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Climatic Conditions, Cultural Diversity, and Labor Productivity

by

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Abstract

Countries with the highest labor productivity overwhelmingly lie in the world's temperate climatic zones far away from the equator. The question we address is whether climatic conditions as measured by distance from the equator remain correlated with labor productivity after other variables are taken into account. We find that climatic conditions do not have a significant impact on labor productivity once we control for factor accumulation and cultural diversity within countries. Our regression results suggest that cultural diversity as measured by the degree of ethnolinguistic fractionalization may severely limit economic development in presently poor countries.

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Keywords: productivity, climatic conditions, factor accumulation, ethnolinguistic diversity

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I. Introduction

The international evidence for a strong impact of climatic conditions on labor productivity seems striking. Countries with the highest output per worker overwhelmingly lie in the world's temperate zones outside the tropics (Figure 1). Not all countries with moderate climate conditions are rich, but those that are not are either formerly socialist or landlocked. By contrast, highly indebted poor countries are typically either landlocked, desert, or tropical. The world's poor obviously live in different climatic zones than the world's rich. Economies further away from the equator tend to be more successful in terms of per capita income. Hence unfavorable climatic conditions may be a fundamental cause of persisting poverty, as argued for instance by Sachs (1999).

The positive correlation between distance from the equator and output per worker has been interpreted very differently in the literature. A positive correlation may arise through the prevalence of disease and the presence of highly variable rainfall and inferior soil quality in tropical countries. This line of reasoning has been emphasized by Sachs and Warner (1997). Theil and Chen (1995) conclude that distance from the equator accounts for about two thirds of the variance of GDP per capita in their sample of 138 countries. Ram (1997) finds that even after controlling for international differences in factor accumulation, distance from the equator accounts for a substantial part of the international variation in output per worker. Hall and Jones (1997) report on the basis of their cross-country regressions that distance from the equator is the single strongest predictor of international differences in output per worker.

By contrast, Nordhaus (1994) claims that the possible effect of climate on income is swamped by other variables. His calculations suggest that distance from the equator explains less than 1 percent of the international variation in per capita income. Frankel and Romer (1999) argue that it's difficult to think of reasons that a country's geographic characteristics could have important effects on its income except through their impact on trade. Geographically and climatically disadvantaged countries may depend more on trade than others to specialize their production structure according to comparative advantage. Hence limiting trade flows by tariffs and other measures may have severe negative income effects particularly for this group of countries.

Along these lines, Hall and Jones (1999) claim that the direct effect of climatic conditions on labor productivity is zero. Instead, they view distance from the equator as one of several proxies for the extent of Western European influence the average region might have had over the past five centuries. Strong Western European influence is seen as explaining a present institutional infrastructure conducive for efficient production. Considering that Europeans were more likely to settle in sparsely populated areas with moderate climatic conditions similar to Europe, these historical circumstances may explain the relatively high per capita incomes of countries such as the United States, Canada, Australia, New Zealand, and Argentina. However, such an interpretation is not completely convincing. Leading European nations also settled in regions close to the equator where they actually imposed their own institutional framework without generating a high level of development. Furthermore, presently rich countries like Japan where not subject to a strong Western European institutional influence in past centuries.

We conclude from this literature that there is no generally accepted explanation for the strong bilateral correlation between climatic conditions as measured by distance from the equator and labor productivity. Distance from the equator may be spuriously correlated with labor productivity, it may directly proxy for climatically determined transaction costs, or it may indirectly proxy for other variables such as the institutional infrastructure which happen to be correlated with distance from equator. We reconsider the empirical evidence by asking whether distance from the equator remains correlated with output per worker after other variables are taken into account that might also explain international differences in labor productivity.

Similar to climatic conditions, cultural diversity within countries can be considered as a truly exogenous variable which may be correlated with labor productivity and growth. For instance, ethnic, linguistic, or religious differences between various groups of the population may result in culturally determined transaction costs which in turn could lead to a lower level of development than in more homogenous countries, where such transaction costs do not apply. For instance, Temple (1998) reports for the case of African countries that there is some evidence that an intermediate range of ethnic diversity is worst for growth. Easterly and Levine (1997) also find that the cross-country variation in ethnic diversity helps explain international differences in growth. They emphasize that Africa's high ethnic diversity is likely to have raised political instability, thereby undermining investment and growth. By contrast, Lian and Oneal (1997) reject the idea that cultural diversity may have a significant growth impact. According to their results, ethnic, linguistic, and religious differences are not significantly related to the growth rate in GDP per capita.

