve the efficiency of society by facilitating coordinated action (Putnam, 1993). We use generalized trust as a measure of informal institutions. These data are taken from Bjørnskov (2008) who obtains them primarily from the World Values Survey but supplemented from other sources. The importance of social capital for financial development has been highlighted by Guiso et al. (2004), who provide empirical evidence showing that a higher level of social capital, as characterized by the presence of high levels of trust and holding of less cash among households, is associated with higher levels of investment, the use of more checks and greater access to institutional credit in various districts of Italy. Consistent with the literature, our results indicate that social capital enters with a positive and significant sign, implying that increasing trust is associated with higher levels of financial development. However, the coefficient of *GD* remains highly statistically significant, even after controlling for the effect of social capital.

Columns (4a) and (4b) include the level of income in 2000 as an additional regressor.[2] While the OLS coefficient of *GD* becomes insignificant at any conventional levels, its 2SLS counterpart remains statistically significant at the 5% level. This result supports the demand-following hypothesis of Robinson (1952). Finally, the last two columns examine the robustness of the baseline result by including continental dummies as additional regressors. This allows us to check if the presence of continent-specific unobserved effects has influenced the results. The results do not significantly vary when dummies for Africa, Europe, Asia and the Americas (Oceania is the excluded group) are included in the regressions.

5.4. Alternative country samples

To further assess the robustness of the results, we exclude all OECD countries from the total sample, given that these countries typically have high levels of financial development and similar genetic characteristics. Similarly, the neo-Europes, consisting of

[2] The estimations here involve only 122 observations since data on GDP per capita in 2010 (PPP, constant 2005 international dollars) for Zimbabwe is not available. For the same reason, the number of countries included in the regressions reported in Table 8 is also one less than those employed in the baseline regressions.

Table 8
2SLS regressions of log GDP per capita.

Dep. var. = logs of per capita GDP	Panel A: Second-stage regressions							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Private Credit/GDP	3.298***	2.570***	2.642***	1.456***	2.349***	3.354***	3.007***	2.569***
	(8.36)	(4.89)	(5.43)	(3.94)	(5.16)	(7.68)	(6.05)	(9.25)
Creditor Rights		0.0263		0.131**	0.011	−0.003	−0.005	
		(0.37)		(2.09)	(0.18)	(−0.038)	(−0.061)	
Trade Openness		0.201	0.207		0.212	0.189	0.200	
		(0.70)	(0.71)		(0.83)	(0.51)	(0.62)	
Financial Openness		−0.331***	−0.338***		−0.315***	−0.390***	−0.351***	
		(−3.33)	(−3.41)		(−3.56)	(−3.40)	(−3.45)	
Trade Openness × Financial Openness		0.0847	0.0847		0.0799	0.0864	0.0853	
		(1.54)	(1.49)		(1.63)	(1.33)	(1.51)	
French Legal Origin		0.284	0.276	0.170		0.450*	0.498**	
		(1.41)	(1.37)	(0.91)		(1.94)	(2.46)	
German Legal Origin		0.0404	0.0308	0.146		0.212	0.128	
		(0.13)	(0.095)	(0.65)		(0.53)	(0.32)	
Scandinavian Legal Origin		0.0340	−0.0123	0.750		−0.0695	−0.0319	
		(0.046)	(−0.017)	(1.58)		(−0.079)	(−0.041)	
Latitude		0.878	0.867	1.067	1.034		0.699	
		(1.14)	(1.10)	(1.29)	(1.52)		(0.83)	
Tropics		−0.260	−0.242	−0.656**	−0.325		−0.0612	
		(−0.76)	(−0.71)	(−2.21)	(−1.07)		(−0.19)	
Fraction Catholic		0.416	0.394	1.181***	0.689	0.0735		
		(0.77)	(0.71)	(2.75)	(1.53)	(0.11)		
Fraction Muslim		−0.0502	−0.0492	0.257	0.126	−0.0738		
		(−0.10)	(−0.098)	(0.61)	(0.27)	(−0.12)		
Fraction Other Religion		−0.317	−0.327	0.379	−0.193	−0.531		
		(−0.58)	(−0.58)	(0.89)	(−0.40)	(−0.77)		
Constant	7.047***	7.321***	7.355***	6.955***	7.408***	7.339***	7.074***	7.426***
	(35.6)	(14.0)	(13.4)	(15.3)	(13.8)	(10.9)	(17.9)	(48.6)
R^2	0.25	0.62	0.61	0.69	0.65	0.43	0.51	0.45
Excluded Instruments	GD	GD	GD + cred. rights	GD + trade & fin.open.	GD + legal orig.	GD + geo. endow.	GD + religion	GD + all controls
Dep. var. = Private Credit/GDP	Panel B: First-stage regressions							
F_{ST} gen. dist. to the US	−1.022***	−0.846***	−0.846***	−0.846***	−0.846***	−0.846***	−0.846***	−0.846***
	(7.78)	(4.85)	(4.85)	(4.85)	(4.85)	(4.85)	(4.85)	(4.85)
F-test on Excluded Instrument	60.5	23.5	13.4	13.1	10.1	16.9	11.1	16.1
Partial R^2	0.29	0.15	0.18	0.30	0.20	0.31	0.22	0.59
Endogeneity Test	[0.000]	[0.002]	[0.249]	[0.242]	[0.003]	[0.000]	[0.000]	[0.000]
Observations	122	122	122	122	122	122	122	122
Over-identifcation	–	–	[0.714]	[0.000]	[0.453]	[0.301]	[0.095]	[0.027]

