NBER WORKING PAPER SERIES

THE PRODUCTIVITY OF NATIONS

Robert E. Hall
Charles I. Jones

Working Paper 5812

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 1996

This research was supported by the Center for Economic Policy Research at Stanford and by the National Science Foundation under grants SBR-9410039 (Hall) and SBR-9510916 (Jones). We thank Bobby Sinclair for excellent research assistance and colleagues too numerous to list for an outpouring of helpful commentary. Data used in this paper are available from "http://www.stanford.edu/~chadj/." This paper is part of NBER's research programs in Economic Fluctuations and Growth and Productivity. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper 5812
November 1996

THE PRODUCTIVITY OF NATIONS

ABSTRACT

Output per worker varies enormously across countries. Why? Our analysis shows that differences in governmental, cultural, and natural infrastructure are important sources of this variation. According to our results, a high-productivity country (i) has institutions that favor production over diversion, (ii) is open to international trade, (iii) has at least some private ownership, (iv) speaks an international language, and (v) is located in a temperate latitude far from the equator. A favorable infrastructure helps a country both by stimulating the accumulation of human and physical capital and by raising its total factor productivity.

Robert E. Hall
Hoover Institution
and Department of Economics
Stanford University
Stanford, CA 94305-6010
and NBER
Hall@Hoover.Stanford.edu

Charles I. Jones
Department of Economics
Stanford University
Stanford, CA 94305-6010
Chad.Jones@Stanford.edu

1 Introduction

In 1988, output per worker was 48 times higher in the most productive compared to the least productive country. Explaining such vast differences in long-run economic performance is one of the fundamental challenges of economics. To start to address this challenge, we begin with an application of the Solow (1957) productivity analysis to differences in levels of output per worker across countries. Solow's approach, applied across countries rather than over time, enables us to decompose differences in output per worker into components attributable to differences in human capital per worker, physical capital per worker, and total factor productivity. We document that differences in productivity are substantial: some countries get much more output than others from their labor forces and stocks of human and physical capital. Differences in productivity contribute approximately as much as differences in physical and human capital to differences in output per worker.

We then turn to the determinants. Why do some countries have higher levels of productivity, physical capital, and human capital than others? What are the underlying determinants of the 48-fold difference in output per worker across countries? Broadly speaking, our answer is infrastructure, which we take to include characteristics of the government, the culture, and the climate of a country. A good infrastructure provides an environment that supports productive activities, thereby encouraging capital accumulation, skill acquisition, invention, and technology transfer. Across 133 countries, our measures of infrastructure are able to explain about 3/4 of the variation in output per worker and its components.[1]

[1] Mankiw, Romer and Weil (1992) use the neoclassical growth model of Solow (1956) to explain differences in levels of output per adult by appealing to differences in investment rates in physical and human capital, but this explanation raises another question: Why do some countries have much higher investment rates than others? Their approach also differs in that they do not emphasize differences in productivity across countries.

What constitutes a good infrastructure? Social institutions that protect the output of individual productive units from diversion are potentially of greatest importance. Thievery, squatting, and Mafia protection are examples of diversion undertaken by private agents. Social control of diversion has two benefits. First, in a society free of diversion, productive units are rewarded by the full amount of their production—where there is diversion, on the other hand, it acts like a tax on output. Second, where social control of diversion is effective, individual units do not need to invest resources in avoiding diversion. In many cases, social control is much cheaper than private avoidance. Where there is no effective social control of burglary, for example, property owners must hire guards and put up fences. These consume resources. Social control of burglary involves two elements. First is the teaching that stealing is wrong. Second is the threat of punishment. The threat itself is free—the only resources required are those needed to make the threat credible. The value of infrastructure goes far beyond the notion that collective action can take advantage of returns to scale in avoidance. It is not that the city can put up fences more cheaply than can individuals—in a well run city, no fences are needed at all.

Paradoxically, while the government is potentially the most efficient provider of infrastructure that protects against diversion, it is also in practice a primary agent of diversion throughout the world. Expropriation, confiscatory taxation, and corruption are examples of public diversion. Regulations and laws may protect against diversion, but they all too often constitute the chief vehicle of diversion in an economy.

Many economists, deeply influenced by Adam Smith, have concluded that the most important element of the infrastructure, from the point of view of encouraging high levels of economic activity, is the enforcement of private property rights. Among countries that rely on the private organization of production, our findings strongly support this proposition. In countries we classify as capitalist, those with effective governments devoted to protection of private productive units achieve much higher levels of output per worker than those with incompetent or dishonest governments. On the other hand, our results give much less support to the hypothesis that private organization of production is far superior to social organization. Non-capitalist economies with effective governments tend to produce about as much per worker as capitalist economies with similarly effective governments. By effective we mean the use of policies that serve the interests of citizens, not policies that divert resources from individual uses to government uses. Italy and Taiwan are leading examples of countries with high levels of output per worker and non-capitalist economic systems sustained by effective government.

We also consider several other measures of infrastructure. Openness to international trade may be a sensitive indicator of the extent to which government policies favor production over diversion. More generally, openness may provide direct economic benefits that encourage production such as the presence of a large market for domestically produced goods and access to world markets for capital and ideas.

Another measure of infrastructure that we consider is language. Countries that share a common language are likely to share elements of infrastructure that are imperfectly measured by other variables. For example, Australia and the United States benefit from infrastructure such as a strong judicial system first put in place by the British when the countries were colonies. Our results indicate that economic performance is higher in countries in which a large fraction of the population speak an international language such as Arabic, Chinese, or English. Interestingly, our results do not assign a special role to the English language beyond its place as one of eight international languages.

Finally, we also consider one aspect of the nation's natural infrastructure, its climate. We find that economic performance is substantially higher in countries in temperate latitudes in comparison to those close the equator.

Our research is related to many earlier contributions. The large body of theoretical and qualitative analysis of property rights and economic success will be discussed in Section 3. The recent empirical growth literature associated with Barro (1991) and others shares some common elements with our work, but our empirical framework differs fundamentally in its focus on levels instead of rates of growth. Levels capture the differences in long-run economic performance in which we are most interested.[2] Our focus is easily motivated with a simple analogy to time series econometrics. Differencing a time series removes the effect of permanent or long-run influences and highlights the role of transitory movements. Our empirical work studies variables that change so slowly over time that their effects on growth may be hard to detect, even though their role in levels is large. Since most recent research on growth has concluded that the empirical correlation between levels of income and growth rates of income is close to zero, our work on levels uncovers empirical relations that may be invisible in the growth framework.

2 Levels Accounting

The growth accounting literature following Solow (1957) decomposes changes in output over time into changes in inputs and changes in productivity. We exploit symmetry between time and space and perform the same exercise across countries, rather than over time, in order to examine the relative im-

[2]Several recent contributions to the growth literature point toward a focus on levels. Easterly, Kremer, Pritchett and Summers (1993) document the relatively low correlation of growth rates across decades, which suggests that differences in growth rates across countries may be mostly transitory. Jones (1995) questions the empirical relevance of endogenous growth and presents a model in which different government policies are associated with differences in levels, not growth rates. Finally, a number of recent models of idea flows across countries such as Parente and Prescott (1994), Barro and Sala-i-Martin (1995) and Eaton and Kortum (1995) imply that all countries will grow at a common rate in the long run: technology transfer keeps countries from drifting indefinitely far from each other. In these models, long-run differences in levels are the interesting differences to explain.

portance of inputs and total factor productivity in determining differences in levels of output per worker across countries. Up to this point, we have followed other economists in using productivity to refer to both output per worker and total factor productivity. From now on, we will use the word productivity specifically to mean total factor productivity.

Consider a continuum of countries, indexed by a variable i, each with output Y_i, Hicks-neutral productivity A_i, human capital-augmented labor input H_i, and capital K_i. They share a common production kernel, $F(K, H)$:

$$Y_i = A_i F(K_i, H_i). \tag{1}$$

We assume labor L_i is homogeneous within a country and that each unit of labor has been trained with S_i years of schooling. Human capital-augmented labor is given by

$$H_i = e^{\phi(S_i)} L_i. \tag{2}$$

In this specification, $\phi(S)$ reflects the efficiency of a unit of labor with S years of schooling relative to one with no schooling ($\phi(0) = 0$). The derivative $\phi'(S)$ is the return to schooling estimated in a Mincerian wage regression (Mincer 1974): an additional year of schooling raises a worker's efficiency proportionally by $\phi'(S)$. Note that if $\phi(S) = 0$ for all S this is a standard production function with unskilled labor.

This setup is identical to the one considered by Solow (1957), with the country index i replacing time and with the addition of human capital. We can move directly to Solow's conclusion,

$$\hat{y} = \alpha\hat{k} + (1 - \alpha)\hat{h} + \hat{A}, \tag{3}$$

where $y \equiv Y/L$, $k \equiv K/L$, $h \equiv H/L$, and the hat ($\hat{}$) indicates the log derivative with respect to the country index i, e.g. $\hat{A} \equiv d \log A_i/di$. Equation 3 states that the proportional increment in output per worker, $\hat{y}$, is equal to a weighted average of the proportional increment in physical and human capital per worker, $\hat{k}$ and $\hat{h}$, where the weight is capital's factor share, α_i, plus the proportional increment in productivity, $\hat{A}$. The only assumptions about the production kernel are constant returns to scale and differentiability. The measurement of capital's factor share typically requires the assumption that firms face competitive factor markets. The shares are functions of i, not constants. For further discussion, see Hall (1990).

Another assumption in the derivation is that the technology, A_i, labor input L_i, capital K_i, and the factor share α_i are differentiable functions of the country index, i. Thus, to apply Solow's method across countries, the countries must be ordered so that similar ones are next to each other. To order the countries in our sample, we sort them by a combination of their physical and human capital/labor ratios and their capital shares.[3] Then the value of the productivity index for country i can be recovered as

$$\log A_i = \int_0^i \hat{A}_j \, dj + \log A_0. \tag{4}$$

Finally, we use finite differences in place of derivatives, so that equations 3 becomes

$$\Delta \log y_i = \bar{\alpha}_i \Delta \log k_i + (1 - \bar{\alpha}_i) \Delta \log h_i + \Delta \log A_i, \tag{5}$$

where $\bar{\alpha}_i \equiv .5(\alpha_i + \alpha_{i-1})$. As in the traditional application to changes over time, equation 5 implicitly determines the productivity residual, $\Delta \log A$: that is, the difference in productivity between two adjacent countries can be computed by subtracting a weighted average of the difference in physical and human capital per worker from the difference in output per worker. The use of the arithmetic average of the two factor shares makes this a Törnqvist

[3]To sort, we use an index z given by $z_{\log k} + z_{\alpha} + z_{\log h}$, where $z_x \equiv (x - mean(x))/std(x)$. Other methods such as sorting by only the capital-labor ratio or only the capital share yield similar results; the correlation among the productivity series computed in these different ways is above 0.98.

or Fisher ideal index, known to be the best discrete Divisia index (see Diewert (1978)). Although the use of finite differences is an approximation, it is extraordinarily accurate, even when there are large differences between factor intensities for adjacent observations; see Star and Hall (1976).

