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# **Cross-Country Growth Spillovers: Separating the Impact of Cultural Distance from Geographical Distance**

**Azam Chaudhry, Rabia Ikram**



**Centre for Research in Economics and Business  
Lahore School of Economics**

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## Lahore School of Economics

Intersection Main Boulevard Phase VI, DHA and Burki Road  
Lahore 53200, Pakistan  
Tel: 042-36561230; 042-36560936  
Email: creb@lahoreschool.edu.pk

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Department of Economics  
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Lahore School of Economics  
Intersection of Main Boulevard, Phase VI, DHA and Burki Road  
Lahore 53200, Pakistan  
Tel.: +92 42 3656 1230  
creb@lahoreschool.edu.pk  
www.creb.org.pk

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## **Preface**

The Centre for Research in Economics and Business (CREB) was established in 2007 to conduct policy-oriented research with a rigorous academic perspective on key development issues facing Pakistan. In addition, CREB (i) facilitates and coordinates research by faculty at the Lahore School of Economics, (ii) hosts visiting international scholars undertaking research on Pakistan, and (iii) administers the Lahore School's postgraduate program leading to the MPhil and PhD degrees.

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The CREB Working Paper Series was initiated in 2008 to bring to a wider audience the research being carried out at the Centre. It is hoped that these papers will promote discussion on the subject and contribute to a better understanding of economic and business processes and development issues in Pakistan. Comments and feedback on these papers are welcome.



## **About the Authors**

Dr Azam Chaudhry is an associate professor of economics, and Rabia Ikram an assistant professor of economics at the Lahore School of Economics.





## **Abstract**

While advances in technology have effectively reduced the distance that knowledge and innovations have to travel between countries, cultural differences between countries can still limit the ease with which innovations are transferred and adapted. Thus, countries with common cultural characteristics are more easily able to share technology and innovations. This working paper separates out the impact of cultural distance from geographical distance on growth spillovers between countries. We find that, after controlling for geographical distance, cultural distance has a significant impact on growth spillovers between countries. Therefore, even if a country is geographically located in a low-growth “neighborhood,” it can still benefit from spillovers from culturally close high-growth countries. We also find that there are larger growth spillovers between countries that have greater bilateral trust, even when one controls for the bilateral geographical distance.

**JEL classifications:** O11, O33, O57.

**Keywords:** Economic growth, spillovers, distance, culture, geography.



# Cross-Country Growth Spillovers: Separating the Impact of Cultural Distance from Geographical Distance

## 1 Introduction

Traditional empirical analyses of economic growth have examined not only the factors that affect a particular country's growth rate, but also how growth can spill over from one country or region to another. So, growth in Japan boosts growth in Korea, and growth in the US spurs growth in Canada. But instead of simply looking at cross-country convergence in growth rates (as well as regional convergence), the literature has also started to analyze the specific mechanisms through which growth can be transferred. In particular, it has looked at how technological transfers from a high-technology to a lower-technology country can lead to growth spillovers, as well as at what links between countries aid these technological transfers.

In an era where technological innovations have reduced the cost of transportation—of goods, services, and people—and increased the flow of both knowledge and people across borders, it is natural to ask if it is only geography that links countries or whether there are other factors involved, such as common languages, common cultures, related business practices, and similar institutions. The recent literature has focused on various economic linkages across countries, ranging from production externalities across regions to the impact of ethnic and social networks on trade. This working paper combines various strands of research to examine how economic growth can spill over between countries that are separated both geographically and culturally.

Before the advent of modern technology, innovative ideas impacting growth traveled across borders with the physical movement of people and goods. Thus, it made sense that innovations should spill over between neighboring regions or countries that were linked in terms of migration and trade. More recently, advances in communications technology have reduced the need for physical movement in the spread of innovation, since ideas can be easily transmitted over vast distances. Yet even in this modern era of near-instantaneous transfers of

information, distance still plays a role: Countries that are physically nearer one another tend to have closer historical links and share common geographical characteristics, which means that innovations can be more easily transferred, absorbed, and adapted. So, an innovation that takes place in the US can be more easily absorbed in Canada than in Ghana. Similarly, cultural “distance” also plays a role: Countries with ethnic or cultural characteristics in common—even if they are separated by significant distances—can transfer innovations more easily because of common languages, common business practices, common areas of economic interest, and similar institutions.

Obviously, countries in geographical proximity might also be ethnically or culturally more alike, but research has shown that migration has led to many countries being relatively close ethnically or culturally while significantly separated geographically. So countries that are geographically distant can still be close culturally. This is the idea behind this paper: Is it possible to separate out the growth spillovers that occur due to physical proximity from those that occur from cultural and linguistic proximity? Unlike others papers that look at income convergence due to genetic linkages, we look at how growth spills over from all other countries to one country, and how the effect of these spillovers is based on both the geographical and genetic distances between that country and all other countries. So, even if a country lies in a low-growth “neighborhood,” it can still benefit from growth spillovers from all other countries to which it is culturally similar.

The setup of the paper is as follows: Section 2 reviews some of the literature on growth spillovers; Section 3 investigates the link between genetic distance and cultural, linguistic, and geographical distances. Section 4 develops a simple model of geographical and genetic distance-weighted growth spillovers; Section 5 discusses the basic spillovers model and presents its empirical results. Section 6 estimates a variation of the spillovers model in which the size of economies is taken into account; Section 7 estimates a model of trust-weighted spillovers between European countries. Section 8 discusses the robustness of the empirical results, and Section 9 presents our conclusions.

## **2 The Literature on Growth Spillovers**

Over the last few decades, numerous studies have looked at how cross-country linkages have had an impact on economic growth. A well-explored channel of linkages is the impact of foreign research and development (R&D) investments among trading partners (Coe & Helpman, 1995; Coe, Helpman, & Hoffmaister, 1997; Park, 1995). This literature focuses on how R&D investments in foreign countries—embodied in traded goods—are the main channel for technological diffusion. Subsequently, however, the literature (Keller, 2002) has found that the channel for technology diffusion is far wider than R&D spillovers alone.