Notes: The dependent variable is the logs of per capita GDP (PPP) in 2010. The instrument for the private credit ratio is genetic distance to the United States. Figures in round parentheses are *t*-statistics whereas those in square brackets are *p*-values. Robust standard errors are used.
* Significance at 10% level.
** Significance at 5% level.
*** Significance at 1% level.

Australia, Canada, New Zealand and the United States, are also excluded from the analysis to check if the results are driven by the effects of massive migration. It is evident from the estimates reported in Table 7 that our core results are unaffected by these considerations.

5.5. Alternative measures for genetic distance to the frontier

The analyses so far have considered the United States as the global technological leader. To the extent that significant innovations also occur in other advanced nations, the use of the United States as the only frontier may be somewhat restrictive. Consequently, we also use the UK and the G7 as the alternative global frontiers. In the latter, an overall genetic distance to the frontiers is constructed by taking the simple average of the genetic distances to all seven leaders. Columns (3a) to (4b) show that the results are not driven by the assumed identity of the global leader.

Finally, while the F_{ST} measure of genetic distance is most commonly used in the literature, we also present results using an alternative measure of genetic distance based on the *Nei* approach using data from Spolaore and Wacziarg (2009). The *Nei* genetic distance approach considers the case that genetic variations which emerge are driven by genetic drift and mutations. Cavalli-Sforza et al. (1996) argue that, compared to the *Nei* measure, F_{ST} is a more precise indicator of genetic distance under the condition that only a few new mutations develop within the period under investigation, which is precisely the case of the evolutionary time period of modern humans. As such, we use the F_{ST} measure as our default indicator for human genetic distance, but check the results using this alternative indicator. Again, the results are largely similar to our baseline estimates when the *Nei* approach is used.[3]

6. Genetic distance, financial development and current output

Previous findings by Spolaore and Wacziarg (2009) suggest that genetic distance to the frontier and current income are highly correlated. However, it is plausible that this correlation reflects

[3] See Cavalli-Sforza et al. (1996, p. 27) for technical details on the derivation of the *Nei* formula.

the effect of cultural barriers to the diffusion of financial knowledge working through financial development. If this is the case, differences in genetic distance to the frontier can be a source of exogenous variations in financial development when estimating its effect on current income. Accordingly, this possibility is tested by using *GD* along with other determinants of financial development considered in the previous sections as instruments for the ratio of private credit to GDP. Table 8 reports the results based on several different identification assumptions.