In contrast to this literature, our approach focuses on explaining differences in the level of labor productivity across countries. Levels of economic development differ enormously across countries, and these differences appear to be relatively persistent over time. Most recent empirical work on long-run economic performance has chosen instead to focus on explaining differences in average growth rates across countries. Yet international differences in growth rates do not necessarily illuminate the reasons for the large international differences in output per worker. As suggested by a large class of traditional and endogenous growth models, international differences in growth rates should turn out to be a transitory phenomenon due to knowledge diffusion. This insight implies that the fundamental sources of growth, which have created the fairly persistent distribution of world income, should be studied with level equations rather than with growth equations.

We begin by specifying a basic neoclassical growth model which identifies the role of factor accumulation in explaining international differences in the level of labor productivity. We employ two modifications. We augment the efficiency term of the basic model to capture the impact of additional variables, and we model human capital as a factor which is directly related to labor input rather than as an independent production factor.

We augment the constant term of our empirical model by three variables which act as proxies for various transaction costs which may impact on the level of labor productivity in addition to the rate of factor accumulation. First, we use distance from the equator as a measure of climatically determined transaction costs, which may be higher for tropical countries than for countries in moderate climatic zones. Second, we use a measure of so-called government anti-diversion policies as a proxy for institutionally determined transaction costs, which should be high in countries where the government does not protect against private diversion of resources or acts itself as a large diverter of income. Third, we use a measure of ethnic diversity as a proxy for culturally determined transaction costs, which should be high if the probability is low that any two people chosen at random from within a country will belong to the same ethnic or linguistic groups.

II. The Empirical Model

The empirical model for our estimation of the presumed productivity effect of climatic conditions and other variables is a variant of the textbook neoclassical growth model, except that human capital enters in a non-standard way. As recently suggested by Jones (1996) and Klenow and Rodriguez-Clare (1997), we consider human capital as being directly linked to labor and not as an independent factor of production as in Mankiw et al. (1992). That is, our production function reads

$$(1) \qquad Y = K^{a} \left(AL\, e^{school} \right)^{b} \ ,$$

where Y is output, K is the stock of capital, L is the workforce, A is the level of technology, and *school* is a variable which measures the combined impact of the rate of return to investment in education r and the average number of years of schooling S. The specification implies that our measure of human capital H is given as

$$(2) \qquad H = L \cdot e^{r \cdot S} \ .$$

This functional form has a straightforward interpretation. First, if $r = 0$, a standard production function with undifferentiated labor would apply. Second, the productivity of S years of schooling depends on the rate of return to education r. In contrast to specifications which only rely on average years of education as a proxy for human capital, equation (2) allows for diminishing returns to investment in human capital by considering that different rates of return apply for different levels of education. Hence, this specification presumes a non-linear relation between the stock of human capital and average years of education, as suggested by a large body of microeconometric evidence based on the Mincerian wage equation.

Following Knight et al. (1993), we augment the efficiency term of equation (1) to capture the possible productivity effect of additional variables. We assume that technology A grows according to

$$(3) \qquad A = A(0) e^{g}\, e^{f \cdot CLIM + j \cdot INST + g \cdot CULT} \ ,$$

where $A(0)$ is the initial level of technology, g is the rate of technological change, and *CLIM*, *INST*, and *CULT* stand for climatic, institutional, and cultural factors which might influence output through the parameters f, j, and g.

Given that constant returns to scale prevail ($a + b = 1$), equation (1) can be rewritten in terms of output per worker and estimated in a reduced-form version which partly reflects the availability of data. The model assumes that a constant fraction of output, *inv*, is invested. As shown by Mankiw et al. (1992), the derivation of the equation describing the evolution of capital intensity per effective worker, $k \equiv K / AL$, is given as

$$(4) \qquad \dot{k} = inv\, k^{a}\; e^{(1-a)\cdot school} - (n+g+d)k \ ,$$

where $n = L(0)e^{n}$ is the growth rate of the labor force and d is the rate of depreciation of physical and human capital. Equation (3) implies that k converges to a steady state value k* which follows as

$$(5) \qquad k^{*} = \left[inv\, e^{(1-a)\cdot school} / (n+g+d)\right]^{1/(1-a)} \ .$$

Substituting (5) into the production function and taking logs, we find that output per worker equals

$$(6) \qquad \begin{aligned} \ln(Y/L) = {} & (1-a)(\ln A(0) + g) \\ & +(1-a)(f\, CLIM + j\ INST + g\ CULT) \\ & +\frac{a}{1-a}\ln(inv) - \frac{a}{1-a}\ln(n+g+d) + \frac{1-a}{1-a} school \ , \end{aligned}$$

where the first row on the right-hand-side represents the regression constant, the second row captures the effects of the three additional variables, and the third row controls for differences in factor accumulation and labor force growth. The uncommon feature of equation (6) is that the right-hand-side variable *school* does not enter in logarithmic form.