We compute the level of productivity for a country using the finite difference version of equation 4

$$\log A_i = \sum_{j=2}^{i} \Delta \log A_j + \log A_1. \tag{6}$$

The level of productivity in country i is found by summing up the relevant productivity differences. The level for the first country is not defined by equation 6 but is normalized to an arbitrary value. Because of the normalization, the intercept in our models with $\log A$ on the left side is indeterminate and is not reported.[4]

Our use of the cross-sectional version of Solow's method has two advantages over the estimation of production functions, as in Mankiw et al. (1992). First, we make no assumption about the functional form of production. Second, because Solow's method does not require the estimation of parameters of the production function, we can use data on human and physical capital that are plainly endogenous without making use of questionable assumptions to identify parameters.

2.1 Data

To perform the levels accounting exercise, we use data on output, labor input, average educational attainment, and physical capital for the year 1988. National income and product account data and labor force data are

[4] In principle, our method, based on Solow's idea of comparing adjacent economies, is superior to the proposal of Christensen, Cummings and Jorgenson (1981) based on comparisons of each country to the mean of all countries. In fact, the accuracy of Törnqvist comparisons is so high even for countries that are quite different that all methods that use that form of comparison give essentially identical results.

taken from the Penn World Tables Mark 5.6 revision of Summers and Heston (1991). We do not have data on hours per worker for most countries, so we use the number of workers instead of hours to measure labor input. Educational attainment data are for the year 1985 and are from Barro and Lee (1993). Physical capital stocks are constructed using the perpetual inventory method.[5] Because we only need data on the capital stock for 1988, our measure is quite insensitive to the choice of the initial value.

We do not have satisfactory data for capital's share for most of the countries in the sample. Instead, we make the assumption that the service price of physical capital is roughly the same across countries. Under this assumption, we can calculate capital's share using data on the capital stock, the volume of output, and a common rate of return.[6] Although we probably understate capital's share in countries where the relative price of capital is high because of limitations of imports, the consequence for measuring productivity seems to be small. Alternative measures based, for example, on the use of a uniform capital share give very similar results, as discussed below.

We assume that human capital is labor augmenting, as noted above. Psacharopoulos (1994) surveys evidence from many countries on return-to-schooling estimates. Based on his summary of Mincerian wage regressions, we assume that $\phi(S)$ is piecewise linear. Specifically, for the first 4 years of education, we assume a rate of return of 13.4 percent, corresponding to the average Psacharopoulos reports for sub-Saharan Africa. For the next 4 years, we assume a value of 10.1 percent, the average for the world as a whole.

[5] We limit our sample to countries with investment data going back at least to 1970 and use all available investment data. For example, suppose 1960 is the first year of investment data for some country. We estimate the initial value of the 1960 capital stock for that country as $I_{60}/(g+\delta)$ where g is calculated as the average geometric growth rate from 1960 to 1970 of the investment series. We assume a depreciation rate of 6 percent.

[6] The rate of return is chosen to give a value of 1/3 for the U.S. capital share. This implies a rate of return of 13.53 percent.

Finally, for education beyond the 8th year, we use the value Psacharopoulos reports for the OECD, 6.8 percent.

Our calculations of productivity also incorporate a correction for natural resources used as inputs. Because of inadequate data, our correction is quite coarse: we subtract value added in the mining industry (which includes oil and gas) from GDP in computing our measure of output. That is, we assign all of mining value added to natural resource inputs and neglect capital and labor inputs in mining. Without this correction, resource-rich countries such as Oman and Saudi Arabia would be among the top three in terms of productivity.[7]

2.2 Accounting for Differences in Output per Worker across Countries

By taking the appropriate sums over the terms in equation 5, Table 1 decomposes the difference in the log of output per worker between the United States and a number of other countries into differences in physical and human capital per worker and differences in productivity.[8] For example, according to this table, output per worker in Canada is about 6.1 percent lower than in the U.S. The contribution from physical capital per worker is essentially zero while a difference of about 5 percentage points is attributable to lower human capital per worker. Differences in inputs almost entirely explain lower Canadian output per worker, so Canadian productivity is about the same as U.S. productivity. Other OECD economies also have productivity levels close to U.S. productivity. Italy and France are slightly higher; Germany and the U.K. are slightly lower.

Puerto Rico deserves special mention as it is — by far — the most

[7] Apart from the ranking of productivity and output per worker, none of our empirical results that follow are sensitive to this correction. We compute the mining share of GDP in current prices from United Nations (1994) for most countries. Data for China, Israel, Czechoslovakia, Ireland, Italy, Poland, and Romania are taken from United Nations (1993).

[8] A complete set of results is reported in the Appendix table.

Table 1: Levels Accounting: Difference from U.S.

Country	Departure below U.S. $\log Y/L$	—Contribution from— $\log K/L$	$\log H/L$	$\log A$
Canada	-0.061	0.001	-0.049	-0.013
Italy	-0.182	-0.011	-0.260	0.089
West Germany	-0.201	0.031	-0.127	-0.105
France	-0.201	0.013	-0.244	0.029
United Kingdom	-0.318	-0.168	-0.112	-0.039
Puerto Rico	-0.341	-0.458	-0.392	0.509
Hong Kong	-0.498	-0.435	-0.150	0.086
Japan	-0.533	-0.107	-0.130	-0.296
Mexico	-0.838	-0.567	-0.405	0.134
Argentina	-0.873	-0.339	-0.219	-0.315
U.S.S.R.	-1.043	-0.230	-0.196	-0.618
India	-2.454	-0.883	-0.503	-1.068
China	-2.815	-1.033	-0.319	-1.462
Kenya	-2.876	-0.939	-0.499	-1.438
Zaire	-3.429	-0.995	-0.564	-1.871
Average, 132 Countries:	-1.754	-0.618	-0.390	-0.747
Standard Deviation:	1.072	0.344	0.195	0.642
Results with $\alpha = 1/3$				
Average, 132 Countries:	-1.754	-0.723	-0.414	-0.618
Standard Deviation:	1.072	0.523	0.189	0.479

Note: The elements of this table reflect the appropriate summations calculated using equation (5). The components of the production function are weighted by factor shares.

productive country according to our calculation. Its output per worker is similar to that in the U.K. but measured inputs are much lower.[9] The result is a high level of productivity. Baumol and Wolff (1996) comment on

[9] As discussed in a later section, we imputed educational attainment data for 31 countries. Part of the explanation of Puerto Rico's high productivity is probably that educational attainment in Puerto Rico is greater than our imputation procedure estimates.

Puerto Rico's extraordinary recent growth in output per worker. In addition, there is good reason to believe that Puerto Rico's national income accounts overstate output. Many U.S. firms have located production facilities there because of low tax rates. To take maximum advantage of those low rates and to avoid higher U.S. rates, they report exaggerated internal transfer prices when the products are moved within the firm from Puerto Rico back to the U.S. When these exaggerated non-market prices are used in the Puerto Rican output calculations, they result in an overstatement of real output.

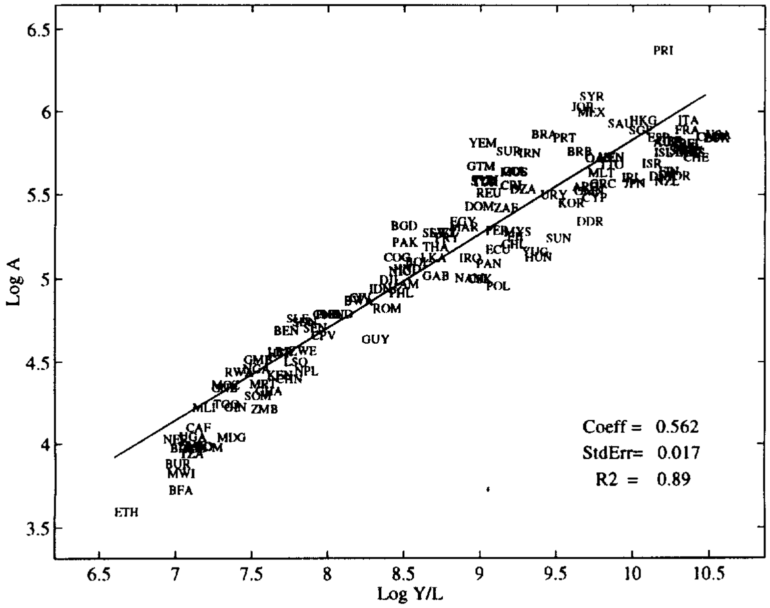
Consistent with conventional wisdom, the U.S.S.R. has relatively high levels of both physical and human capital but a rather low productivity level. For the developing countries in the table, differences in productivity are the most important factor in explaining differences in output per worker. For example, $\log Y/L$ is lower in China by 2.815, and more than half of this difference is due to lower productivity.

The bottom half of Table 1 reports the average and standard deviation of the contribution of inputs and productivity to differences in output per worker between the U.S. and the other 132 countries in our sample. According to either statistic, differences in productivity across countries are substantial. In terms of levels accounting, differences in A are more important than differences in h and at least as important as differences in k in explaining differences in output per worker across countries.[10]

Figure 1 shows productivity levels across countries plotted against output per worker. The figure illustrates that differences in productivity are very similar to differences in output per worker; the correlation between the two series is 0.94. Nevertheless, there are interesting differences between the two series. For example, the most productive country is Puerto Rico, which produces more than 16 times as much output per unit of input as the least

[10]The correlation between productivity levels calculated assuming the capital share varies across countries and the productivity levels calculated assuming $\alpha = 1/3$ for all countries is .938.