Specifically, column (1) uses as the only instrument for financial development without including any control variables. Column (2) uses the same strategy but includes all controls stated in Eq. (1). Each group of control variables is then separately added to columns (3) to (7) and jointly in column (8) as instruments. The results highlight the following. First, the coefficients of private credit ratio are found to be highly significant and have the expected positive sign in all regressions. Second, genetic distance to the frontier is found to be a strong and valid instrument in all cases, as shown in the first-stage F-statistics. The results are most satisfactory when only is used as the instrument (columns (1) and (2)). Third, including any additional instruments in columns (3) to (8) does not improve the results of the first-stage regressions, as indicated by the partial R-squared statistics. In half of the cases, over-identification tests suggest that these additional instruments appear to be weak. Taken together, these results suggest that the effect of genetic distance on income works through financial development, and genetic distance appears to be the best instrument.

7. Summary and conclusion

We investigated whether variations in the levels of financial development across countries can be attributed to the international diffusion barriers to financial innovations due to genealogical differences. To our knowledge, this is the first study that documents a link between these two variables. We use genetic distance to the global technology frontier, which reflects the degree of historical relatedness between the population of the frontier country and the population of the country under consideration, as a summary measure for cultural barriers to the diffusion of financial technology. A greater genetic distance to the frontier reflects greater genealogical unrelatedness between the technology leader and the country under consideration or a longer separation time between their populations. The longer two populations have been separated, the more they are expected to differ in their traits, characteristics, and norms (such as customs, habits, beliefs, values) which are passed on across generations over a long period of time. This divergence in traits between populations therefore acts as a barrier, which impedes the diffusion of financial knowledge across borders.

Using a cross-sectional sample for 123 countries, we find evidence that endorses the proposition that genetic distance to the technological frontier exerts a large negative influence on financial development. The results prevail even after controlling for creditor rights, trade openness, financial openness, legal origins, geographic factors and religions – variables which have been found to be influential for financial development in the literature. The findings are qualitatively identical when an instrumental variable approach is used to account for the endogeneity of genetic distance to the frontier with respect to financial development. Furthermore, the effect of genetic distance to the frontier on financial development also remains consistent when several other robustness checks are carried out. These include using alternative indicators of financial development, considering different measures of genetic distance to the technology frontier, restricting the sample, and adding ethnic fractionalization, the quality of institutions, social capital, or continent fixed effects as additional controls.

Overall, the results are consistent with our interpretation of genetic distance to the frontier as capturing cultural barriers to the diffusion of financial innovations, where societies that are genetically more distant from the frontier tend to face a higher cost of imitating and adopting financial knowledge, thus hindering the development of their financial systems. Furthermore, there is also some evidence supporting the role of financial system development as a causal mechanism of cultural diffusion barriers affecting current income.

This is the first paper that attempts to examine the effect of genetic distance on financial development by providing an interpretation in terms of barriers to the diffusion of financial innovation. Our work should be placed in the context of an extensive literature that seeks to identify forces that promote financial development (e.g., La Porta et al., 1997, 1998; Beck et al., 2003; Stulz and Williamson, 2003; Ang, 2013a). Future work in this direction might consider the potential role of long-term genealogical relatedness. Moreover, it would be interesting to link our research to an emerging literature that focuses on the importance of culture for promoting financial development (see, e.g., Guiso et al., 2008).

A useful extension would be to adopt a microeconomic framework to investigate how genetic distance is related to the spread of different types of financial (i.e., institutional, process or product) innovations. Future efforts could also be directed at shedding some light on which types of barriers (e.g., communication difficulties, lack of trust, or differences in customs, morals, traits, norms, habits and beliefs) prevent the adoption of financial knowledge developed at the frontier.