Given that constant returns to scale prevail and factors are paid their marginal products, equation (6) not only predicts the signs but also the magnitudes of the regression coefficients to be estimated. For instance, with a share of capital in factor income of about one third, the model predicts that increasing the share of investment in GDP by 1 percent will increase output per worker by 0.5 percent. Furthermore, the regression coefficients on investment and on labor force growth are predicted to be the same except for their sign. Finally, the regression coefficient on the human capital variable *school* is predicted to be equal to 1. All these restrictions can be tested empirically. In case they are not rejected, equation (6) can be estimated as

$$\begin{aligned} (7) \qquad \ln(Y/L) - school = {} & (1-a)\left(\ln A(0) + g\right) \\ & + (1-a)\left(f\,CLIM + j\ INST + g\,CULT\right) \\ & + \frac{a}{1-a}\left[\ln(inv) - \ln\left(n + g + d\right)\right]\ . \end{aligned}$$

Central assumptions of this model are that the rate of technical change is the same for all countries and that each country's initial level of technology is uncorrelated with the error term of the regression equation. Hence all countries are assumed to be close to the same production function, given that international differences in climatic, institutional, and cultural conditions, which may inhibit countries from using the best-practice technology, are properly accounted for.

III. Data and Sample

The basic data for the estimation of our model are taken from the Penn World Tables (PWT 1995). Output per worker (*Y/L*) is real GDP per worker in 1990 or in the next available year. Investment (*inv*) is the average share of investment in

GDP for the period 1960-1990. Labor force growth (*n*) is measured as the average growth rate of the working age population in 1960-1990, conditioned for a constant rate of technological change of 2 percent and a constant rate of depreciation of 5 percent, which are the standard parameterizations used in the empirical growth literature (Barro et al. 1995).

We measure the variable *school* in 1990 as a function of averages years of schooling and world-average rates of return to investment in various levels of education. Average years of education in the population aged 25 and older in 1990 are taken from Barro and Lee (1996). World-average social rates of return to investment in education in primary, secondary and higher schooling, calculated by the full method, are taken from Psacharopoulos (1994).

In contrast to the human capital measure used by Hall and Jones (1999), our human capital measure also considers that countries do not only differ with respect to the quantity of their education but also with respect to the quality of education. Following Gundlach et al. (1998), we proxy these differences by using a measure of the quality of education calculated by Hanushek and Kim (1995), which is based on the results of international cognitive achievement tests of students in mathematics and natural sciences. That is, we calculate the variable *school* for country *i* as

$$school_i = \begin{cases} r^{Pri} \cdot S_i \cdot Q_i & if\ S_i \le Pri_i \\ \left(r^{Pri} Pri_i + r^{Sec} \cdot (S_i - Pri_i)\right) \cdot Q_i & if\ Pri_i < S_i \le Pri_i + Sec_i \\ \left(r^{Pri} \cdot Pri_i + r^{Sec} \cdot Sec_i + r^{High} \cdot (S_i - Pri_i - Sec_i)\right) \cdot Q_i & if\ S_i > Pri_i + Sec_i \end{cases}$$

where r^{Pri}, r^{Sec} and r^{High} are world-average social rates of return to primary, secondary, and higher schooling (20 percent, 13.7 percent, and 10.7 percent, respectively); Pri_i and Sec_i are country-specific measures of the duration of the primary and the secondary level of schooling; S_i is average years of educational attainment in country *i*, and Q_i is an index of schooling quality, measured on a 0 to 1 scale.[1] Multiplying quantity of schooling by quality of schooling to arrive at a measure of quality-adjusted schooling appears to be justified because estimated regression coefficients on quantity and quality did not differ when the log values of these variables were entered separately on the right-hand side of a conventional production function by Hanushek and Kim (1995).

We use distance from the equator to proxy for climatically determined transaction costs (*CLIM*). The data, here taken from Hall and Jones (1999), were generated by the global demography project at UC at Santa Barbara. Distance from the equator is measured in latitudes and corresponds to the center of the country or province within a country that contains the largest number of people. In our regression estimates, we use the absolute value of latitude in degrees divided by 90 to place it on a 0 to 1 scale.