Figure 1: Productivity and Output per Worker



productive country, Ethiopia.[11] Also, the countries with the highest levels of productivity are Puerto Rico, Syria, Jordan, Mexico, Italy, and Hong Kong. Those with the lowest levels are Ethiopia, Burkina Faso, Malawi, Myanmar, Tanzania, and Chad. U.S. productivity ranks 11th out of 133 countries.[12]

The first half of Mankiw et al. (1992) can be read as an exercise in levels accounting. Three important differences are worth noting. First, instead of following Solow (1957), they attempt to estimate the shape of the production function econometrically. Their identifying assumption is that differences in productivity across countries are uncorrelated with physical and human cap-

[11]This distribution is more compact than the distribution for output per worker, but this partly reflects the fact that they are not measured in the same units — for example, if the technology is Cobb-Douglas and the output/capital ratio is the same in every country, the productivity index is the output/labor ratio raised to the power α.

[12]The productivity ranking, especially at the top, is somewhat sensitive to our ordering of countries and to our allowing factor shares to differ across countries.

ital accumulation. Our results sharply call this identifying assumption into question since our measure of productivity is highly correlated with physical and human capital. Second, they argue that differences in productivity are relatively unimportant; differences in factor inputs are sufficient to explain most of the differences in output across countries. In contrast, we find substantial differences in productivity levels across countries. Explaining these differences is one of the goals of the rest of the paper.[13]

The third difference between our work and Mankiw et al. (1992) is that we measure the role of capital by the actual stock, whereas they use the investment/GDP ratio. The interpretation of our results needs to keep this difference in mind. A country that enjoys higher GDP because of favorable infrastructure will have a higher capital stock even if it does not have a higher investment/GDP ratio. Our approach puts more emphasis on the capital accumulation channel than would an alternative based on the investment/capital ratio. The difference is purely one of interpretation; our results could be restated in a framework that used the investment/GDP ratio to characterize the effects that operate through the capital channel.

3 Determinants of Long-Run Economic Performance

We are now ready to discuss the central issues of the paper. Our primary endogenous variable of interest is output per worker. We are also interested in studying the three-way breakdown of that variable into human and physical capital components and the total factor productivity residual. We

[13]Interpretation of this second difference requires a careful consideration of the Mankiw et al. (1992) results. The R^2 from their (log) level regressions is approximately .75. This implies that the ratio of the variance in labor-augmenting productivity to the variance in output per adult is .25. Therefore the standard deviation of labor-augmenting productivity is about 1/2 the standard deviation in output per adult. Extending the MRW analysis, Islam (1995) reports large differences in productivity levels, but his results are also subject to the endogeneity criticism and, led by econometric estimates, he largely ignores differences in human capital in computing the levels.

examine a reduced-form relationship. The exogenous causal variables measure basic characteristics of each country's economy. The relation between these independent variables and output per worker captures all of the effects of the variables, through capital accumulation and through productivity. Subsidiary relations between the three components of output per worker—weighted human capital per worker, weighted physical capital per worker, and the productivity residual—indicate how the exogenous variables work partly through capital accumulation and partly through productivity.

The determinants considered in our work describe, broadly speaking, the infrastructure of a country. A country with an infrastructure favorable for economic success will both accumulate more human and physical capital and have higher productivity. That is, infrastructure influences both the accumulation of private inputs and the efficiency with which an economy translates these inputs into output.

Part of the infrastructure of an economy is the set of rules and institutions within which productive units operate. Because this type of infrastructure has some of the characteristics of a public good, the role of the government in providing infrastructure is typically large. We start by discussing two basic measures of infrastructure that are directly related to government: (i) the effectiveness of the government's support for productive activities and (ii) the government's involvement in production.

Social action—typically through the government—is a prime determinant of productivity in almost any view. The literature in this area is far too voluminous to summarize adequately here. Previous authors have not focused directly on either output per worker or on productivity, but many of the mechanisms they have stressed affect both of these variables. Key contributions are Olson (1965), Olson (1982), and North (1990). Greif and Kandel (1995) discuss the obstacles that imperfect contract enforcement create for economic activity in Russia. Our empirical results give strong support to the importance of infrastructure. Productive activities are vulnerable to predation. If a farm cannot be protected from theft, then thievery will be an attractive alternative to farming. A fraction of the labor force will be employed as thieves, making no contribution to output. Farmers will spend more of their time protecting their farms from thieves and consequently grow fewer crops per hour of effort.

A number of authors have developed models of equilibrium when protection against predation is incomplete.[14] Workers choose between production and diversion. There may be more than one equilibrium—for example, there may be a poor equilibrium where production pays little because diversion is so common and diversion has a high payoff because enforcement is ineffective when diversion is common. There is also a good equilibrium with little diversion, because production has a high payoff and the high probability of punishment deters almost all diversion. Rapaczynski (1987) gives Hobbes credit for originating this idea. Even if there is only a single equilibrium in these models, it may be highly sensitive to its determinants because of near-indeterminacy.

Thus the suppression of diversion is a central element of social support of production. The government enters the picture in two ways. First, the suppression of diversion appears to be most efficient if it is carried out collectively, so the government is the natural instrument of anti-diversion efforts. Second, government is itself the most effective diverter. A government supports productive activity by deterring private diversion and by refraining from diverting itself. Of course, governments need revenue in order to carry out deterrence, which requires at least a little diversion through taxation.

Both private and government-operated productive activities benefit from protection from diversion. Our results suggest that a combination of gov-

[14]See, for example, Baumol (1990), Murphy, Shleifer and Vishny (1991), Acemoglu (1993), Schrag and Scotchmer (1993), Ljungquist and Sargent (1995),and Grossman and Kim (1996).

ernment operation of large sectors of the economy with efficient government policies for supporting production can achieve a high level of productivity, though generally not as high as private production combined with government infrastructure to support production.

Diversion takes the form of rent seeking in countries of all types, and is probably the main form of diversion in more advanced economies.[15] Potentially productive individuals spend their efforts influencing the government. At high levels, they lobby legislatures and agencies to provide benefits to their clients. At lower levels, they spend time and resources seeking government employment. They use litigation to extract value from private business. They take advantage of ambiguities in property rights.

Successful economies limit the scope of rent seeking. Constitutional provisions restricting government intervention, such as the interstate commerce clause in the U.S. Constitution, reduce opportunities for rent seeking. A good infrastructure will plug as many holes as it can where otherwise people could spend time bettering themselves by methods other than production. In addition to its direct effects on production, a good infrastructure may have important indirect effects by encouraging the adoption of new ideas and new technologies as they are invented throughout the world.

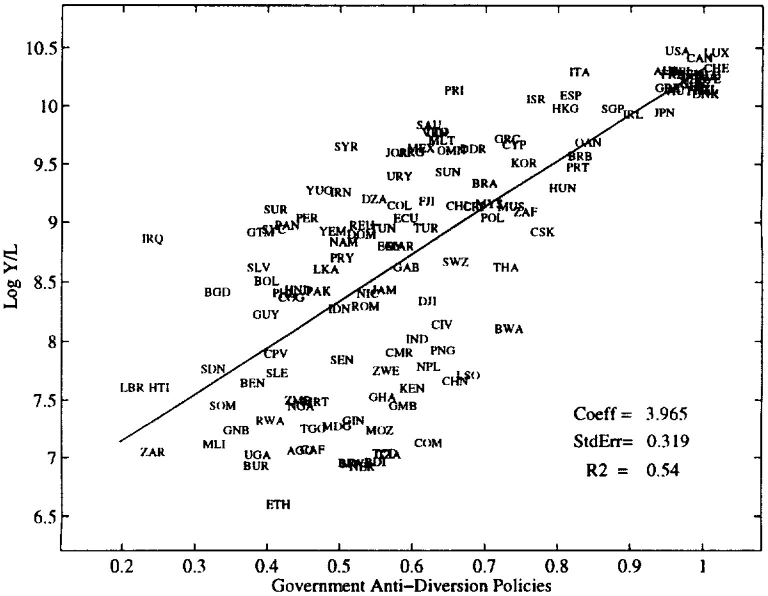
3.1 Government Anti-Diversion Policy

Our first measure of government anti-diversion policy (GADP) is assembled by a firm that specializes in providing assessments of risk to international investors, Political Risk Services.[16] Their *International Country Risk Guide* rates 130 countries according to 24 categories. We follow Knack and Keefer

[15] Krueger (1974).

[16] See Coplin, O'Leary and Sealy (1996) and Knack and Keefer (1995). Barro (1996) considers a measure from the same source in regressions with the growth of GDP per capita. Mauro (1995) uses a similar variable to examine the relation between investment and growth of income per capita, on the one hand, and measures of corruption and other failures of protection, on the other hand.

Figure 2: Output per Worker and Government Anti-Diversion Policy



(1995) in using the average of 5 of these categories for the years 1986-1995. Two of the categories relate to the government's role in protecting against private diversion: (i) law and order, and (ii) bureaucratic quality. Three categories relate to the government's possible role as a diverter: (i) corruption, (ii) risk of expropriation, and (iii) government repudiation of contracts. Our GADP variable is an equal-weighted average of these 5 variables, each of which has higher values for governments with more effective policies for supporting production.[17] GADP is highly correlated with output per worker, as shown in Figure 2.

3.2 Openness to International Trade

Policies toward international trade are a sensitive index of infrastructure. Interference with trade is a leading tool of diversion. Not only does the

[17]We convert all of these variables to a common 0 to 1 scale before averaging.

imposition of tariffs divert resources to the government, but tariffs, quotas, and other trade barriers create lucrative opportunities for private diversion by government officials.

In addition, policies favoring free trade yield benefits associated with the trade itself. Trade with other countries facilitates the adoption of ideas and technologies from those countries. Trade yields benefits from specialization.[18] Our work does not attempt to distinguish between trade policies as measures of a country's general infrastructure and the specific benefits that come from free trade itself.

Sachs and Warner (1995) have compiled an index of infrastructure that focuses on the openness of a country to trade with other countries. An important advantage of their variable is that it considers the time since a country adopted a more favorable infrastructure. The Sachs-Warner index measures the fraction of years during the period 1950 to 1994 that the economy has been open. A country is open if it satisfies all of the following criteria: (i) nontariff barriers cover less than 40 percent of trade, (ii) average tariff rates are less than 40 percent, (iii) any black market premium was less than 20 percent during the 1970s and 1980s, (iv) the country is not classified as socialist by Kornai (1992), and (v) the government does not monopolize major exports.