More recently, the literature on growth spillovers from geographical proximity has focused on regional externalities, using spatial econometrics to measure the degree of economic spillover across national borders. López-Bazo, Vayá, and Artís (2004) look at regional spillovers for a sample of European regions and find significant spatial dependence in growth rates, while Behar (2008) uses a panel of 134 countries to find significant neighborhood growth effects (Fingleton & López-Bazo, 2006, present similar results). Going beyond neighborhood effects, authors such as Conley and Ligon (2002), Moreno and Trehan (1997), and Vayá, López-Bazo, Moreno, and Surinach (2004) focus on the impact of distance on cross-country growth spillovers. They find that “distance”—which can be measured as either geographical or “economic” distance—has a significant impact on long-term growth rates.

The literature on inter-country links that stem from cultural or ethnic similarities has looked at how business and ethnic networks can impact the level of interaction between and within countries. Rauch (2001) and Rauch and Trindade (2002) examine how ethnic networks promote international trade by reducing contract enforcement problems and information costs across countries. Bandyopadhyay, Coughlin, and Wall (2007), Bardhan and Guhathakurta (2004), Combes, Lafourcade, and Mayer (2004), Dunlevy (2006), and Herander and Saavedra (2005) all find that ethnic networks have a significant impact on trade within countries.

The common theme in both the theoretical and empirical literature is how cultural or ethnic links increase the probability of (i) matching buyers and sellers (and thus completing transactions), and (ii) successfully enforcing contracts (through both formal and informal

channels). This paper takes the analysis a step further by arguing that, the greater the number of transactions between countries due to ethnic or cultural links, the greater the probability of technology spillovers, which in turn lead to growth spillovers.

More recently, studies have tried to empirically estimate the impact of genetic and cultural distance on differences across countries. Giuliano, Spilimbergo, and Tonon (2006) compare genetic, cultural, and geographical distances among countries and find that, after controlling for geographical distance, genetic distance does not explain differences in economic outcome across countries. They conclude that genetic distance captures transportation costs but not cultural differences. On the other hand, Spolaore and Wacziarg (2009) find that genetic distance has a significant impact on income differences across countries even after controlling for geography. Ashraf and Galor (2008) argue that genetic diversity had a significant impact on pre-colonial development outcomes. Gorodnichenko and Roland (2010) construct an endogenous growth model and—using genetic distance as an instrument for culture—conclude that individualism leads to more innovation.

Instead of using genetic differences, Guiso, Sapienza, and Zingales (2009) look at how cultural “trust” between countries affects their level of economic interaction; they find that lower levels of bilateral trust lead to less trade, less portfolio investment, and less direct investment. In the same vein, Putterman and Weil (2010) construct a unique cross-country dataset that captures the proportion of a country’s population in the year 2000 that is descended from different source countries in 1500; they hold that this has significant predictive power for current gross domestic product (GDP). They also find that the ethnic and linguistic heterogeneity of a country’s ancestors has a significantly greater impact on current income inequality than does the heterogeneity of a country’s current population.

This working paper is, however, unique because it separates the impact of geographical spillovers from that of cultural spillovers, using Spolaore and Wacziarg’s (2009) data on genetic distance. The question we ask is whether, when controlling for geographical distance, economic growth might spill over from one country to another on the basis of cultural links. Since genetic divergence can be viewed as a divergence in beliefs, customs, habits, etc., genetic differences may act as a barrier to the flow of technological and institutional innovations between countries. If that

is the case, then a country will benefit more from innovations occurring in countries to which it is genetically closer than countries farther away. Thus, not only does physical distance-weighted growth affect a country's growth rate, so does genetic distance-weighted growth.

### **3 Measuring Genetic Distance and its Relationship with Cultural Distance, Geographical Distance, and Trade Flows**

One of the central ideas of this paper is the link between genetic distance, cultural distance, and trade, since we argue that one of main channels through which inter-country growth spillovers occur comprises cultural, ethnic, and trade links. So, two countries might be separated by a significant geographical distance, but remain culturally or ethnically close, which would aid the transmission of information, ideas, innovations, and even people. The Chinese ethnic networks mentioned above are a good example of these links. However, before we try and measure the significance of cultural spillovers, we need to define "genetic distance" and establish its link with cultural distance, geographical distance, and bilateral trade.

#### **3.1 What is Genetic Distance?**

Genetic distance is computed on the basis of distance in vertically transmitted characteristics, which are assumed to incorporate all those characteristics that are passed on from parents to children, whether through DNA or cultural mechanisms (for detailed discussions on cultural and genetic characteristics, see Cavalli-Sforza & Cavalli-Sforza, 1995; Diamond, 1992, 1997; Spolaore & Wacziarg, 2009).

In order to measure genetic distance, the allele—the basic unit of analysis relevant to our study—is used to construct unit frequencies that represent the proportion of population with a gene of a specific variant. Cavalli-Sforza and Cavalli-Sforza (1995) have used similar allele frequencies to construct bilateral co-ancestor coefficients for a set of 42 populations around the world. Here, we also use the similar co-ancestor coefficient, which is known as  $F_{st}$  distance—the probability that two randomly selected genes come from the same population. If two populations are exactly the same, it takes the value of 0; otherwise, for completely different populations, it takes the value of 1.

$F_{st}$  is also used to construct family trees of human population, and is referred to as a measure of the “genealogical distance” between populations. Specifically, the genetic distance between two populations is taken as the horizontal distance separating them from the next common node in the family tree (Spolaore & Wacziarg, 2009). Therefore, genetic distance is related to how long two populations have been separated from each other.

### 3.2 Measuring the Relationship between Cultural and Genetic Distance

One relationship of interest to us is the relationship between cultural and genetic distance. Although the data on bilateral cultural distance between countries is limited, the recent literature has looked at the link between cultural psychology and genetic distance: Chiao and Blizinsky (2010) and Way and Lieberman (2010) find a strong correlation between collectivism and genetic characteristics. Fincher, Thornhill, Murray, and Schaller (2008) reveal a strong correlation between pathogen prevalence and collectivism across countries. Gorodnichenko and Roland (2010) use the link between genetic data and cultural data to instrument culture with genetic data, and find evidence of a strong causal effect between individualism and income per worker.

Our analysis follows Gorodnichenko and Roland (2010) in using the individualistic-collectivistic measures of culture given by Hofstede (2001). These measures show the differences between countries in terms of autonomous or embedded cultures in which people are viewed as either autonomous entities or identified with a certain group. In order to find the relationship between cultural distance and genetic distance, we divide countries into different genetic groups, i.e., countries with the same genetic characteristics are put into the same group. We then calculate the average bilateral cultural distance between each group on the basis of the Hofstede index of cross-country individualism. Finally, we calculate the average bilateral genetic distance between each group, using the genetic distance data provided by Spolaore and Wacziarg (2009).