A final remark concerns the policy implications of our results. Some critics may argue that the knowledge about whether genetic distance accounts for differences in the level of financial development provides little guidance for policy formulation, given that genetic distance cannot be changed, at least in the short run. While it is true that genetic distance cannot be easily reduced by government policy, the magnitude of its deleterious effect on financial development could be ameliorated through the adoption of an appropriate policy mix. In particular, significant improvements in financial development could be achieved by implementing policies that offset the barriers to diffusion. These include but are not limited to efforts aimed at facilitating the transfer of financial innovations horizontally into different cultural traditions, bridging cultural gaps, fostering financial openness, and the exchange of ideas and human capital.

Acknowledgement

Comments and suggestions received from two referees of this journal are much appreciated.

Appendix A. Data sources and summary statistics of variables

See Tables A1 and A2.

Appendix B. Definition of F_{ST} genetic distance

B.1. Construction of F_{ST} genetic distance measure at the population level

This section describes how the measures F_{ST} distance used throughout the paper are constructed. The basic unit of analysis for measuring the global genetic difference between two populations is the allele. An allele is one of a number of alternative forms of the same genetic locus. For example, the ABO blood group

Table A1
Definitions and Sources of variables.

Variables	Definition	Source
Private credit	Value of financial intermediaries credits to the private sector as a share of GDP (excludes credit to the public sector and credit issued by central and development banks), average over 2000–2010	World Bank WDI online database; Beck et al. (2010)
Domestic credit	Comprised of private credit as well as credit to the public sector (central and local governments and public enterprise) as a share of GDP, average over 2000–2010	World Bank WDI online database; Beck et al. (2010)
Stock market capitalization	Value of listed companies shares on domestic exchanges as a share of GDP, average over 2000–2010	World Bank WDI online database; Beck et al. (2010)
Total value of stock market trade	Total value of domestic shares traded (on domestic exchanges) during the period as a share of GDP, average over 2000–2010	World Bank WDI online database; Beck et al. (2010)
Stock market turnover ratio	Ratio of trades in domestic shares divided by market capitalization, average over 2000–2010	World Bank WDI online database; Beck et al. (2010)
Genetic distance to the US or UK (weighted)	The F_{ST} genetic distance between the current national population of a given country and the US (or UK), calculated as the average pairwise genetic distance across all ethnic group pairs, where each pair is composed of two distinct ethnic groups, one from each country, and is weighted by the product of the proportional representations of the two groups in their respective national populations. The measure of genetic distance captures the general relatedness of the population of a particular country to that of the technological frontier	Spolaore and Wacziarg (2009)
Genetic distance to the UK (1500 match)	The F_{ST} genetic distance between the populations of a given country and the UK in the year 1500, calculated as the genetic distance between the two ethnic groups comprising the largest shares of each country's population in the year 1500	Spolaore and Wacziarg (2009)
Creditor rights	An index of the protection of creditor rights in 2000. It reflects the ease with which creditors can secure assets in the event of bankruptcy. It takes on discrete values of 0 (weak creditor rights) to 4 (strong creditor rights)	Djankov et al. (2007)
Trade openness	Sum of exports and imports of goods and services as a share of GDP in 2000	World Bank WDI online database
Financial openness	Sum of gross stock of foreign assets and liabilities as a share of GDP in 2000	Lane et al. (2007)
Legal Origins	Dummy variable that takes a value of one if a country's legal system is of French, German or Scandinavian Civil Law origin and zero otherwise	La Porta et al. (2008)
Latitude	Absolute value of the latitude of a country, scaled between zero and one, where zero is for the location of the equator and one is for the poles	La Porta et al. (1999)
Tropics	The percentage of land area classified as tropical and subtropical based on the Koeppen-Geiger system	Gallup et al. (1999)
Religion variables	A set of three variables that identifies the percentage of a country's population in the 1980s that follows Catholic, Muslim and Other religion	La Porta et al. (1999)
Ethnic Fractionalization	An index of ethnic fractionalization, constructed as one minus the Herfindahl index of the share of the largest ethnic groups. It reflects the probability that two individuals, selected at random from a country's population, will belong to different ethnic groups. The index ranges from 0 to 1 where the higher the value the greater the fractionalization in a country	Alesina et al. (2003)
Institutional Quality	An overall indicator of institutional quality measured as the sum of the six sub-indices for 2000 from World Bank Governance Indicators (WBGI): voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. Countries with higher values on this index have institutions of greater quality	Kaufmann et al. (2010)
Social Capital	Data on trust between individuals in a given country. Measured by taking the percentage of a population that answers 'Yes' to the World Value Survey (WVS) question 'In general, do you think that most people can be trusted?', supplemented by data from the Danish Social Capital Project, the Latinobarometro and the Afrobarometer	Bjørnskov (2008)

Table A2
Summary statistics.