Figure 3 shows the relation between output per worker and the Sachs-Warner measure of openness. Economies that adopt infrastructures classified as open tend to be more productive.

3.3 Type of Economic Organization

To measure the extent of government involvement in production, we use a classification made by the Freedom House (1994). They distinguish six types of economies, described in Table 2.

[18] Frankel and Romer (1996) emphasize these benefits in their cross country growth

Figure 3: Output per Worker and the Fraction of Years Open

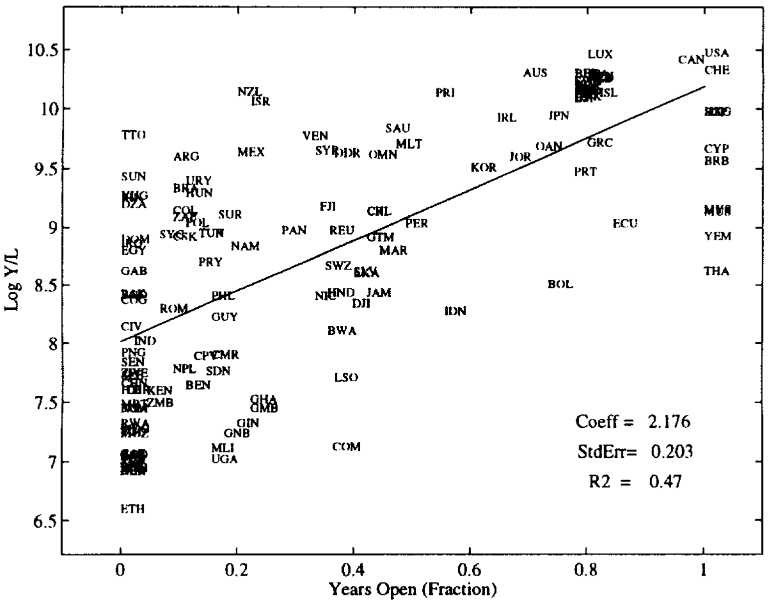


Figure 4 shows the relationship between output per worker and the type of economic organization. The positive slope evident in the figure suggests that economies which favor capitalist forms of production tend to have higher output per worker, but the relationship is far from tight. Statist economies such as the former Soviet Union and Czechoslovakia were able to achieve much higher levels of output per worker than the capitalist countries Sierra Leone and Malawi. Barro (1991) considers the relation between growth of GDP per capita and a measure of the type of economic system; he finds that socialist economies grow more slowly than mixed or capitalist economies, but his findings are inconclusive because he excludes the eastern European countries that provide the strongest test of the relationship. Tian (1995) discusses reasons that economies lacking effective anti-diversion

---

framework.

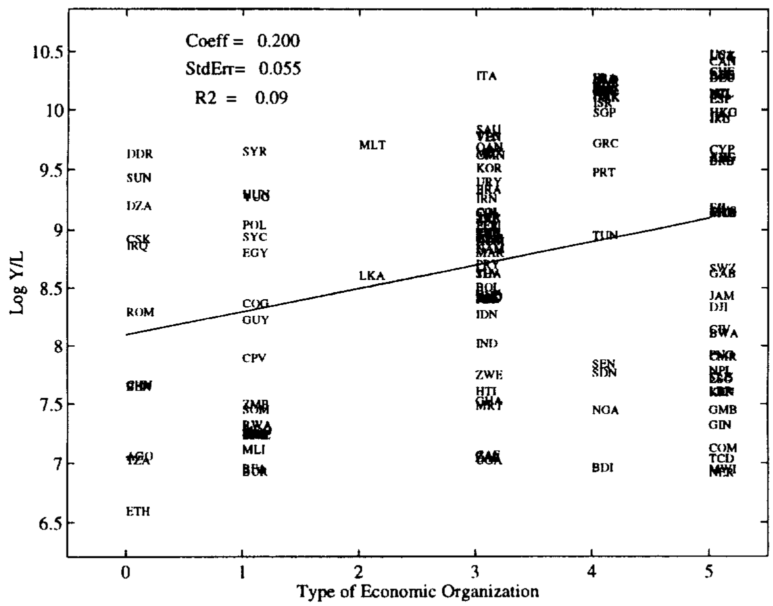
Table 2: Types of Economic Organization

Capitalist	Developed market economies and other countries with a modern market sector
Mixed capitalist	Combination of private enterprise with substantial government involvement in the economy for social welfare purposes
Capitalist-statist	Large market sectors and government-owned productive enterprises, due either to elitist economic policies or state dependence on key natural resource industries
Mixed capitalist-statist	Capitalist-statist economies with major social welfare programs
Mixed statist	Primarily government controlled, but with significant private enterprise
Statist	Have the goal of placing the entire economy under direct or indirect government control

infrastructure may achieve superior results with government rather than private ownership of businesses.

Figure 5 provides insight into the relationship between type of economic organization and government anti-diversion policies. As with output per worker, GADP is positively correlated with the type of economic organization, but the correlation is not overwhelming. The countries with the most effective governments are all capitalist or mixed capitalist, but governments of Hungary and Czechoslovakia, two non-capitalist countries, provide approximately the same level of anti-diversion policies as Taiwan, Italy, and Hong Kong. Furthermore, governments in a number of capitalist countries such as Sierra Leone, Malawi, and Niger provide as little protection from diversion as the least protective statist governments.

Figure 4: Output per Worker and Economic Organization



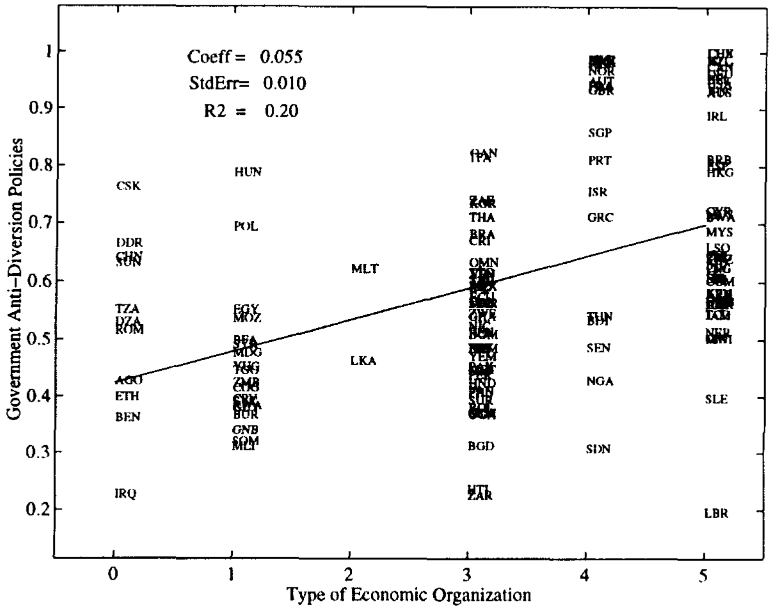
Note: The values of the capitalism variable correspond to the categories in Finn, ed (1994): 0=statist, 1=mixed statist, 2=mixed capitalist-statist, 3=capitalist-statist, 4=mixed capitalist, 5=capitalist.

3.4 Language

Language incorporates cultural and institutional linkages between countries. Our hypothesis is that the following eight languages, classified as the major international languages by Gunnemark (1991), carry the bulk of international communication of the ideas that contribute to productivity: Arabic, Chinese, English, French, German, Portuguese, Russian, and Spanish. We obtained data from two sources on the incidence of the knowledge of these languages: Hunter, ed (1992), and, to a lesser extent, Gunnemark (1991).[19] Ideally, we would like information about the fraction of the population who

[19]The sources often disagree on exact numbers. Hunter, ed (1992) is much more precise, containing detailed data on various dialects and citations to sources (typically surveys).

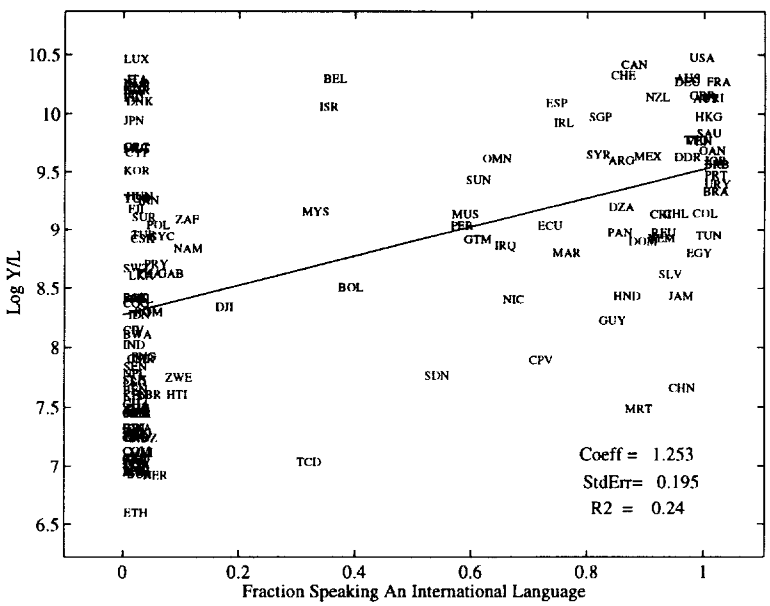
Figure 5: Economic Organization and Government Anti-Diversion Policies



speak a language well enough to engage in a sophisticated interaction with a native speaker in another country. Our sources use detailed census data on the primary language spoken at home. Data on second languages are available in some countries, but collection is not uniform and interpretation is much more subjective. Pending availability of better measures, we use data in each country for the fractions of the population who speak each of the eight major languages at home. From this data, we construct two language variables: the fraction of a country's population that speaks English at home and the fraction of a country's population that speaks one of the other international languages at home.

Figure 6 shows the relationship between the fraction of a country's population that speaks any international language and output per worker. The countries divide naturally into two groups: those with large fractions of the

Figure 6: Output per Worker and International Languages



population who speak an international language and those whose population does not. A positive relationship between the language variable and output per worker is evident, despite the fact that a number of productive OECD economies such as Sweden, Italy, and Japan are not linked to other countries by the language channel. Of course, Sweden, a country where large numbers of people speak English and German fluently, is a good example of the limitations of our language measure.