To verify the relationship between genetic distance and cultural distance, we perform a Mantel test on our matrices—the standard method used to find the correlation between distance matrices. For example, in our case, one matrix contains the bilateral cultural distance between two groups of

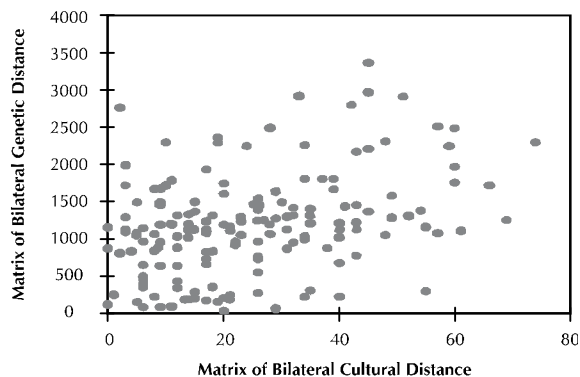


countries, while the other contains the corresponding genetic distance between the two similar groups of countries. In this case, the Mantel test allows us to compute the relationship between the two matrices by calculating a Pearson correlation coefficient between the two sets of distances and testing its statistical significance.

The Mantel test is a randomization or permutation test. If there are  $n$  countries, and the matrix is symmetrical (i.e., the distance from country  $a$  to country  $b$  is the same as the distance from  $b$  to  $a$ ), the matrix will contain  $n(n-1)/2$  distances. Because distances are not independent from one another—that is, changing the “position” of one country would change  $n-1$  of these distances, i.e., the distance from that country to each of the others—this test computes a correlation coefficient on the basis of multiple permutations that give a high degree of correlation. To test the significance of the relationship, the null hypothesis of no relationship between the matrices is tested against the alternative hypothesis that the two matrices are correlated.

Figure 1 illustrates the graphical relationship between the bilateral cultural distance matrix and bilateral genetic distance matrix for a sample of 80 countries. The plot shows a significant positive correlation between the two matrices. The Mantel test gives a value for the Pearson correlation coefficient of 0.4, which is statistically significant at 1 percent, and points to a positive and significant relationship between bilateral cultural distance and bilateral genetic distance.

**Figure 1: Relationship between Bilateral Cultural Distance Matrix and Bilateral Genetic Distance Matrix**

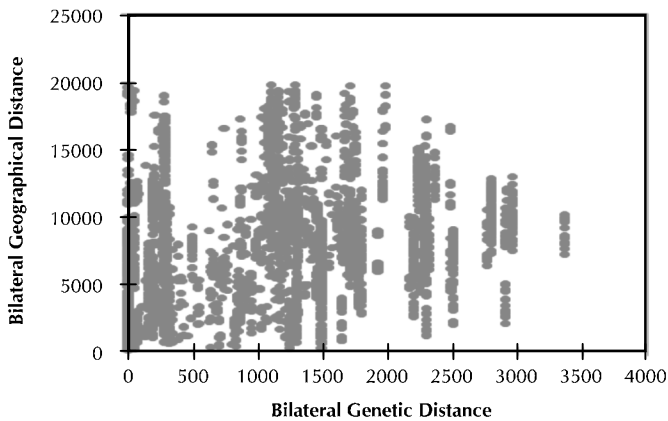


Source: Authors' estimates.

### 3.3 Measuring the Relationship between Geographical and Genetic Distance

Since we will include both genetic and geographical distance spillovers in our growth model, it is logical to ask if they measure the same thing, i.e., does greater geographical distance between countries automatically imply greater genetic distance? Figure 2 illustrates the positive relationship between the geographical distance matrix and genetic distance matrix for a sample of 80 countries, while the Mantel test yields a Pearson correlation coefficient of 0.28, which is statistically significant at 1 percent. Thus, there is a significant positive relationship between genetic distance and geographical distance, though it is far from perfect. This implies that countries that are geographically distant from each other may still share cultural similarities, which is important if we want to separate the impact of cultural distance on growth from that of geographical distance.

**Figure 2: Relationship between Bilateral Geographical Distance Matrix and Bilateral Genetic Distance Matrix**



Source: Authors' estimates.

### 3.4 Measuring the Relationship between Trade and Genetic Distance

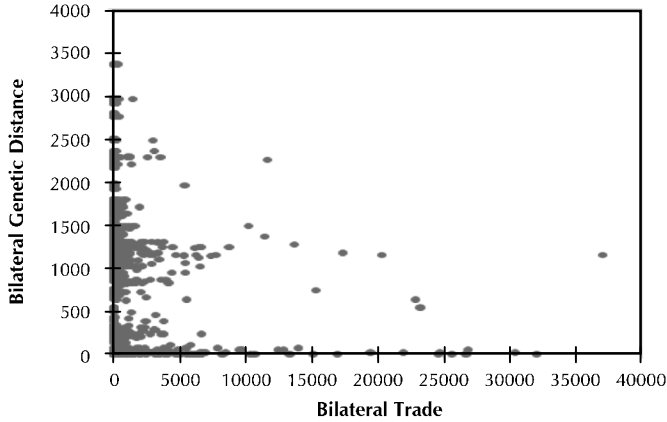
Finally, an important relationship that we are interested in testing is the relationship between genetic distance and bilateral trade. Since countries that share common cultural characteristics tend to trade more,

it makes sense to determine whether higher trade flows between countries are associated with lower bilateral genetic distances. Therefore, the correlation between genetic distance and bilateral exports should be significantly negative.

Figure 3 illustrates the negative relationship between the bilateral genetic distance matrix and bilateral trade matrix for a sample of 80 countries. The Mantel test leads to a Pearson correlation coefficient of  $-0.088$ , which is statistically significant at the 1-percent level. Hence, there is a significant negative relationship between genetic distance and bilateral exports, and the correlation coefficient is far from perfect. This reinforces the results of Spolaore and Wacziarg (2009) who found that genetic similarities between countries lead to a larger volume of trade.