Variable	Obs.	Mean	Std. dev.	Min	Max
(1) Private Credit	123	0.520	0.488	0.035	2.303
(2) F_{ST} gen. dist. to USA, weighted	123	0.464	0.262	0.151	1
(3) F_{ST} gen. dist. to UK (1500 match)	123	0.441	0.311	0	1
(4) Creditor Rights	123	1.792	1.112	0	4
(5) Trade Openness	123	0.838	0.501	0.205	3.720
(6) Financial Openness	123	1.999	1.882	0.425	13.145
(7) Catholic	123	0.353	0.369	0	0.973
(8) Muslim	123	0.206	0.329	0	0.994
(9) Other Religion	123	0.315	0.307	0.003	1
(10) Latitude	123	0.304	0.198	0.011	0.722
(11) Tropics	123	0.373		0	1
(12) French Legal Origin	123	0.577		0	1
(13) German Legal Origin	123	0.122		0	1
(14) Scandinavian Legal Origin	123	0.041		0	1

Notes: the standard deviations for dummy variables are not reported.

system, discovered more than one century ago, comprises three alleles of the same gene, namely A, B and O. The variation in these allele frequencies can be clearly distinguished among different peoples. These differences are sampled and used to compute aggregate measures of genetic distance between populations.

Next, we illustrate the construction of F_{ST} for a given locus with A alleles (see Cavalli-Sforza et al., 1996, pp. 25–30 for details). The Hardy-Weinberg theorem states that $\sum_a^A p_{ab} = 1$, where p_{ab} is the gene frequency of allele a in population b. The homozygosity (the probability that two randomly chosen alleles at a given locus

Table A3
Genetic distances between populations.

Population	East African	Indian	Japanese	Korean	Malaysian	Southern Chinese	English	Italian	North American	Australian
East African	0									
Indian	0.1078	0								
Japanese	0.1345	0.0718	0							
Korean	0.1475	0.0681	0.0137	0						
Malaysian	0.1216	0.1130	0.1175	0.1001	0					
Southern Chinese	0.1664	0.0847	0.0541	0.0498	0.0635	0				
English	0.1163	0.0280	0.1244	0.0982	0.1275	0.1152	0			
Italian	0.1234	0.0261	0.1145	0.0936	0.1599	0.1236	0.0051	0		
North American	0.1358	0.0752	0.0721	0.0762	0.1726	0.1250	0.0947	0.0954	0	
Australian	0.2131	0.1176	0.0821	0.0850	0.1665	0.1081	0.1534	0.1413	0.1264	0

Notes: The above table presents only a subset of 10 of the 42 populations reported in Cavalli-Sforza et al. (1996, p. 75).

within the population will be different) of population b is $H_b = \sum_a^A p_{ab}^2$, and the heterozygosity (the probability that they are identical) of population b is $h_b = 1 - H_b$.

For a cluster of B populations, the average gene frequency of allele a is given as $\bar{p}_a = \sum_{b=1}^B p_{ab}/B$. Considering n_b as the number of individuals in a sample of population b, the average gene frequency of allele a weighted by sample size is $\bar{p}_a = \sum_{b=1}^B n_b p_{ab}/\sum n_b$. The heterozygosity of a population cluster can be expressed as $h = 1 - \sum_a^A (\bar{p}_a)^2$ when the subdivisions in N populations are not considered. The average heterozygosity of B population is $h_B = \sum_{b=1}^B h_b/B$.