We use a measure of government anti-diversion policies as a proxy for institutionally determined transaction costs (*INST*), also taken from Hall and Jones (1999). This measure was created from data assembled by a commercial firm that specializes in providing risk assessments to international investors. The International Country Risk Guide rates 130 countries according to 24 categories. Hall and Jones construct an index ranging from 0 to 1 by using the average of 5 of these categories for the years 1986-1995. The five categories are: bureaucratic quality, law and order, corruption, risk of expropriation and government repudiation of contracts. The first two categories refer to the government's role in protecting against private diversion, while the latter three refer to the government’s possible role as a diverter.

We use a measure of the ethnolinguistic fractionalization within a country to proxy for culturally determined transaction costs (*CULT*). This measure is an average value of five different indices of ethnolinguistic fractionalization taken

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[1] For details of the calculation, including the imputation of missing values for selected countries, see Gundlach et al. (1998).

from La Porta et al. (1998). The five components are the probability that two randomly selected people from a given country will not belong to the same etholinguistic group, the probability of two randomly selected individuals speaking different languages, the probability of two randomly selected individuals not speaking the same language, the percentage share of the population not speaking the official language, and the percentage share of the population not speaking the most widely used language.

Our sample includes all countries for which we were able to collect data, but we excluded countries with a population of less than one million in 1990, countries with oil production as the dominant industry, and formerly centrally planned countries. We also excluded Lesotho because labor income from abroad constitutes an extremely large fraction of GNP. That is, starting from the PWT data base we excluded 46 countries for these reasons. The remaining countries are listed together with all variables used in the Appendix Table.

IV. Estimation Results

We first estimate our empirical model without the proposed extensions of the constant term in equation (3). The first column of Table 1 presents the results. All regression coefficients have the expected sign and are statistically significant at the 5 percent level (except for the conditioned growth rate of the labor force). Columns (2)-(4) show how the basic results change if we separately include our three additional measures of transaction costs, namely distance from the equator (*CLIM*), government anti-diversion policies (*INST*), and ethnolinguistic fractionalization (*CULT*). In each case, the regression coefficient of the additional variable is statistically significant and the results for the other variables (except for the conditioned rate of labor force growth) more or less remain the same.[2]

Once we add all three additional variables to our unrestricted basic model (column (5)), we find that the distance-parameter is reduced to about one half of the value in column (2) and becomes statistically insignificant. Institutional differences also lose some of their economic and statistical significance in explaining international differences in output per worker. However, the regression coefficient on cultural diversity remains statistically significant and basically unchanged in size.

However, this result is not sufficient to reject the idea that climatic conditions or institutions may have a substantial impact on labor productivity, even after international differences in factor accumulation are accounted for. The reason is that the results based on the unrestricted specification are somewhat at odds with the underlying theoretical model. First, the (statistically insignificant) regression coefficient on the conditioned rate of labor force growth has the wrong sign, which is obviously due to the introduction of *CLIM.* Second, the estimated regression coefficient on *school* is statistically different from 1, which is inconsistent with the model assumption of constant returns to scale.

We therefore restrict our empirical model as suggested by equation (7) in order to improve the statistical reliability of our point estimates. The two restrictions are that the regression coefficients on investment and on the conditioned growth rate of the labor force are equal except for their sign and that the regression coefficient on *school* equals 1. We can test whether the restrictions are rejected by the data by computing an F-statistic from the sum of squared residuals of the

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[2] In terms of statistical significance, the results in column (2) largely resemble the results of Ram (1997) for 1985 data. However, the parameter estimates are not comparable in quantitative terms because we use a different measure of human capital and because Ram does not restrict his measure of distance from the equator to the 0 to 1 scale. Furthermore, Ram (1997) does not consider further explanatory variables.

restricted and the unrestricted model. The results of this test are presented in Table 2. The listed *p*-value reports the level of statistical significance with which the restrictions are accepted by the data. Maddala (1992) recommends to apply a higher level of statistical significance for pretests than the usual 5 percent level before accepting any restrictions imposed.

The first column of Table 2 shows that the two theoretical restrictions are not rejected if no additional variables are included in the empirical model. Moreover, the implied production elasticity of physical capital turns out to be statistically significant and also conforms with international estimates of capital's share in factor income in the range of 30 percent. Since the estimated production elasticity is broadly in line with a priori expectations and theoretical restrictions, we conclude that the potential endogeneity of physical and human capital accumulation does not lead to upwardly biased regression coefficients in our specification.