These results show the significant relationships between genetic distance and cultural distance, geographical distance, and trade. Countries that are closer genetically tend to be closer culturally and linguistically, which in turn means that genetic proximity could play a positive role in the transfer of technology and innovations. Also, we have shown that, though there is a significant and positive relationship between genetic and geographical distance, the correlation between the two is far from perfect. Thus, countries that are geographically distant are not automatically genetically distant and vice versa, and we should be able to separate the impact of both geographical distance and genetic distance-weighted growth spillovers. Finally, we should also be able to separate the impact on growth of genetic distance between countries and trade between countries.

**Figure 3: Relationship between Bilateral Exports Matrix and Bilateral Genetic Distance Matrix**



Source: Authors' estimates.

#### 4 A Simple Model of Growth Spillovers

Our model is based on the basic Solow model in which the aggregate production per unit of labor is a function of the stock of physical capital per unit of labor ( $k$ ), the stock of human capital per unit of labor ( $h$ ), and a technology parameter ( $A$ ):

$$y_i = A_i k_i^{\tau_k} h_i^{\tau_h} \quad (1)$$

$\tau_k$  and  $\tau_h$  represent internal returns to physical and human capital, respectively. As in the standard model (also discussed in detail by López-Bazo et al., 2004), the returns are considered the result of the sum of a firm's internal returns and a Romer-Lucas externality. However, in this case, the internal externality is not large enough to exhibit increasing returns to scale, so that we assume  $\tau_k + \tau_h < 1$ ,  $\tau_k > 0$  and  $\tau_h > 0$ .

Technology ( $A$ ) in equation (1) in any country  $i$  is assumed to depend on the level of technology of its neighbor  $j$ , which in turn depends on the physical and human capital stocks of the neighboring country, weighted by the factor  $(\gamma_1 + \gamma_2)$ . The  $\gamma$  parameters measure the strength of each externality:  $\gamma_1$  shows the degree to which country  $j$  invests in human and physical capital or introduces new technology that will spill over to country  $i$  due to the geographical distance between countries  $i$  and  $j$ ;

and  $\gamma_2$  shows the effect of a similar externality based on the cultural distance between countries  $i$  and  $j$ .

The idea behind this formulation is that the amount of technological spillover between countries  $i$  and  $j$  depends on their physical distance from each other (because a country will absorb technology more easily from a geographically closer country as opposed to a country that is farther away) and on the cultural distance between countries (since countries that are closer culturally will have a greater chance of sharing common languages, cultures, business practices, etc., and thus a greater chance of technology spillover). If  $(\gamma_1 + \gamma_2) = 0$ , this means that spillovers are not transferred between country  $i$  and country  $j$  and we are taking into account only internal externalities. Note that  $\varphi$  is an exogenous technological shock parameter.

$$A_i = \varphi(k_{ij}^{\tau_k} h_{ij}^{\tau_h})^{\gamma_1 + \gamma_2} \quad (2)$$

Equation (3) expresses the output level of country  $i$  by combining (1) and (2). The equation shows that spillovers have a positive effect on the level of output of country  $i$  even if country  $i$  maintains a constant level of human and physical capital stock.

$$y_i = \varphi k_i^{\tau_k} h_i^{\tau_h} (k_{ij}^{\tau_k} h_{ij}^{\tau_h})^{\gamma_1 + \gamma_2} \quad (3)$$

Using a capital accumulation equation and substituting the value of  $\gamma$ , the growth rates of human and physical capital stock for country  $i$  are

$$g_{\bar{k}} = \frac{\dot{\bar{k}}}{\bar{k}} = s_k \bar{k}^{-(1-\tau_k)} \bar{h}^{\tau_h} (\bar{k}_{ij}^{\tau_k} \bar{h}_{ij}^{\tau_h})^{\gamma_1 + \gamma_2} - (n + g + d) \quad (4a)$$

$$g_{\bar{h}} = \frac{\dot{\bar{h}}}{\bar{h}} = s_h \bar{k}^{\tau_k} \bar{h}^{-(1-\tau_h)} (\bar{k}_{ij}^{\tau_k} \bar{h}_{ij}^{\tau_h})^{\gamma_1 + \gamma_2} - (n + g + d) \quad (4b)$$

$s_k$  and  $s_h$  are the saving rates for the accumulation of human and physical capital, respectively, and  $n$ ,  $g$ , and  $d$  are the rates of population growth, technological growth, and the rate of depreciation, respectively. The equation assumes decreasing returns for the country's own capital accumulation but positive returns for spillovers transmitted by other countries. This means that countries that are geographically and biologically closer to the  $i^{\text{th}}$  country will have a more pronounced effect

on the latter's growth than countries that are located farther away and have fewer cultural links with country  $i$ .

Combining equations (4a) and (4b), we obtain the steady-state level of human and physical capital and output per effective labor as

$$\check{k}^* = \left( \frac{s_k^{1-\tau_k} s_h^{\tau_k} (\check{k}_j^{\tau_k} \check{h}_j^{\tau_h})^{\gamma_1 + \gamma_2}}{n + g + d} \right)^{\frac{1}{1-\tau_k - \tau_h}} \quad (5a)$$

$$\check{h}^* = \left( \frac{s_k^{\tau_k} s_h^{1-\tau_k} (\check{k}_j^{\tau_k} \check{h}_j^{\tau_h})^{\gamma_1 + \gamma_2}}{n + g + d} \right)^{\frac{1}{1-\tau_k - \tau_h}} \quad (5b)$$

$$\check{y}^* = \left( \frac{s_h^{\tau_h} s_k^{\tau_k} (\check{k}_j^{\tau_k} \check{h}_j^{\tau_h})^{\gamma_1 + \gamma_2}}{(n + g + d)^{\tau_k + \tau_h}} \right)^{\frac{1}{1-\tau_k - \tau_h}} \quad (5c)$$

Using the capital accumulation equation given in (4) and applying first-order Taylor expansion around the steady state, the growth between periods 0 and  $T$  can be expressed as

$$g_i = \tau_k g_k + \tau_h g_h + \gamma_1 (\tau_k g_{kj} + \tau_h g_{hi}) + \gamma_2 (\tau_k g_{kj} + \tau_h g_{hi})$$