3.5 Climate

It is widely thought, and confirmed by our results, that economies in temperate climates are more successful than those in the tropics. Nordhaus (1994) presents evidence on differences in income associated with differences in latitude and climate, and concludes that they are present but small. In contrast, we find much larger effects of climate on economic performance.

Some of the ways climate affects long-run economic success are purely physical—hot and cold climates require cooling and heating that consume resources not needed in temperate areas. In addition, climate appears to affect human productivity. Depression and alcoholism are much more common in polar climates with low temperatures and short winter days. Diseases spread much more easily in warm, humid climates than in temperate ones.

As a rough measure of climate, we use distance from the equator, measured as the absolute value of latitude in degrees divided by 90 to place it on a 0 to 1 scale.[20] The simple correlation between output per worker and this measure of climate is shown in Figure 7.

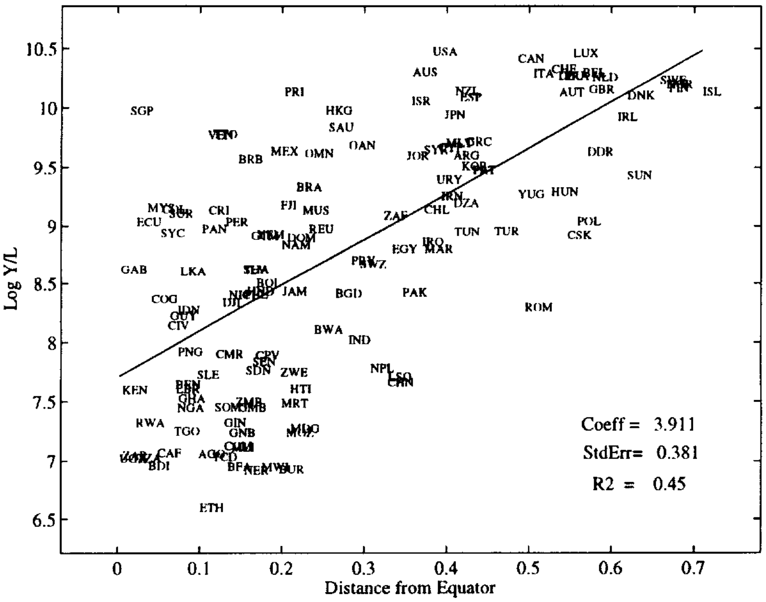
4 Econometrics and Data

Our basic econometric approach is to examine the relation between a collection of determinants—GADP, Type of Economic Organization, Openness, Language, and Climate—and the log of output per worker. Later, we decompose this relation into components associated with physical capital, human capital, and productivity. Our identifying assumption is that these determinants are uncorrelated with the random element of output per worker, and later, uncorrelated with the random elements of the components. We use ordinary least squares to estimate the parameters of the relation.

Our identifying hypothesis is probably very reasonable for most of the determinants. Certainly climate (distance from the equator) and languages spoken at birth are plausibly exogenous. For our government anti-diversion policy variable, there may be some question of whether Political Risk Services uses levels of output to infer measures of rule of law or bureaucratic

[20]The latitude of each country was obtained from the Global Demography Project at U.C. Santa Barbara, discussed by Tobler, Deichmann, Gottsegen and Maloy (1995). These location data correspond to the center of the county or province within a country that contains the largest number of people. One implication of this choice is that the data source places the center of the United States in Los Angeles County, California, somewhat south of the median latitude of the country.

Figure 7: Output per Worker and Climate



quality.

Our data set includes 133 countries for which we were able to construct measures of the physical capital stock using the Summers and Heston data set. For these 133 countries, we were also able to obtain data on the type of economic organization, primary languages spoken, and geographic information. However, missing data was a problem for four variables: 19 countries in our sample were missing data on the openness variable, 20 were missing data on the GADP variable, 28 were missing data on educational attainment, and 16 were missing data on the mining share of GDP. We imputed values for these missing data using the 80 countries for which we have a complete set of data.[21]

[21] For each country with missing data, we used a set of independent variables to impute the missing data. Specifically, let C denote the set of 80 countries with complete data. Then, (i) For each country i not in C, let W be the independent variables with data and V be the variables that are missing data. (ii) Using the countries in C, regress V on W. (iii)

Table 3: Basic Results

Dependent variable: Log of Output per Worker.

Variable or Category	Coefficient	Standard Error
Constant	6.596	.208
Government anti-diversion policies	1.523	.421
Fraction of years open since 1950	0.822	.194
Type of economy		
Statist or mixed statist	-0.028	.157
Capitalist-statist (or mixed)	0.398	.118
Capitalist or mixed capitalist	0	—
Fraction speaking English	0.782	.186
Fraction speaking other	0.659	.122
Distance from equator	2.184	.370
R^2	.77	
S.E.E.	.527	
Number of Observations	133	

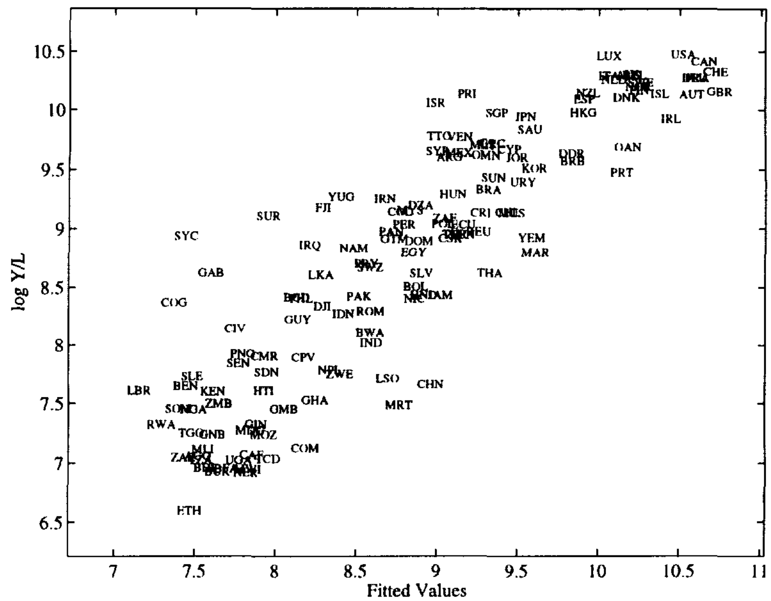
Note: White's heteroskedasticity-robust standard errors are reported.

5 Basic Results

Table 3 gives the results for the estimation of the basic relation between output per worker and the determinants. Note that all regressors are measured on a [0,1] scale so that the coefficients are directly comparable across variables. Figure 8 displays the overall fit of the equation. As the figure shows, 77 percent of the variation in $\log Y/L$ is accounted for by our

Use the coefficients from these regressions and the data $W(i)$ to impute the values of $V(i)$. The variables in V and W were indicator variables for type of economic organization, the fraction of years open, GADP, the fraction of population speaking English at home, and the fraction of population speaking another international language at home. In addition, total educational attainment and the mining share of GDP were included in V but not in W, i.e. they are not treated as independent.

Figure 8: Actual and Predicted Output Per Worker



determinants.

Countries above the 45 degree line produce more output per worker than our specification predicts, while countries below the 45 degree line produce less than predicted. For example, Singapore produces more than our specification predicts, in part due to the negative effects in our model associated with being near the equator; Singapore's output per worker is more than twice that of any other country within 9 degrees of the equator. On the other hand, China produces substantially less per worker than the specification predicts; China's government support of production ranks in the 65th percentile, according to *Political Risk Services*, but it has not achieved corresponding output per worker. We do not have an infrastructure variable that captures the adverse effects of China's past communist policies.

We will now discuss our findings for each of the various measures of infrastructure. Except where noted, the coefficients are estimated reasonably precisely, as indicated by their standard errors.

5.1 Government Infrastructure

Government anti-diversion policies: Countries in western Europe—Luxembourg, Switzerland, and the Netherlands—enjoy the largest contributions from the GADP variable. The highest values of GADP in our sample raise output per worker by more than 90 percent relative to the baseline country, Colombia, which has the median value of the variable in our sample. The top 16 countries in terms of GADP are all either western European or settled primarily by western Europeans, and all have GADP contributions more than 75 percent above the median. Japan is the first country not in the western European orbit, with a GADP contribution also of 75 percent. Liberia, Zaire, and Iraq provide the least protection from diversion in our sample, reducing output per worker by 40 percent or more relative to the median. Differences in government anti-diversion policies predict differences in output per worker of more than 240 percent between the worst and best countries as measured by our GADP variable.

Years open: The United States, Hong Kong, Mauritius, Singapore, and Switzerland are among the countries classified as open for the entire period since 1945, leading to a boost in output per worker of more than 93 percent relative to Mexico and New Zealand, countries at the median of the openness category. Countries such as China, the Soviet Union, and a number of Sub-Saharan African countries that are classified by Sachs and Warner as closed during this entire period suffer a penalty of about 15 percent relative to Mexico and New Zealand according to the results. Differences in openness contribute to differences in output per worker of about 128 percent between the most and least open countries in our sample.

Type of Economic Organization: Capitalist and mixed-capitalist economies form the baseline in the equation. Capitalist-statist and mixed capitalist-

Table 4: Types of Economic Organization: Examples

Capitalist	Botswana, Malawi, Niger, Barbados, Argentina, Jordan, Nepal, Tonga, United States
Mixed capitalist	Sudan, Tunisia, Singapore, Sweden
Capitalist-statist	South Africa, Bahamas, Zaire, Mexico, India, Republic of Korea, Saudi Arabia, Italy
Mixed capitalist-statist	Kuwait, Sri Lanka, Malta
Mixed statist	Congo, Egypt, Laos, Syria, Poland
Statist	China, USSR, Ethiopia

statist economies produce about 49 percent more per worker than the baseline and mixed statist and statist economies are only 3 percent below the baseline. To explain this surprising finding, we present some examples of the various types of economies in Table 4. The capitalist and mixed capitalist economies include all of the high-output-per-worker countries of the OECD, but also many other countries with low output per worker. Capitalism by itself is not associated with higher output per worker. Rather, it takes a combination of effective government policies favoring production and an economic organization that harnesses private economic activity in at least part of the economy to reach the highest levels of output per worker.