These findings confirm the ability of the neoclassical growth model to account for international differences in labor productivity, as suggested in the seminal paper by Mankiw et al (1992). However, if we add our three additional variables either one by one or all together to our basic model, the test statistics reveal that only one other restricted specification satisfies the theoretically predicted conditions at a reasonable level of statistical significance. This is the model augmented by culturally determined transaction costs as measured by ethnolinguistic diversity (column (4)). By contrast, the specifications with climatic conditions (columns (2) and (5)) or institutional factors (columns (3) and (5)) as additional explanatory variables are rejected by the data. Since both climatic conditions and cultural diversity within countries are likely to be truly exogenous variables, and both appear to be correlated with labor productivity, the question arises why only specifications of the model with cultural diversity as an additional explanatory variable survive statistical tests of the restrictions imposed.

In light of our empirical findings, it is tempting to speculate that although climatic conditions (for that matter, distance from the equator) cannot be changed, economic policies encouraging a high rate of factor accumulation through international trade, capital inflows, and technology adoption may help to overcome geographic and climatic disadvantages fairly easily. By contrast, cultural diversity within countries may be open to change in principle, but probably at a slow rate only or only at the entire dissolution of countries. While there is no apparent link from climatic conditions to inconsistent economic policies, strong cultural diversity within a country may actually inhibit economic policies conducive to aggregate development. Our point estimates suggest that even with the same factor endowment, countries with extreme rates of ethnolinguistic fractionalization like Cameroon, Tanzania, or Zaire would have to face a level of output per worker of more than 70 percent below the level of culturally homogeneous countries like Japan, a developing country not long ago.

V. Conclusion

Our regression results for a cross-section of countries confirm the theoretical predictions of a standard neoclassical growth model with regard to factor accumulation. In addition, we find that neither climatic conditions nor institutional factors have a significant direct impact on labor productivity once international differences in factor accumulation and cultural diversity are accounted for. Cultural diversity appears to have a large negative impact on labor productivity. Hence our results differ from Ram (1997), who found a statistically significant impact of climatic conditions on labor productivity and growth, and they also differ from Lian and Oneal (1997), who did not find an impact of cultural diversity on growth.

In our unrestricted empirical model, the estimated regression coefficient on the variable which proxies for climatic conditions becomes insignificant once we allow for factor accumulation and additional explanatory variables. Once we impose theoretical restrictions on the parameters of the estimation equation, the empirical model is rejected by the data whenever we include our measure of climatic conditions as an additional variable. These results support the view that distance from the equator appears to be spuriously correlated with output per worker.

We also cannot confirm that climatic conditions may proxy the extent of Western European influence on the present institutional framework. We estimate a statistically significant regression coefficient on our measure of institutional differences across countries in our unrestricted empirical model, but the regression coefficient turns out to be statistically insignificant and the model is rejected by the data once we impose theoretical restrictions on the parameters. Hence institutional differences may only indirectly affect output per worker through their effect on factor accumulation, which we take into account directly.

By contrast, the negative regression coefficient on our measure of cultural diversity within countries remains statistically robust and basically unchanged in size independent of the other variables included in the specification. Adding this variable to our empirical model is the only specification which survives a statistical test of the theoretical restrictions which can be imposed. Hence, we conclude that cultural factors such as the ethnic diversity within countries rather than climatic conditions may limit economic development in presently poor countries.