Based on the methodology followed by Mankiw, Romer, and Weil (1992), the derivation of this equation can be expressed in terms of the rate of convergence, a country's internal factors, and spillover effects as

$$g_i = \varepsilon - (1 - e^{-\beta T}) \ln y_o + \frac{(1 - e^{-\beta T}) \gamma_1}{1 - (\tau_k + \tau_h)} \ln y_{o_j} + \frac{(1 - e^{-\beta T}) \gamma_2}{1 - (\tau_k + \tau_h)} \ln y_{o_j} + \gamma_1 g_{y_j} + \gamma_2 g_{y_j} + \frac{(1 - e^{-\beta T})}{1 - (\tau_k + \tau_h)} [\tau_k (\ln s_k - \ln(n + g + d)) + \tau_h (\ln s_h - \ln(n + g + d))] \quad (6)$$

where

$$\varepsilon = (1 + \gamma_1)g + (1 + \gamma_2)g - (1 - e^{-\beta T}) \left( 1 - \frac{\gamma_1}{1 - (\tau_k + \tau_h)} \right) (\ln \Delta_o + gT) - (1 - e^{-\beta T}) \left( 1 - \frac{\gamma_1}{1 - (\tau_k + \tau_h)} \right) (\ln \Delta_o + gT)$$

Note that  $\beta = (1 - (\tau_k + \tau_h)) (n + g + d)$  is the convergence rate,  $\gamma_0$  is initial output per unit of labor in country  $i$ , and  $\gamma_{0j}$  is the initial output per unit of labor of the other country,  $j$ . Equation (6) shows that growth in country  $i$  is a function of its own initial level of output, the initial level of

output of its neighbor  $j$  weighted by  $\gamma_1$  and  $\gamma_2$ , the weighted growth rates of neighboring countries, and the country's own factors of production.

According to this expression, the growth rates of two countries with similar economic and technological conditions—and that started from the same initial conditions—can differ if they have different neighbors. This means that  $\gamma_1$  and  $\gamma_2$  are important in terms of the effect of technology spillovers from country  $i$  to  $j$ : If country  $i$  is geographically located near a high-growth country to which it is also culturally similar, there will be significant technological (and growth) spillovers from the latter to country  $i$  (assuming that  $\gamma_1 > 0$  and  $\gamma_2 > 0$ ). In terms of separating out channels of technological spillover, the model also implies that technology will spill over between countries based on both the physical and cultural distances between the two.

## 5 A Basic Cultural and Geographical Spillovers Model

In this section, we develop an empirically testable model based on equation (6), which can be written as

$$g_i = \text{constant} + \alpha_0 \ln y_0 + \delta_1 s_k + \delta_2 s_h + \theta_{1wi} \ln W_1 y_0 + \theta_{2wi} \ln W_2 y_0 + \gamma_1 W_d + \gamma_2 W_{gen} + u_i \quad (7)$$

The effect of  $\ln(n + g + d)$  in equation (7) is included in the constant term. Note that  $W_d$  represents the geographical distance-weighted growth rates of all other countries,  $j$  (where the weight is inversely proportional to the physical distance of any country  $j$  from country  $i$ ), and  $W_{gen}$  represents the genetic distance-weighted growth rates of all other countries  $j$  (where the weight is inversely proportional to the genetic distance of any country  $j$  from country  $i$ ). Based on the standard empirical literature on growth, we also include a measure of institutional quality in our model:

$$g_i = \pi_0 - \alpha_0 \ln y_0 + \delta_1 \Delta(\ln(k)) + \delta_2 \Delta(\ln(h)) + \gamma_1 W_d + \gamma_2 W_{gen} + \delta_3 cpi + XiB + e_i \quad (8)$$

The dependent variable  $g_i$  is the annualized change in a country's growth rate between 1960 and 2000;  $k$  is investment in physical capital;  $h$  is human capital taken as the educational attainment of the total population aged 25 or over (and represented by  $ys$  in our regressions);  $X$

is a set of standard variables used in growth regressions, which includes convergence and endogenous growth factors;  $cpi$  is a measure of institutional quality;  $W_d$  is the geographical distance-weighted growth variable; and  $W_{gen}$  is the genetic distance-weighted growth variable.

The inclusion of the variables  $W_d$  and  $W_{gen}$  in the growth regression shows that growth in country  $i$  depends on the growth of all other countries in the sample, weighted by the average distance between two countries. Also, countries that are closer geographically or genetically have a greater influence than countries that are farther away. This relationship is quite similar to a time series autoregression process in which error terms are serially correlated and OLS estimates are not consistent. However, in this case, it is not the nearby time periods that matter, rather it is the influence of spatial variables that causes the residuals to be spatially correlated, resulting in inconsistent OLS estimates. Therefore, we will calculate maximum likelihood estimates for equation (8).

### 5.1 Construction of Spillover Variable

Genetic and geographical distances are used to construct two weighting matrices,  $W_{1ij}$  and  $W_{2ij}$ . The definitions of each matrix are given below.

For geographical distance,

$$W_{1ij} = \frac{\frac{1}{d_{ij}}}{\sum_j 1/d_{ij}} \quad i \neq j$$

$$W_{1ii} = 0$$

For genetic distance,

$$W_{2ij} = \frac{\frac{1}{gen_{ij}}}{\sum_j 1/gen_{ij}} \quad i \neq j$$

$$W_{2ii} = 0$$

$d_{ij}$  is the geographical distance between country  $i$  and  $j$ , and  $gen_{ij}$  is the genetic distance between country  $i$  and  $j$  ( $gen_{ij}$  represents the  $F_{st}$  index). These weighting matrices link each country to all other countries in the sample, both geographically and genetically. However, the relative



importance of any country  $i$  is inversely proportional to its geographical and genetic distance from country  $j$ .

In order to construct the geographical distance-weighted growth variable ( $W_d$ ) and genetic distance-weighted growth variable ( $W_{gen}$ ) for each country, the weighting matrices  $W_{1ij}$  and  $W_{2ij}$  are multiplied by the column matrix  $G$ , which consists of cross-country growth rates:

$$W_d = \sum_{j=1}^n w_{1ij} g_j$$

and

$$W_{gen} = \sum_{j=1}^n w_{2ij} g_j$$

$W_d$  and  $W_{gen}$  represent the geographical and genetic distance-weighted growth spillovers, respectively, from all other countries  $j$  to country  $i$ .