5.2 Language

Fraction speaking English: Countries in which the entire population speaks English receive a boost in $\log Y/L$ of 0.782, which corresponds to a 119 percent increase relative to a country in which no international language is spoken. This effect is largest in the U.K. and a number of its former colonies: the U.S., Canada, Australia, New Zealand, Barbados, and Jamaica, for example.

Fraction speaking another international language: The effect on $\log Y/L$

of speaking a non-English international language is estimated to be 0.659. The hypothesis of equality of the English and non-English coefficients is easily accepted with a p-value of 0.58.[22] Countries such as France, Uruguay, Jordan, and Taiwan receive a contribution from language of more than 90 percent relative to a country in which no international language is spoken.

5.3 Climate

The results for climate strongly support the hypothesis that temperate or even cool climates favor productivity. Countries in the 45 to 70 degree latitude bands (above and below the equator) receive the highest benefit of climate, and typically these countries are European. Iceland, Finland, Norway, Sweden, and Denmark all receive more than a 145 percent increment in output per worker due to their location, relative to the median country of Mozambique. At the other extreme, Singapore, Zaire, Kenya, Gabon, and Uganda—the countries closest to the equator—suffer disadvantages of more than 34 percent relative to the median. According to our results, differences in latitude account for an enormous amount of variation in output per worker: 369 percent between the most and least favorably located countries.

5.4 Results by Component

Table 5 examines in more detail the source of differences in output per worker across countries by considering why some countries have higher productivity or more physical or human capital per worker than others. The dependent variables in this table use the contributions to output per worker, so that adding the coefficients across columns reproduces the coefficients in Table 3. In general, the explanations are similar. Countries which are close to the equator, do not speak an international language, have ineffective government

[22]This finding is comforting to authors named Hall and Jones who might otherwise be accused of linguistic jingoism.

Table 5: Results for $\log K/L$, $\log H/L$, and $\log A$

Variable or Category	—— Contribution from —— $\log K/L$	$\log H/L$	$\log A$
Government anti-diversion policies	0.633	0.520	0.371
	(.168)	(.094)	(.275)
Years open (fraction)	0.208	0.074	0.540
	(.077)	(.053)	(.126)
Type of economy			
Statist or mixed statist	0.020	0.082	-0.130
	(.047)	(.033)	(.119)
Capitalist-statist (or mixed)	0.054	0.084	0.260
	(.043)	(.025)	(.082)
Capitalist or mixed capitalist	0	0	0
Fraction speaking English	0.191	0.161	0.430
	(.085)	(.032)	(.101)
Fraction speaking other	0.094	0.024	0.541
	(.045)	(.026)	(.091)
Distance from equator	0.723	0.316	1.144
	(.144)	(.068)	(.255)
R^2	0.74	0.69	0.66
S.E.E.	.183	.112	0.385

Note: The dependent variables are the *contributions* of the components of the production function. For example, $\log K/L$ is weighted by the factor shares. An unreported constant term is included in each specification. White's heteroskedasticity-robust standard errors are reported in parentheses.

anti-diversion policies, or are not open to international trade have low physical capital per worker, low human capital per worker, and low productivity. Each of these components contributes to low output per worker.

Apart from this broad similarity, however, some interesting differences are evident in Table 5. For example, non-capitalist countries appear to invest more heavily in education than capitalist countries, leading to an 8 percent increase in output per worker via additional education. And while the effects of speaking an international language, whether English or not, are roughly the same for physical capital and productivity, English-speaking countries tend to accumulate much more human capital than other countries, leading to approximately 16 percent more output per worker.

6 Robustness of the Results

In this section, we present results for alternative specifications to test the robustness of our findings. First, Table 6 reports regression results for the 80 country sample in which no data are imputed. Overall, the results are quite similar to the results for the 133 country sample. If anything, the results are stronger, as reflected by the higher fraction of variation explained by these specifications. For example, in the 80 country sample, our specification explains 83 percent of the variation in $\log Y/L$ across countries.

As a specification test, based on findings in the growth literature, we added indicator variables for Latin American and African countries to our basic equation for output per worker. On average, the basic equation explains the performance of Latin American countries successfully; the hypothesis that the coefficient of the corresponding indicator variable was zero is easily accepted. On the other hand, African countries fell below the equation on the average and the hypothesis that this occurred from random sources only is rejected with a t-statistic of about 3. The other coefficients in the specification are quite robust to the addition of these continent dummies. One exception is that we can no longer reject the hypothesis that economies with different types of economic organization have the same levels of output per worker, after adjusting for all the other determinants. Africa contains many of the countries that identify the separate role of capitalism, because they are capitalist but have low values of government protection from diversion. In the presence of the indicator variable for Africa, the identifying

Table 6: Regressions without Imputed Data

Variable or Category	$\log Y/L$	—— Contribution from —— $\log K/L$	$\log H/L$	$\log A$
Government anti-diversion policies	1.926	0.736	0.585	0.605
	(.436)	(.146)	(.118)	(.285)
Years open (fraction)	0.582	0.141	0.080	0.361
	(.184)	(.064)	(.069)	(.104)
Type of economy				
Statist or mixed statist	0.122	0.081	0.127	-0.086
	(.192)	(.049)	(.052)	(.136)
Capitalist-statist (or mixed)	0.395	0.072	0.098	0.225
	(.131)	(.042)	(.038)	(.084)
Capitalist or mixed capitalist	0	0	0	0
Fraction speaking English	0.728	0.167	0.152	0.409
	(.197)	(.067)	(.037)	(.111)
Fraction speaking other	0.838	0.193	0.041	0.603
	(.121)	(.039)	(.036)	(.082)
Distance from equator	2.197	0.523	0.299	1.375
	(.405)	(.135)	(.086)	(.267)
R^2	0.83	0.83	0.68	0.78
S.E.E.	.439	.129	.124	.289

Note: N=80. Except for $\log Y/L$, the dependent variables are the *contributions* of the components of the production function. For example, $\log K/L$ is weighted by the factor shares. A constant term is included but not reported. White's heteroskedasticity-robust standard errors are reported in parentheses.

power falls sharply.

Additional robustness results are reported in Table 7, which considers alternative specifications for the independent variables.

The first two specifications consider the density of economic activity. The

Table 7: Alternative Specifications for $\log Y/L$

1. Ciccone-Hall Density (log)	Simple	Partial			
Coefficient	3.576	0.696			
(S.E.)	(1.114)	(.657)			
2. Raw Density (log)	Simple	Partial			
Coefficient	0.147	0.021			
(S.E.)	(.057)	(.034)			
3. Population (log)	Simple	Partial			
Coefficient	0.015	-0.061			
(S.E.)	(.051)	(.034)			
4. ELF (Mauro)	Simple	Partial			
Coefficient	-1.973	-0.144			
(S.E.)	(.278)	(.173)			
5. Distance from Equator	Dist	$Dist^2/100$			
Coefficient	1.413	1.319			
(S.E.)	(1.014)	(1.464)			
6. Degrees from Equator	Lat015	Lat1530	Lat3045	Lat4570	
Coefficient	0	0.126	0.885	0.999	
(S.E.)	—	(.128)	(.133)	(.166)	
7. Years Open (fraction)	0	0-.33	.33-.67	.67-1	1.00
Coefficient	0	0.333	0.433	0.697	0.852
(S.E.)	—	(.146)	(.175)	(.201)	(.225)
8. Economic Organization	0	1	2	3	4
Coefficient	-0.195	0.063	0.878	0.376	0.017
(S.E.)	(.206)	(.191)	(.118)	(.133)	(.144)
9. GADP-Organization Interaction	[0 1]	[2 3]	GADP*[0 1]	GADP*[2 3]	GADP
Coefficient	0.402	0.330	-0.889	0.161	1.637
(S.E.)	(.438)	(.382)	(.766)	(.599)	(.509)

Note: Except where noted, all specifications include the variables of the full specification. The notes below correspond to the specification number listed in the table. White's heteroskedasticity-robust standard errors are reported in parentheses.

1, 2, 3, 4. "Simple" refers to the univariate regression , while "Partial" refers to the basic specification with the variable added. ELF is Ethnolinguistic Fractionalization.

5. Quadratic specification for degrees from equator.
6. Indicator variables for the latitude categories are used in place of degrees from equator.
7. Indicator variables for the Years Open categories are used in place of Years Open.
8. Separate indicator variables for each type of economic organization are used. The capitalist category is omitted. See notes to Figure 4.
9. GADP is interacted with indicator variables for type of economic organization.

first uses the density measure proposed by Ciccone and Hall (1996).[23] The density measure is constructed to have a theoretical coefficient of one—it would have precisely this value in Ciccone and Hall's cross section of states. The coefficient is actually higher than one in the simple regression. But, in our complete specification, the density measure enters with a coefficient that is around two-thirds, with a standard error of the same magnitude. The Ciccone-Hall measure performs better than the raw density measure employed in the second specification: the latter's coefficient is close to zero when added to our main specification. In contrast to the data used by Ciccone and Hall, in a cross section of countries, the variation in other determinants of output per worker is so large that it is difficult to measure the effects of density with much precision.[24]

The third specification adds the log of population to the regression. A number of recent growth models in the tradition of Romer (1990) emphasize that nonrivalry of ideas should lead to increasing returns to scale. Our simple attempt to measure scale with population does not find evidence of this effect. One explanation is that national boundaries do not limit the areas where ideas are applied.

The fourth specification examines the ethnolinguistic fractionalization (ELF) index computed by Taylor and Hudson (1972) and used by Mauro (1995). ELF measures the probability that any two people chosen at random from within a country will belong to different ethnic or linguistic groups.

[23] The Ciccone-Hall measure for country i is given by

$$D_i = \frac{1}{N_i} \sum_{s \epsilon S_i} n_s^{\gamma} a_s^{-(\gamma-1)}$$

where N_i is the population of country i, S_i is the set of all provinces in country i, n_s is the population of province s, and a_s is the area of province s. We use a value of $\gamma = 1.058$, as estimated by Ciccone and Hall. This value implies that doubling density increases D_i by about 6 percent.

[24] When the Ciccone-Hall density measure is added to the specification for $\log A$, it enters with a coefficient of .868 and a standard error of .433.