Appendix Table

	GDP per worker	Invest. share of GDP	Labor force growth	*school*	*CLIM*	*INST*	*CULT*
ALGERIA	12176	21.38	2.34	0.337	0.408	0.529	0.294
ANGOLA	1471	3.51	2.39	0.589	0.098	0.427	0.773
BENIN	1903	6.58	2.34	0.205	0.071	0.376	0.683
BOTSWANA	6533	19.10	2.38	0.354	0.239	0.713	0.378
BURKINA FASO	1058	7.56	1.80	0.378	0.134	0.498	0.547
BURUNDI	1062	4.82	1.61	0.378	0.037	0.528	0.013
CAMEROON	2489	8.49	2.75	0.418	0.119	0.563	0.852
CENTRAL AFR.R.	1217	6.49	1.31	0.139	0.048	0.420	0.786
CHAD	1148	1.99	1.67	0.378	0.115	0.554	0.666
CONGO	4497	10.24	3.28	0.853	0.041	0.415	0.669
EGYPT	6889	4.60	2.25	0.409	0.333	0.551	0.023
ETHIOPIA	715	4.91	2.32	0.378	0.100	0.339	0.677
GHANA	1873	6.16	3.00	0.308	0.074	0.540	0.706
GUINEA	1594	6.06	0.63	0.378	0.130	0.504	0.760
IVORY COAST	3075	11.15	2.71	0.589	0.061	0.626	0.857
KENYA	1863	15.51	4.00	0.359	0.006	0.582	0.827
LIBERIA	2151	12.76	2.46	0.309	0.071	0.197	0.803
MADAGASCAR	1561	1.40	2.09	0.378	0.211	0.476	0.627
MALAWI	1217	9.85	2.45	0.389	0.176	0.503	0.622
MALI	1107	6.12	3.48	0.121	0.139	0.311	0.809
MAURITANIA	1648	15.09	3.37	0.378	0.199	0.406	0.270
MAURITIUS	10198	10.53	2.25	1.210	0.225	0.704	0.709
MOROCCO	6770	9.02	2.87	0.604	0.373	0.563	0.348
MOZAMBIQUE	1560	1.86	1.73	0.088	0.206	0.536	0.786
NAMIBIA	9528	24.91	1.52	0.589	0.200	0.462	0.728
NIGER	1043	8.65	2.22	0.088	0.154	0.514	0.733
NIGERIA	2082	12.48	2.57	0.395	0.073	0.428	0.857
RWANDA	1539	3.88	2.68	0.236	0.023	0.387	0.061
SENEGAL	2398	5.13	2.50	0.314	0.164	0.487	0.779
SIERRA LEONE	2487	1.47	1.36	0.209	0.097	0.398	0.813
SOMALIA	1638	8.61	3.19	0.378	0.118	0.320	0.079
SOUTH AFRICA	9595	18.38	2.42	1.062	0.324	0.740	0.831
TANZANIA	1126	10.72	2.46	0.378	0.024	0.551	0.890
TOGO	1583	15.86	2.50	0.345	0.069	0.446	0.729
TUNISIA	8861	14.67	2.74	0.518	0.409	0.541	0.070
UGANDA	1142	2.43	3.02	0.226	0.003	0.368	0.836
ZAIRE	1118	4.09	2.04	0.317	0.006	0.225	0.872
ZAMBIA	2061	21.87	2.91	0.634	0.144	0.424	0.829
ZIMBABWE	2437	17.24	3.74	0.392	0.199	0.545	0.599
CANADA	34380	23.86	2.32	2.040	0.486	0.976	0.376
COSTA RICA	10040	16.15	3.38	1.066	0.111	0.670	0.053
DOMINICAN REP.	6898	15.23	2.83	0.633	0.206	0.510	0.011
EL SALVADOR	5485	8.31	2.42	0.381	0.153	0.372	0.051
GUATEMALA	7435	9.08	2.60	0.438	0.163	0.371	0.477
HAITI	1990	5.16	0.74	0.358	0.210	0.236	0.064
HONDURAS	4464	13.85	3.19	0.450	0.158	0.424	0.097
JAMAICA	5146	21.80	1.90	0.938	0.201	0.544	0.013
MEXICO	17012	16.51	3.05	0.935	0.186	0.592	0.174
NICARAGUA	4159	11.44	2.83	0.386	0.136	0.523	0.099
PANAMA	7999	20.27	2.81	1.410	0.102	0.410	0.191
PUERTO RICO	26137	22.15	2.03	1.082	0.203	0.640	0.027
TRINIDAD&TOBAGO	19880	12.40	2.11	1.245	0.116	0.616	0.231
U.S.A.	36771	21.45	1.75	1.926	0.382	0.947	0.209