## 5.2 Data

Our sample contains 80 countries for the period 1960–2000. The data on genetic distance  $F_{st}$  is taken from Spolaore and Wacziarg (2009). The bilateral geographical distance data is taken from CEPII, and GDP data from the Madison World data series. We have taken physical capital data from the WPD-UNIDO datasets, and human capital data from the Barro and Lee (2010) data series (where the average number of years of schooling is used to measure human capital). Data for the institutional quality variable ( $cpi$ ) has been taken from Transparency International.

## 5.3 Results

Table 1 presents the maximum likelihood estimates of the impact of the geographical distance-weighted growth ( $W_d$ ) and genetic distance-weighted growth ( $W_{gen}$ ) of other countries on cross-country growth rates for a sample of 80 countries. Across the various specifications, the results show that both geographical and genetic distance-weighted growth spillovers coefficients are significant. Thus, cross-country growth is affected by growth spillovers from countries that are geographically closer as well as from countries that are culturally closer.

**Table 1: Basic Model of Growth Spillovers (Maximum Likelihood Estimates)**

Dependent variable = annualized change in log (GDP).

	(1)	(2)	(3)
$W_d$	1.31** (0.28)	-	1.07*** (0.31)
$cpi$	0.002** (0.0005)	0.002** (0.0006)	0.002*** (0.0005)
$W_{gen}$	-	0.95** (0.28)	0.52* (0.29)
Countries	80	80	80

Notes: Standard errors are reported in parentheses. Asterisks indicate that coefficient is statistically significant at \*\*\* 1 percent, \*\* 5 percent, and \*10 percent.

While Table 1 shows the simple specification, Table 2 shows the results obtained from different growth specifications for all countries in the sample (Cohen & Soto, 2001, present a detailed discussion of standard growth specification). The results for all four growth specifications (shown in columns 1–4) indicate that both geographical distance- and cultural distance-weighted growth spillovers have a significantly positive impact on cross-country growth. This means that, even if a country is located farther away from high-growth countries, it can still grow more if it is genetically similar to a fast-growing country. For example, suppose country A is located far away from a fast-growing country B, to which it is culturally close. In this case, country A can still grow at a higher rate, since there will be large growth spillovers from a genetically similar country, regardless of the geographical distance amongst them. So, while there are larger growth spillovers between countries that are culturally similar, the magnitude of larger growth spillovers due to geographical proximity is greater than that due to genetic proximity.

**Table 2: Basic Model of Growth Spillovers (Maximum Likelihood Estimates)**

Dependent variable = annualized change in log (GDP).

	(1)	(2)	(3)	(4)
$\Delta (\log (k))$	0.27*** (0.06)	0.30*** (0.05)	0.27*** (0.06)	0.24*** (0.05)
$\Delta (ys)$	-	-	-	0.16*** (0.03)
$ys_{60}$	-	-	-	0.001 (0.0008)
$\Delta ((\log (e^{0.1*ys} - 1))$	-	0.07 (0.08)	0.09 (0.08)	-
$\Delta (\log (ys))$	-0.19** (0.08)	-	-	-
$\log (y_0)$	-0.004 (0.01)	-	-	-0.030** (0.01)
$\Delta (\log (L))$	0.02 (0.15)	-	-	-
$W_d$	0.76*** (0.24)	0.76*** (0.27)	0.77*** (0.27)	0.37 (0.25)
$cpi$	0.0009 (0.0007)	0.0010 (0.0005)	0.0020*** (0.0007)	0.0020*** (0.0007)
$W_{gen}$	0.52** (0.24)	0.37*** (0.26)	0.48* (0.28)	0.54** (0.25)
Countries	69	76	76	76

Notes: Standard errors are reported in parentheses. Asterisks indicate that coefficient is statistically significant at \*\*\* 1 percent, \*\* 5 percent, and \*10 percent.

## 6 Income-Weighted Cultural and Geographical Spillovers

The model above assumes that countries are affected by growth spillovers that decrease as the geographical and cultural distances between countries increase. But the relative size of the country from which the spillover occurs is ignored, i.e., growth spillovers from

Denmark and Germany are assumed to be equal if a country is equidistant from them both geographically and culturally. In this section, we incorporate the relative size of economies into both geographical and cultural distance-weighted spillovers by weighting the relative size of these spillovers by relative GDP (ratio of foreign output to domestic output). The argument is that a country's relative size as well as its geographical and genetic distance from other countries should have an impact on growth spillovers from that country.

### 6.1 Model and Construction of Income-Weighted Genetic and Geographical Spillover Variables

In order to estimate the effect of income-weighted genetic and geographical spillovers, equation (8) can be modified as follows:

$$g_i = \pi_0 + \alpha_0 \ln y_0 + \delta_1 \Delta(\ln(k)) + \delta_2 \Delta(\ln(h)) + \gamma_3 W_{yd} + \gamma_4 W_{ygen} + \delta_3 cpi + X_i B + e_i \quad (8')$$

$W_{yd}$  and  $W_{ygen}$  measure the impact of income-weighted genetic and geographical spillovers, respectively, and the other variables are defined as above.

The genetic and geographical distances and the ratios of foreign to domestic output are used to construct two weighting matrices,  $W_{3ij}$  and  $W_{4ij}$ . The definition and construction of each matrix is given below.

For income-weighted geographical distance,

$$W_{3ij} = \frac{\frac{1}{d_{ij}} \frac{y_f}{y_d}}{\sum_j \frac{1}{d_{ij}} \frac{y_f}{y_d}} \quad i \neq j$$

$$W_{3ii} = 0$$

For income-weighted genetic distance,

$$W_{4ij} = \frac{\frac{1}{gen_{ij}} \frac{y_f}{y_d}}{\sum_j \frac{1}{gen_{ij}} \frac{y_f}{y_d}} \quad i \neq j$$

$$W_{4ii} = 0$$

$d_{ij}$  is the geographical distance between countries  $i$  and  $j$ ,  $gen_{ij}$  is the genetic distance between countries  $i$  and  $j$ , and  $\frac{y_f}{y_d}$  is the ratio of foreign output to domestic output (income-weighted factor).