While the simple association with output per worker is quite strong, the partial regression coefficient is small in magnitude and statistically insignificant.

The next five specifications provide basic support for the functional forms used in the main regressions by considering alternative specifications with quadratic forms, indicator variables, or interaction terms. Specification 5 shows no evidence of an quadratic relationship between Y/L and distance from the equator—over the observed range, it is always better to be closer to the North or South Poles. Specification 6 confirms this with indicator variables, showing that output per worker is highest among countries between latitudes 45 and 70 degrees. Specification 7 shows that output per worker rises with years open roughly in proportion to the value of the variable, as assumed in our base results. Specification 8 shows that distinguishing all 6 categories of economic organization does not reject our aggregation of adjacent pairs.

Finally, the last specification considers interactions of the GADP variable and the type of economic organization. Our base specification assumes that the complementarity between these effects is multiplicative, that is, additive in logs. The two added variables, GADP*[0 1] and GADP*[2 3] allow different slope coefficients for GADP for the less-capitalist values of the organization variable. There is little evidence that these coefficients should be different.

In addition to the results reported here, we have conducted a number of other robustness checks: we have measured output without a correction for natural resources and we have explored alternative assumptions about the shape of the production function (Cobb-Douglas, $\phi = 0$, $\phi = .05$), among others. The results in all of these cases are similar to those reported above.

Table 8: Explaining Differences in Y/L

Variable	$\beta(X_{max} - X_{min})$	Percent Increment
Government anti-diversion policies	1.224	240
Years open (fraction)	0.822	128
Type of economy		
Statist or mixed statist	0.028	3
Capitalist-statist (or mixed)	0.398	49
Capitalist or mixed capitalist	—	—
Fraction Speaking English	0.782	119
Fraction Speaking Other	0.661	94
Degrees from Equator	1.545	369
Total	5.460	23,400

Note: The β coefficients are taken from Table 3. Percent increment is calculated as $e^{\beta(X_{max}-X_{min})} - 1$.

7 Conclusion

Countries are able to achieve a high level of output per worker in the long run because they are able to achieve high levels of physical capital, human capital, and productivity. Our empirical analysis suggests that success on each of these fronts is driven by a common set of determinants.

Table 8 summarizes the importance of each of the determinants in explaining differences in output per worker across countries. As the last row of the table shows, differences in these determinants are more than sufficient to account for the 48-fold difference in output per worker observed among the world's countries. A hypothetical country with the most favorable value of every determinant would be 23,400 percent more productive than one with the least favorable values.

We can summarize our conclusions in terms of the profile of a country with high output per worker. First, the citizens of the country have adopted an infrastructure that favors production over diversion. It probably takes the form of government institutions, especially law enforcement, but it also likely includes systems of morals and ethics supported by other non-government institutions. Talented people never pursue careers of rent seeking or corruption; they produce goods. Among the important principles the country has adopted to this end is strict free trade. The economy is at least partly founded on the principle of private ownership.

Second, the citizens of the country speak an international language. Future work will be needed to learn exactly how to interpret this finding, but we suspect that it involves at least two features of a successful economy. International languages allow their speakers to communicate effectively with the world, facilitating trade and the exchange of ideas. In addition, the speaking of an international language may indicate the presence of favorable infrastructure not captured by our other measures.

Finally, the country is located far from the equator. Even controlling for the other determinants of long-run economic performance, distance from the equator is the single most powerful variable in our specification.

References

Acemoglu, Daron, "Reward Structures and the Allocation of Talent," May 1993. Discussion Paper 143, Centre for Economic Performance, London School of Economics.

Barro, Robert J., "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, May 1991, *106*, 407–443.

___ , "Determinants of Economic Growth: A Cross-Country Empirical Study," August 1996. NBER Working Paper 5698.

___ **and Jongwha Lee**, "International Comparisons of Educational Attainment," *Journal of Monetary Economics*, December 1993, *32*, 363–394.

___ **and Xavier Sala-i-Martin**, "Technological Diffusion, Convergence, and Growth," 1995. NBER Working Paper #5151.

Baumol, William J., "Entrepreneurship: Productive, Unproductive, and Destructive," *Journal of Political Economy*, 1990, *98*, 893–921.

___ **and Edward N. Wolff**, "Catching up in the Postwar Period: Puerto Rico as the Fifth 'Tiger'?," *World Development*, 1996, *24* (5), 869–885.

Christensen, Laurits R., Dianne Cummings, and Dale W. Jorgenson, "Relative Productivity Levels, 1947-1973," *European Economic Review*, May 1981, *16* (1), 61–94.

Ciccone, Antonio and Robert E. Hall, "Productivity and the Density of Economic Activity," *American Economic Review*, March 1996, *86* (1), 54–70.

Coplin, William D., Michael K. O'Leary, and Tom Sealy, *A Business Guide to Political Risk for International Decisions*, Syracuse: Political Risk Services, 1996.

Diewert, Erwin W., "Superlative Index Numbers and Consistency in Aggregation," *Econometrica*, July 1978, *46* (4), 883–900.

Easterly, William, Michael Kremer, Lant Pritchett, and Lawrence Summers, "Good Policy or Good Luck? Country Growth Performance and Temporary Shocks," *Journal of Monetary Economics*, December 1993, *32*, 459–483.

Eaton, Jonathan and Samuel S. Kortum, "Trade in Ideas: Patenting and Productivity in the OECD," 1995. NBER Working Paper No. 5049.

Finn, James, ed., *Freedom in the World: The Annual Survey of Political Rights and Civil Liberties, 1993-1994*, New York: Freedom House, 1994.

Frankel, Jeffrey A. and David Romer, "Trade and Growth: An Empirical Investigation," March 1996. NBER Working Paper 5476.

Greif, Avner and Eugene Kandel, "Contract Enforcement Institutions: Historical Perspective and Current Status in Russia," in Edward P. Lazear, ed., *Economic Transition in Eastern Europe and Russia: Realities of Reform*, Stanford, CA: Hoover Institution Press, 1995, pp. 292–321.

Grossman, Herschel I. and Minseong Kim, "Inequality, Predation, and Welfare," August 1996. NBER Working Paper 5704.

Gunnemark, Erik V., *Countries, Peoples, and their Languages: The Geolinguistic Handbook*, Dallas, Texas: Summer Institute of Linguistics, Inc., 1991.

Hall, Robert E., "Invariance Properties of Solow's Productivity Residual," in Peter Diamond, ed., *Growth/ Productivity/Unemployment: Essays to Celebrate Robert Solow's Birthday*, Cambridge, MA: MIT Press, 1990, pp. 71–112.

Hunter, Barbara F., ed., *Ethnologue: Languages of the World*, twelth ed., Gothenburg, Sweden: Lanstryckeriet, 1992.

Islam, Nazrul, "Growth Empirics: A Panel Data Approach," *Quarterly Journal of Economics*, November 1995, *110*, 1127–1170.

Jones, Charles I., "R&D-Based Models of Economic Growth," *Journal of Political Economy*, August 1995, *103*, 759–784.

Knack, Stephen and Philip Keefer, "Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures," *Economics and Politics*, November 1995, *7*, 207–227.

Kornai, Janos, *The Socialist System: The Political Economy of Communism*, Princeton: Princeton University Press, 1992.

Krueger, Anne, "The Political Economy of the Rent-Seeking Society," *American Economic Review*, 1974, *64*, 291–303.

Ljungquist, Lars and Thomas J. Sargent, "The Swedish Unemployment Experience," *European Economic Review*, 1995, *39*, 1043–1070.

Mankiw, N. Gregory, David Romer, and David Weil, "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, May 1992, *107*, 407–438.

Mauro, Paolo, "Corruption and Growth," *Quarterly Journal of Economics*, August 1995, *110*, 681–713.

Mincer, Jacob, *Schooling, Experience, and Earnings*, New York: Columbia University Press, 1974.

Murphy, Kevin M, Andrei Shleifer, and Robert W. Vishny, "The Allocation of Talen: Implications for Growth," *Quarterly Journal of Economics*, May 1991, *106*, 503–530.

Nordhaus, William D., "Climate and Economic Development," *Proceedings of the World Bank Annual Conference on Development Economics 1993*, 1994, pp. 355–376.

North, Douglass C., *Institutions, Institutional Change, and Economic Performance*, Cambridge: Cambridge University Press, 1990.

Olson, Mancur, *The Logic of Collective Action*, Cambridge: Cambridge University Press, 1965.

——, *The Rise and Decline of Nations*, New Haven: Yale University Press, 1982.

Parente, Stephen L. and Edward C. Prescott, "Barriers to Technology Adoption and Development," *Journal of Political Economy*, April 1994, *102*, 298–321.

Psacharopoulos, George, "Returns to Investment in Education: A Global Update," *World Development*, 1994, *22* (9), 1325–1343.

Rapaczynski, Andrzej, *Nature and Politics: Liberalism in the Philosophies of Hobbes, Locke, and Rousseau*, Ithaca: Cornell University Press, 1987.

Romer, Paul M., "Endogenous Technological Change," *Journal of Political Economy*, October 1990, *98*, S71–S102.

Sachs, Jeffrey D. and Andrew Warner, "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity*, 1995, *1*, 1–95.

Schrag, Joel and Suzanne Scotchmer, "The Self-Reinforcing Nature of Crime," 1993. Working Paper 93-11, Center for the Study of Law and Society, School of Law, University of California, Berkeley.

Solow, Robert M., "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, February 1956, *70*, 65–94.

—— , "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, 1957, *39*, 312–320.

Star, Spencer and Robert E. Hall, "An Approximate Divisia Index of Total Factor Productivity," *Econometrica*, March 1976, *44* (2), 257–264.

Summers, Robert and Alan Heston, "The Penn World Table (Mark 5): An Expanded Set of International Comparisons: 1950–1988," *Quarterly Journal of Economics*, May 1991, *106*, 327–368.

Taylor, Charles L. and Michael C. Hudson, *World Handbook of Political and Social Indicators*, New Haven: Yale University Press, 1972.

Tian, Guoqiang, "A Theory of Endogenous Ownership Arrangements in Imperfect Market and Transitional Economies," 1995. Working Paper 9512, Private Enterprise Research Center, Texas A&M University.

Tobler, Waldo, Uwe Deichmann, Jon Gottsegen, and Kelly Maloy, "The Global Demography Project," April 1995. NCGIA Technical Report TR-95-6, Department of Geography, U.C. Santa Barbara.