Appendix Table continued

	GDP per worker	Invest. share of GDP	Labor force growth	*school*	*CLIM*	*INST*	*CULT*
ARGENTINA	13406	16.50	1.12	1.560	0.408	0.579	0.177
BOLIVIA	5315	16.52	2.14	0.483	0.169	0.381	0.599
BRAZIL	11041	19.32	2.87	0.557	0.217	0.682	0.056
CHILE	11854	19.64	2.17	0.652	0.373	0.646	0.051
COLOMBIA	10108	15.78	2.64	0.688	0.053	0.565	0.056
ECUADOR	9032	22.00	2.59	0.929	0.023	0.573	0.325
PARAGUAY	6383	13.33	2.92	0.807	0.284	0.486	0.411
PERU	6847	17.67	2.60	0.969	0.131	0.438	0.432
URUGUAY	11828	12.80	0.52	1.445	0.387	0.564	0.067
VENEZUELA	17426	17.76	3.69	0.817	0.109	0.612	0.053
BANGLADESH	4790	4.23	1.87	0.409	0.265	0.313	0.000
CHINA	2189	20.27	2.26	1.420	0.329	0.641	0.233
HONG KONG	22827	19.89	2.77	2.335	0.252	0.791	0.237
INDIA	3235	13.78	1.89	0.316	0.281	0.591	0.742
INDONESIA	5024	16.54	2.20	0.724	0.073	0.484	0.691
ISRAEL	23780	26.12	2.97	1.874	0.357	0.756	0.327
JAPAN	22624	34.21	1.15	2.278	0.397	0.932	0.010
JORDAN	12634	13.89	2.10	0.946	0.351	0.562	0.030
KOREA, REP.	16022	23.20	2.60	2.043	0.417	0.735	.
MALAYSIA	12527	22.91	3.19	1.288	0.036	0.687	0.610
MYANMAR	1362	8.59	2.11	0.394	0.196	0.367	0.384
NEPAL	2298	5.31	1.69	0.185	0.308	.	0.450
PAKISTAN	4639	10.62	2.87	0.420	0.346	0.453	0.622
PHILIPPINES	4784	15.29	2.55	0.931	0.155	0.407	0.724
SINGAPORE	24369	30.91	2.96	1.687	0.015	0.859	0.322
SRI LANKA	5742	9.11	1.88	0.962	0.076	0.463	0.326
SYRIA	15871	14.72	2.90	0.565	0.372	0.491	0.095
THAILAND	6754	17.39	2.75	1.025	0.153	0.711	0.357
AUSTRIA	26700	25.72	0.27	1.530	0.536	0.949	0.113
BELGIUM	31730	23.78	0.57	1.892	0.565	0.954	0.364
DENMARK	24971	25.78	1.05	2.432	0.619	0.984	0.028
FINLAND	27350	34.78	0.79	2.151	0.669	0.980	0.105
FRANCE	30357	27.25	0.92	1.501	0.543	0.941	0.146
GERMANY, WEST	29509	27.92	0.54	1.511	0.535	0.963	0.047
GREECE	17717	24.70	0.45	1.549	0.423	0.712	0.078
IRELAND	24058	24.70	0.64	1.600	0.607	0.889	0.090
ITALY	30797	27.99	0.41	1.222	0.505	0.815	0.039
NETHERLANDS	31242	24.66	1.43	1.802	0.576	0.988	0.063
NORWAY	29248	31.04	1.45	2.016	0.666	0.968	0.070
PORTUGAL	16637	22.70	0.86	0.683	0.431	0.811	0.003
SPAIN	26364	25.32	0.66	1.297	0.416	0.802	0.275
SWEDEN	28389	23.53	1.03	2.034	0.659	0.987	0.065
SWITZERLAND	32812	29.37	1.00	2.083	0.527	1.000	0.308
TURKEY	8632	21.10	1.87	0.569	0.458	0.601	0.164
U.K.	26755	18.13	0.52	2.091	0.572	0.933	0.106
AUSTRALIA	30312	28.60	2.26	2.213	0.358	0.931	0.113
NEW ZEALAND	25413	24.63	1.81	2.676	0.410	0.986	0.148
PAPUA N.GUINEA	3020	15.47	1.86	0.163	0.073	0.625	0.803