In order to construct the income-weighted geographical distance growth variable ( $W_{yd}$ ) and income-weighted genetic distance growth variable ( $W_{ygen}$ ) for each country, the weighting matrices  $W_{3ij}$  and  $W_{4ij}$  are multiplied by the column matrix  $G$ , which consists of cross-country growth rates:

$$W_{yd} = \sum_{j=1}^n w_{3ij} g_j$$

and

$$W_{ygen} = \sum_{j=1}^n w_{4ij} g_j$$

So,  $W_{yd}$  and  $W_{ygen}$  represent, respectively, the income-weighted, and geographical and genetic distance-weighted growth spillovers from all other countries  $j$  to country  $i$ .

## 6.2 Results

Table 3 presents the results for the various specifications in which the distance matrices are weighted by income. Again, geographical distance-weighted growth spillovers and genetic distance-weighted growth spillovers are significant, but what makes these results interesting is that the coefficient of genetic distance-weighted growth spillovers is now significantly larger than that of geographical distance-weighted growth spillovers, which is the reverse of the results of the unweighted case. This implies that genetic distance-weighted growth spillovers outweigh geographical distance-weighted growth spillovers when one takes into account the size of an economy. In other words, cultural similarities may be more important than geographical proximity in the transfer of technology across countries and the resulting growth spillovers when the size of their economies is taken into account.

**Table 3: Income-Weighted Growth Spillovers (Maximum Likelihood Estimates)**

Dependent variable = annualized change in log (GDP).

	(1)	(2)	(3)	(4)
$\Delta (\log (k))$	0.27*** (0.06)	0.28*** (0.05)	0.27*** (0.06)	0.24*** (0.05)
$\Delta ((\log (e^{0.1*ys} - 1))$	-	-0.08 (0.09)	-0.09 (0.09)	-
$\Delta (\log (ys))$	-0.14 (0.09)	-	-	-
$\Delta (ys)$	-	-	-	0.17*** (0.03)
$y_{S60}$	-	-	-	0.001 (0.0008)
$\log (k_{60})$	-	-	-	-
$\log (y_0)$	-0.0010 (0.002)	-	-0.0007 (0.002)	-0.0040* (0.002)
$W_{ydt}$	0.57* (0.32)	0.57* (0.31)	0.55* (0.32)	0.14 (0.29)
$cpi$	0.002*** (0.0008)	0.002*** (0.0005)	0.002*** (0.0008)	0.002*** (0.0008)
$W_{ygen}$	1.01** (0.50)	0.98** (0.47)	1.04** (0.50)	0.96** (0.46)
Countries	76	76	76	76

Notes: Standard errors are reported in parentheses. Asterisks indicate that coefficient is statistically significant at \*\*\* 1 percent, \*\* 5 percent, and \*10 percent.

## 7 Trust-Weighted Growth Spillovers

Another aspect of cultural links that Guiso et al. (2009) investigate is the impact of bilateral trust between European countries on their level of economic interaction. The authors find that a lower level of bilateral trust leads to less trade, less portfolio investment, and less direct investment between countries. If this is the case, the degree of bilateral trust can also impact the amount of growth spillovers between countries, which can be tested in our framework.

In order to test the impact of trust-weighted growth spillovers, we create a matrix of trust distance-weighted growth (similar to our genetic distance-weighted growth matrix), which allows us to measure the impact on the growth rate of country  $i$  of the trust-weighted growth rates of all other countries  $j$ . Using a simple model, we can separate the impact of distance-weighted growth from trust-weighted growth. Because of data limitations, we limit the analysis to European countries, which restricts us from including genetic distance-weighted growth rates in our model because of the genetic similarity (and resulting lack of genetic distance) between these countries.

### 7.1 Model and Construction of Trust-Weighted Spillover Variable

In order to estimate the effect of trust spillovers, equation (8) can be modified to yield

$$g_i = \pi_0 + \alpha \ln y_0 + \delta_1 \Delta(\ln(k)) + \delta_2 \Delta(\ln(h)) + \gamma W_d + \gamma_5 W_{trust} + \delta_3 cpi + X_i B + e_i \quad (8'')$$

$W_{trust}$  measures the impact of trust spillovers.

The bilateral trust distance between European countries is used to construct a trust-weighted growth spillover variable,  $W_{trust}$ . The construction of the trust-weighted variable is given below.

The trust-weighting matrix is

$$W_{5ij} = \frac{trust_{ij}}{\sum_j trust_{ij}} \quad i \neq j$$

$$W_{5ii} = 0$$

Here,  $trust_{ij}$  is the level of trust between countries  $i$  and  $j$ . In this case, the weighting matrix links every country to all other countries in the sample on the basis of the bilateral trust index. So, the relative importance of any country  $i$  is directly proportional to its trust distance from country  $j$ .

In order to construct the trust-weighted growth variable for each country, the weighting matrices  $W_{5ij}$  are multiplied by the column matrix  $G$ , which consists of cross-country growth rates. This yields

$$W_{trust} = \sum_{j=1}^n w_{5ij} g_j$$

So,  $W_{trust}$  represents the trust distance-weighted growth spillovers from all other countries  $j$  to country  $i$ .

We use the same data as Guiso et al. (2009), who employ measures of trust from a set of surveys conducted by Eurobarometer (sponsored by the European Commission). The data shows the average level of trust that citizens of each European country have toward citizens of other European countries.

## 7.2 Results

Table 4 presents the results for the subsample of 14 European countries when one looks at the impact of geographical distance-weighted growth spillovers and “trust” distance-weighted growth spillovers. As discussed above, we have not included genetic distance-weighted growth spillovers in this regression because the genetic distance between the European countries in question is small, which could have led to insignificant results.

**Table 4: Trust-Weighted Growth Spillovers (Maximum Likelihood Estimates)**

Dependent variable = annualized change in log (GDP).

	(1)	(2)	(3)
$W_d$	-0.22 (1.55)	-	-1.88 (1.21)
$cpi$	-0.002** (0.0010)	-0.001 (0.0008)	-0.001 (0.0008)
$W_{trust}$	-	0.01*** (0.004)	0.01*** (0.004)
Countries	14	14	14

Notes: Standard errors are reported in parentheses. Asterisks indicate that coefficient is statistically significant at \*\*\* 1 percent, \*\* 5 percent, and \*10 percent.

The table shows that trust distance-weighted growth spillovers are significant, implying that there are greater growth spillovers between



countries that share a greater level of bilateral trust. Another interesting result is that the geographical distance-weighted growth spillovers coefficients are insignificant, which implies that geographical distances are not a barrier to growth spillovers in Europe.