Finally, genetic distance measures the variation in the gene frequencies of populations, and is calculated as $F_{ST} = (h - h_B)/h$. F_{ST} takes a value equal to zero if the allele distributions are identical across the populations, whereas it is positive when they are different. A higher F_{ST} is associated with larger variation in the allele frequencies across the populations. Spolaore and Wacziarg (2009) note that F_{ST} distance reflects the duration in which two populations have separated from each other, and hence is a measure of genealogical relatedness between populations.

The F_{ST} genetic distance data used in Spolaore and Wacziarg (2009) are derived from Cavalli-Sforza et al. (1996), who provide data on bilateral genetic distances based on 120 alleles for a set of 42 world populations. Among them, the greatest genetic distance is estimated to be between Mbuti Pygmies and Papua New Guineans (F_{ST} is 0.4573) and the smallest is between the Danish and the English (F_{ST} is 0.0021). Table A3 reports a subset of these data for only 10 populations due to space considerations. The complete set of data are reported in Cavalli-Sforza et al. (1996, p. 75).

B.2. Measuring F_{ST} genetic distance at the country level

Since these data are available at the population level and not at the country level, the ethnic composition data by country from Alesina et al. (2003) were used to match populations to countries. All 1120 country-ethnic group categories provided by Alesina et al. (2003) were successfully matched, except in cases where the groups are labeled as "others". They usually represent only a small share of a country's population, and were not matched to any genetic group due to the lack of information.

Spolaore and Wacziarg (2009) construct two measures of F_{ST}: (1) genetic distance between plurality groups; (2) weighted genetic distance. The first measure is simply the genetic distance between the groups with the largest shares of each country's population. The second measure takes into consideration the shares of all populations in each country. To illustrate the construction of the weighted measure, consider two countries in which country x has populations $i = 1, 2, \ldots, I$ and country y has populations $j = 1, 2, \ldots, J$, the weighted F_{ST} genetic distance between countries x and y developed by Spolaore and Wacziarg (2009) is given as follows.

$$F_{st}(weighted) = \sum_{i=1}^{I}\sum_{j=1}^{J}(pop.sh._{x,i} \times pop.sh._{y,j} \times gen.dist._{ij}) \quad \text{(A1)}$$

where $pop.sh._{x,i}$ is the share of population i in country x, $pop.sh._{y,j}$ is the share of population j in country y, $gen.dist._{ij}$ is the genetic distance between population i and j. Data on *pop.sh.* are available from Alesina et al. (2003) whereas the estimates of $gen.dist._{ij}$ are given by Cavalli-Sforza et al. (1996), as described above. Spolaore and Wacziarg (2009) state that this measure reflects the expected genetic distance between one randomly chosen individual from country x and another one randomly selected from country y. This weighted measure is preferred since it is a more precise indicator of the average genetic distance between two countries, and is therefore used throughout the paper.

B.3. An example

For illustrative purpose, consider the case of Korea and Singapore. In the ethnic composition data provided by Alesina et al. (2003), the population in Korea consist of 99.9% of Koreans and 0.1% of "others" whereas the populations of Singapore are made up of 76.7% of Chinese, 14% of Malays, 7.9% of Indians, and 1.4% of "others". Using Eq. (A1) and the data reported in Table A3, the weighted F_{ST} measure of Spolaore and Wacziarg (2009) can be computed as follows:

$$F_{ST}(weighted) = (0.767 \times 0.999 \times 0.0498) + (0.14 \times 0.999 \times 0.1001) + (0.079 \times 0.999 \times 0.0681) = 0.058$$

In the above calculation, "others" are not matched to the genetic distance data of Cavalli-Sforza et al. (1996). The plurality value is simply 0.0498, which is the genetic distance between Chinese and Koreans, which are respectively the largest population groups in China and Korea. Note that for F_{ST} genetic distance between countries as of 1500 AD, which is used as an instrument for its contemporary counterpart in the 2SLS estimations, the indicator refers only to plurality groups since data on ethnic composition in 1500 AD are not available.

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