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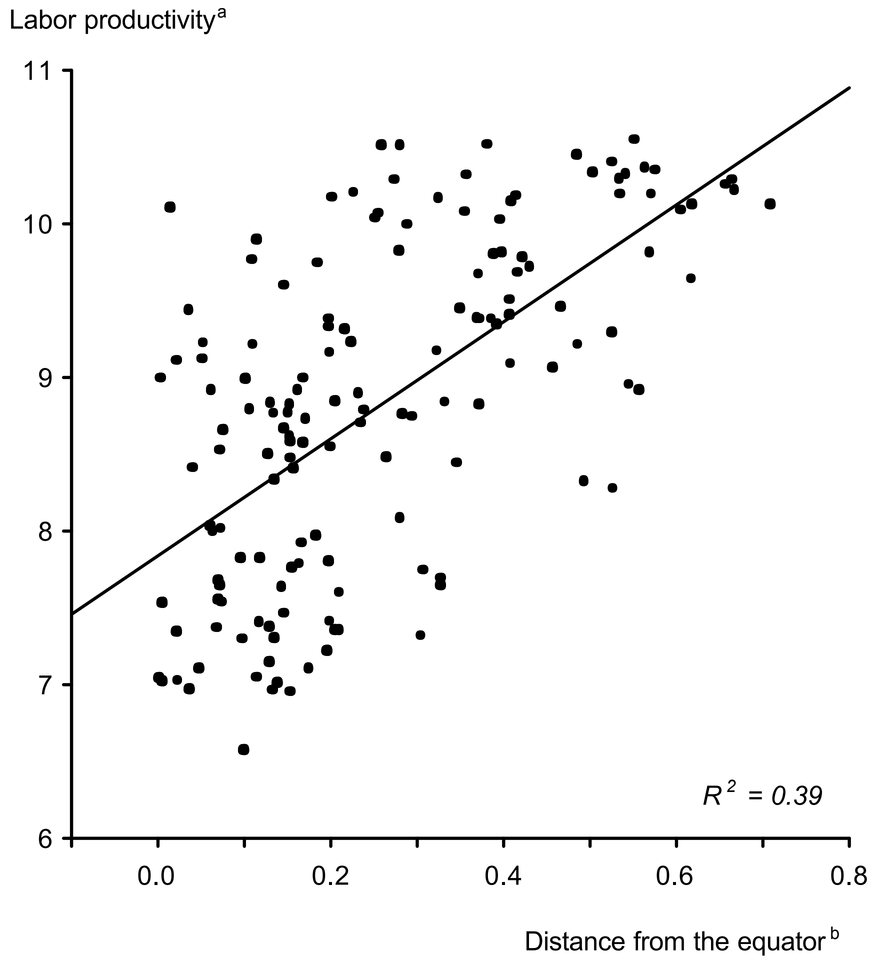
Figure 1 — Labor Productivity and Distance from the Equator



[a]Log output per worker 1990, 151 countries.— [b]Absolute value of distance from the equator, (0,1) scale

Source: Hall and Jones (1999), PWT (1994).

Table 1 - Estimation of the Unrestricted Model

Dependent variable: log GDP per working-age person in 1990.					
	(1)	(2)	(3)	(4)	(5)
Constant	6.30	9.27	6.90	7.72	9.46
	(1.55)	(1.70)	(1.53)	(1.45)	(1.58)
ln(inv)	0.62	0.53	0.54	0.52	0.42
	(0.11)	(0.11)	(0.11)	(0.10)	(0.10)
ln(n+g+δ)	-1.22	0.22	-0.65	-0.73	0.37
	(0.67)	(0.75)	(0.69)	(0.62)	(0.71)
school	0.89	0.73	0.62	0.79	0.50
	(0.13)	(0.13)	(0.16)	(0.12)	(0.15)
CLIM		1.74			0.83
		(0.50)			(0.52)
INST			1.39		1.15
			(0.53)		(0.51)
CULT				-0.95	-0.87
				(0.21)	(0.21)
Adjusted R^2	0.74	0.77	0.75	0.79	0.80
s.e.e.	0.59	0.56	0.57	0.53	0.51
Observations	101	101	100	100	99

Note: standard errors are in parenthesis. For a description of variables, see Section III.

Table 2 - Estimation of the Restricted Model

Dependent variable: log GDP per working-age person in 1990 - school					
	(1)	(2)	(3)	(4)	(5)
Constant	7.64	7.43	7.31	8.03	7.82
	(0.06)	(0.10)	(0.22)	(0.11)	(0.24)
ln(inv) - ln(n+g+δ)	0.57	0.42	0.46	0.41	0.35
	(0.08)	(0.09)	(0.11)	(0.08)	(0.10)
CLIM		1.06			0.49
		(0.39)			(0.48)
INST			0.61		0.11
			(0.39)		(0.44)
CULT				-0.87	-0.76
				(0.20)	(0.21)
Adjusted R^2	0.34	0.38	0.35	0.45	0.45
s.e.e.	0.58	0.57	0.58	0.54	0.54
Observations	101	101	100	100	99
Test of restriction:					
p-value	0.54	0.06	0.07	0.22	0.002
Implied α	0.36	0.30	0.31	0.29	0.26
	(0.03)	(0.05)	(0.05)	(0.04)	(0.06)

Note: standard errors are in parenthesis. For a description of variables, see Section III.