## 8 Robustness of Results

Even though the analysis above looks at multiple growth specifications, an important issue to consider when analyzing cross-country growth is the impact of location, common colonizers, common languages, and bilateral trade on growth spillovers. As is the case with many growth specifications, it is possible that the significant results are simply capturing the impact of factors such as a country's particular location, common languages, common colonizers, or trade links with countries instead of capturing the impact of geographical and genetic distance-weighted growth spillovers. For this reason, we include latitude ( $Lat$ ), common colony-weighted growth ( $W_{col}$ ), common language-weighted growth ( $W_{lang}$ ), and trade-weighted growth ( $W_{trade}$ ) in our basic model as well as our income-weighted model.

Tables 5 and 6 (for the basic model and income-weighted model, respectively) show that, even after the inclusion of these variables, both geographical distance-weighted and genetic distance-weighted growth spillovers have a significantly positive impact on cross-country growth.

**Table 5: Basic Model of Growth Spillovers (Maximum Likelihood Estimates)**

Dependent variable = annualized change in log (GDP) with latitude, common colony, common language, and trade flows.

	(1)	(2)	(3)	(4)
$\Delta (\log (k))$	0.26*** (0.06)	0.28*** (0.06)	0.27*** (0.06)	0.28*** (0.06)
$\Delta (\log (ys))$	-0.147 (0.090)	-0.214** (0.081)	-0.200** (0.080)	-0.220*** (0.080)
$\log (y_0)$	-0.0020 (0.002)	-0.0006 (0.002)	-0.0010 (0.001)	-0.0007 (0.001)
$\Delta (\log (L))$	- -	0.087 (0.15)	0.860*** (0.28)	0.101 (0.15)
$W_d$	0.78*** (0.27)	0.69*** (0.25)	0.03 (0.15)	0.71** (0.28)
$cpi$	0.002*** (0.0007)	0.001 (0.0007)	0.001 (0.0007)	0.001 (0.0007)
$W_{gen}$	0.50* (0.27)	0.49** (0.22)	0.50** (0.21)	0.45** (0.22)
$Lat$	-0.0000071 (0.00004)	- -	- -	0.0000300 (0.00004)
$W_{lang}$	- -	-0.006 (0.005)	- -	-0.005 (0.006)
$W_{col}$	- -	0.008 (0.007)	- -	0.007 (0.280)
$W_{trade}$	- -	- -	-0.060 (0.34)	-0.137 (0.35)
Countries	76	69	69	69

Notes: Standard errors are reported in parentheses. Asterisks indicate that coefficient is statistically significant at \*\*\* 1 percent, \*\* 5 percent, and \*10 percent.

**Table 6: Income-Weighted Growth Spillovers (Maximum Likelihood Estimates)**

Dependent variable = annualized change in log (GDP) with latitude, common colony, common language, and trade flows.

	(1)	(2)	(3)	(4)
$\Delta (\log (k))$	0.27*** (0.06)	0.28*** (0.06)	0.26*** (0.06)	0.27*** (0.06)
$\Delta (\log (ys))$	-0.15 (0.09)	-0.25*** (0.08)	-0.24*** (0.08)	-0.25*** (0.06)
$\log (y_0)$	-0.0010 (0.002)	0.0003 (0.001)	0.0003 (0.001)	0.0002 (0.001)
$\Delta (\log (L))$	-0.01 (0.15)	0.03 (0.15)	-0.04 (0.15)	0.04 (0.15)
$W_{yd}$	0.53* (0.33)	0.69** (0.29)	0.84** (0.33)	0.69** (0.64)
$cpi$	0.0020*** (0.0008)	0.0009 (0.0007)	0.0007 (0.0007)	0.0007 (0.0007)
$W_{ygen}$	1.02** (0.50)	1.27*** (0.45)	1.34*** (0.45)	1.2*** (0.46)
$Lat$	0.00002 (0.00004)	- -	- -	0.00004 (0.00004)
$W_{lang}$	- -	-0.007 (0.006)	- -	-0.006 (0.006)
$W_{col}$	- -	0.007 (0.007)	- -	0.007 (0.007)
$W_{trade}$	- -	- -	-0.05 (0.36)	-0.09 (0.35)
Countries	76	69	69	69

Notes: Standard errors are reported in parentheses. Asterisks indicate that coefficient is statistically significant at \*\*\* 1 percent, \*\* 5 percent, and \*10 percent.

## 9 Conclusion

This paper has attempted to separate the impact of physical distance on growth spillovers from that of cultural distance. Over the last 50 years,

migration patterns have resulted in a far more diversified global population, and so, it is natural to ask if traditional patterns of technology transfer and growth spillover—occurring between countries that are geographically closer to each other—have changed. In particular, the question that arises is whether one can test to see if technology transfers and growth spillovers can occur between countries that are culturally and linguistically close, and separate this channel from the traditional geographically dependent growth spillovers.

Our analysis began by showing the significant relationship between genetic distance and both cultural and trading links between countries. Thus, in order to determine the impact of cultural differences on the level of growth spillovers between countries, we focused on the genetic distance between countries. After this, our results showed that greater technological transfers and growth spillovers occur between countries that are geographically closer to each other and also between countries that are genetically closer to each other.

Additionally, geographical distance-weighted growth spillovers outweigh genetic distance-weighted growth spillovers. But this result is reversed when we take the size of countries into account: In this case, genetic distance-weighted growth spillovers outweigh geographical distance-weighted growth spillovers. So, cultural links between countries are a critical route for the inter-country transfer of innovations and technology. We also checked to see if trust between countries plays a role in growth spillovers. Using a sample of European countries, we found that there were greater growth spillovers between European countries that trusted each other more, even when one controlled for geographical distance-weighted spillovers.

On the whole, our results support the theory that stronger cultural links between countries increase growth spillovers. Also, the more countries trust each other, the more they interact, which in turn leads to greater growth spillovers. These spillovers are in addition to the spillovers that occur between countries due to geographical proximity. So, even if a country is geographically located in a low-growth “neighborhood,” it can still benefit from spillovers from culturally close, high-growth countries. Eventually, as technological innovations continue to reduce the effective geographical distance between countries, their cultural differences in the transfer of innovations and growth will occupy a far more central role.

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