United Nations, *Industrial Statistics Yearbook, 1991*, Vol. 1 1993.

———, *National Accounts Statistics: Main Aggregates and Detailed Tables, 1992* 1994.

Table 9: Levels Accounting, Difference from U.S.

Country	Code	Departure below U.S. $\log Y/L$	Contribution from $\log K/L$	$\log H/L$	$\log A$
U.S.A.	USA	0.000	0.000	0.000	0.000
Luxembourg	LUX	-0.014	0.107	-0.103	-0.018
Canada	CAN	-0.061	0.001	-0.049	-0.013
Switzerland	CHE	-0.146	0.098	-0.108	-0.136
Australia	AUS	-0.171	0.003	-0.067	-0.108
Belgium	BEL	-0.179	-0.028	-0.099	-0.053
Italy	ITA	-0.182	-0.011	-0.260	0.089
Germany, West	DEU	-0.201	0.031	-0.127	-0.105
France	FRA	-0.201	0.013	-0.244	0.029
Netherlands	NLD	-0.216	-0.015	-0.124	-0.077
Sweden	SWE	-0.240	-0.059	-0.089	-0.093
Norway	NOR	-0.276	0.036	-0.063	-0.249
Finland	FIN	-0.309	0.008	-0.094	-0.223
U.K.	GBR	-0.318	-0.168	-0.112	-0.039
New Zealand	NZL	-0.333	-0.051	0.000	-0.282
Iceland	ISL	-0.338	-0.076	-0.156	-0.106
Puerto Rico	PRI	-0.341	-0.458	-0.392	0.509
Austria	AUT	-0.344	-0.064	-0.237	-0.043
Denmark	DNK	-0.371	-0.062	-0.058	-0.251
Spain	ESP	-0.383	-0.072	-0.294	-0.017
Israel	ISR	-0.417	-0.159	-0.084	-0.174
Hong Kong	HKG	-0.498	-0.435	-0.150	0.086
Singapore	SGP	-0.501	-0.165	-0.363	0.027
Japan	JPN	-0.533	-0.107	-0.130	-0.296
Ireland	IRL	-0.550	-0.141	-0.148	-0.261
Saudi Arabia	SAU	-0.640	-0.376	-0.331	0.068
Trinidad/Tobago	TTO	-0.697	-0.284	-0.231	-0.182
Venezuela	VEN	-0.704	-0.259	-0.309	-0.136
Greece	GRC	-0.758	-0.229	-0.231	-0.298
Malta	MLT	-0.769	-0.337	-0.201	-0.231
Taiwan	OAN	-0.787	-0.456	-0.191	-0.141
Cyprus	CYP	-0.808	-0.241	-0.189	-0.378
Syria	SYR	-0.824	-0.611	-0.442	0.228
Mexico	MEX	-0.838	-0.567	-0.405	0.134
Germany, East	DDR	-0.843	-0.143	-0.179	-0.521
Oman	OMN	-0.857	-0.188	-0.329	-0.340
Argentina	ARG	-0.873	-0.339	-0.219	-0.315
Jordan	JOR	-0.877	-0.632	-0.412	0.166
Barbados	BRB	-0.907	-0.641	-0.164	-0.101
Korea, Rep.	KOR	-0.966	-0.425	-0.132	-0.410
Portugal	PRT	-1.000	-0.532	-0.448	-0.020
U.S.S.R.	SUN	-1.043	-0.230	-0.196	-0.618
Uruguay	URY	-1.080	-0.483	-0.233	-0.363
Brazil	BRA	-1.143	-0.653	-0.493	0.002

Country	Code	Departure below U.S. log Y/L	——Contribution from—— log K/L	log H/L	log A
Hungary	HUN	-1.182	-0.405	-0.045	-0.732
Yugoslavia	YUG	-1.205	-0.314	-0.192	-0.698
Iran	IRN	-1.221	-0.606	-0.504	-0.111
Algeria	DZA	-1.279	-0.406	-0.545	-0.328
Fiji	FJI	-1.298	-0.480	-0.208	-0.609
Malaysia	MYS	-1.320	-0.434	-0.306	-0.580
Colombia	COL	-1.331	-0.713	-0.395	-0.223
Chile	CHL	-1.335	-0.452	-0.232	-0.651
Costa Rica	CRI	-1.341	-0.699	-0.336	-0.307
Mauritius	MUS	-1.341	-0.756	-0.359	-0.226
Suriname	SUR	-1.369	-0.643	-0.626	-0.099
South Africa	ZAF	-1.385	-0.592	-0.354	-0.439
Poland	POL	-1.435	-0.403	-0.128	-0.904
Ecuador	ECU	-1.441	-0.466	-0.290	-0.685
Peru	PER	-1.441	-0.583	-0.287	-0.571
Reunion	REU	-1.500	-0.730	-0.420	-0.350
Panama	PAN	-1.501	-0.489	-0.242	-0.770
Turkey	TUR	-1.523	-0.724	-0.512	-0.287
Tunisia	TUN	-1.527	-0.686	-0.569	-0.272
Seychelles	SYC	-1.537	-0.704	-0.551	-0.283
Yemen	YEM	-1.551	-0.760	-0.742	-0.049
Czechoslovakia	CSK	-1.556	-0.511	-0.185	-0.861
Guatemala	GTM	-1.562	-0.808	-0.562	-0.192
Dominican Rep.	DOM	-1.578	-0.734	-0.415	-0.430
Iraq	IRQ	-1.612	-0.422	-0.456	-0.734
Namibia	NAM	-1.639	-0.379	-0.404	-0.856
Egypt	EGY	-1.674	-0.896	-0.258	-0.520
Morocco	MAR	-1.675	-0.824	-0.301	-0.551
Paraguay	PRY	-1.773	-0.785	-0.374	-0.614
Swaziland	SWZ	-1.806	-0.782	-0.440	-0.584
Gabon	GAB	-1.852	-0.516	-0.494	-0.842
Thailand	THA	-1.853	-0.844	-0.342	-0.667
El Salvador	SLV	-1.854	-0.822	-0.446	-0.586
Sri Lanka	LKA	-1.867	-0.836	-0.299	-0.733
Bolivia	BOL	-1.968	-0.804	-0.407	-0.757
Honduras	HND	-2.043	-0.790	-0.451	-0.801
Jamaica	JAM	-2.043	-0.746	-0.406	-0.891
Pakistan	PAK	-2.052	-0.807	-0.605	-0.640
Bangladesh	BGD	-2.062	-0.922	-0.594	-0.545
Philippines	PHL	-2.070	-0.876	-0.248	-0.945
Nicaragua	NIC	-2.072	-0.809	-0.449	-0.814
Congo	COG	-2.106	-0.876	-0.499	-0.731
Djibouti	DJI	-2.136	-0.807	-0.463	-0.867
Romania	ROM	-2.179	-0.804	-0.341	-1.034
Indonesia	IDN	-2.203	-0.830	-0.452	-0.921

Country	Code	Departure below U.S. $\log Y/L$	——Contribution from—— $\log K/L$	$\log H/L$	$\log A$
Guyana	GUY	-2.250	-0.704	-0.324	-1.222
Ivory Coast	CIV	-2.332	-0.853	-0.505	-0.973
Botswana	BWA	-2.369	-0.919	-0.459	-0.991
India	IND	-2.454	-0.883	-0.503	-1.068
Papua N.Guinea	PNG	-2.555	-0.829	-0.654	-1.071
Cameroon	CMR	-2.573	-0.913	-0.591	-1.069
Cape Verde Is.	CPV	-2.583	-0.901	-0.482	-1.200
Senegal	SEN	-2.636	-0.936	-0.547	-1.153
Nepal	NPL	-2.691	-0.921	-0.358	-1.412
Sudan	SDN	-2.710	-0.861	-0.733	-1.116
Zimbabwe	ZWE	-2.727	-0.882	-0.554	-1.292
Sierra Leone	SLE	-2.746	-1.023	-0.627	-1.096
Lesotho	LSO	-2.765	-0.953	-0.452	-1.360
China	CHN	-2.815	-1.033	-0.319	-1.462
Benin	BEN	-2.831	-0.908	-0.752	-1.172
Liberia	LBR	-2.868	-0.937	-0.634	-1.297
Haiti	HTI	-2.869	-0.923	-0.641	-1.306
Kenya	KEN	-2.876	-0.939	-0.499	-1.438
Ghana	GHA	-2.950	-0.962	-0.453	-1.536
Zambia	ZMB	-2.979	-0.965	-0.366	-1.649
Mauritania	MRT	-2.989	-0.994	-0.503	-1.493
Somalia	SOM	-3.023	-0.895	-0.563	-1.566
Gambia	GMB	-3.027	-0.947	-0.734	-1.345
Nigeria	NGA	-3.030	-0.912	-0.717	-1.401
Rwanda	RWA	-3.153	-0.995	-0.738	-1.420
Guinea	GIN	-3.154	-0.975	-0.542	-1.638
Madagascar	MDG	-3.203	-1.043	-0.340	-1.820
Togo	TGO	-3.225	-1.001	-0.607	-1.617
Mozambique	MOZ	-3.238	-1.028	-0.710	-1.500
Guinea-biss	GNB	-3.239	-0.951	-0.769	-1.518
Comoros	COM	-3.351	-1.001	-0.467	-1.883
Mali	MLI	-3.362	-0.984	-0.739	-1.639
Central Afr.R.	CAF	-3.407	-0.963	-0.682	-1.762
Angola	AGO	-3.413	-0.996	-0.543	-1.874
Zaire	ZAR	-3.429	-0.995	-0.564	-1.871
Chad	TCD	-3.439	-1.041	-0.507	-1.891
Tanzania	TZA	-3.451	-0.966	-0.563	-1.922
Uganda	UGA	-3.452	-1.033	-0.601	-1.818
Burundi	BDI	-3.514	-1.004	-0.623	-1.888
Burkina Faso	BFA	-3.523	-1.004	-0.382	-2.138
Malawi	MWI	-3.530	-0.963	-0.528	-2.039
Myanmar	BUR	-3.548	-0.971	-0.594	-1.982
Niger	NER	-3.557	-0.957	-0.767	-1.833
Ethiopia	ETH	-3.877	-1.043	-0.570	-2.264