WHY DO SOME COUNTRIES PRODUCE SO MUCH MORE OUTPUT PER WORKER THAN OTHERS?*

ROBERT E. HALL AND CHARLES I. JONES

Output per worker varies enormously across countries. Why? On an accounting basis our analysis shows that differences in physical capital and educational attainment can only partially explain the variation in output per worker—we find a large amount of variation in the level of the Solow residual across countries. At a deeper level, we document that the differences in capital accumulation, productivity, and therefore output per worker are driven by differences in institutions and government policies, which we call social infrastructure. We treat social infrastructure as endogenous, determined historically by location and other factors captured in part by language.

I. INTRODUCTION

In 1988 output per worker in the United States was more than 35 times higher than output per worker in Niger. In just over ten days the average worker in the United States produced as much as an average worker in Niger produced in an entire year. Explaining such vast differences in economic performance is one of the fundamental challenges of economics.

Analysis based on an aggregate production function provides some insight into these differences, an approach taken by Mankiw, Romer, and Weil [1992] and Dougherty and Jorgenson [1996], among others. Differences among countries can be attributed to differences in human capital, physical capital, and productivity. Building on their analysis, our results suggest that differences in each element of the production function are important. In particular, however, our results emphasize the key role played by productivity. For example, consider the 35-fold difference in output per worker between the United States and Niger. Different capital intensities in the two countries contributed a factor of 1.5 to the income differences, while different levels of educational attainment contributed a factor of 3.1. The remaining difference—a factor of 7.7—remains as the productivity residual.

* A previous version of this paper was circulated under the title "The Productivity of Nations." 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) and is part of the National Bureau of Economic Research's program on Economic Fluctuations and Growth. We thank Bobby Sinclair for excellent research assistance and colleagues too numerous to list for an outpouring of helpful commentary. Data used in the paper are available online from http://www.stanford.edu/~chadj.

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The Quarterly Journal of Economics, February 1999

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that differences in social infrastructure across countries account for much of the difference in long-run economic performance around the world.

II. LEVELS ACCOUNTING

Our analysis begins by examining the proximate causes of economic success. We decompose differences in output per worker across countries into differences in inputs and differences in productivity.

There are three approaches to the decomposition of output per worker into inputs and productivity. One was developed by Christensen, Cummings, and Jorgenson [1981] and involves the comparison of each country to a reference point. A country's productivity residual is formed by weighting the log-differences of each factor input from the reference point by the arithmetic average of the country's factor share and the reference factor share. The second is similar, except that the factor shares are assumed to be the same for all countries; this amounts to calculating the residual from a Cobb-Douglas technology. Finally, there is a method based directly on Solow [1957], discussed in a predecessor to this paper, Hall and Jones [1996], and summarized below. Because the Solow method gives results quite similar to those based on Christensen, Cummings, and Jorgenson or on Cobb-Douglas with standard elasticities, we will not dwell on this aspect of the work. We present results based on the simplest Cobb-Douglas approach.

Assume that output \( Y_i \) in country \( i \) is produced according to

\[
Y_i = K_i^a (A_i H_i)^{1-a},
\]

where \( K_i \) denotes the stock of physical capital, \( H_i \) is the amount of human capital-augmented labor used in production, and \( A_i \) is a labor-augmenting measure of productivity. We assume that labor \( L_i \) is homogeneous within a country and that each unit of labor has been trained with \( E_i \) years of schooling (education). Human capital-augmented labor is given by

\[
H_i = e^{f(E_i)L_i}.
\]

In this specification the function \( f(E) \) reflects the efficiency of a unit of labor with \( E \) years of schooling relative to one with no schooling \((f(0) = 0)\). The derivative \( f'(E) \) is the return to schooling estimated in a Mincerian wage regression [Mincer 1974]: an
from physical capital intensity, the contribution from human capital per worker, and the contribution from productivity. It is important to note that this productivity level is calculated as a residual, just as in the growth accounting literature.

To make the comparisons easier, all terms are expressed as ratios to U. S. values. For example, according to this table, output per worker in Canada is about 94 percent of that in the United States. Canada has about the same capital intensity as the United States, but only 91 percent of U. S. human capital per worker. Differences in inputs explain lower Canadian output per worker, so Canadian productivity is about the same as U. S. productivity. Other OECD economies such as the United Kingdom also have

Table I

<table>
<thead>
<tr>
<th>Country</th>
<th>Y/L</th>
<th>(K/Y)^{1/(1-a)}</th>
<th>H/L</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Canada</td>
<td>0.941</td>
<td>1.002</td>
<td>0.908</td>
<td>1.034</td>
</tr>
<tr>
<td>Italy</td>
<td>0.834</td>
<td>1.063</td>
<td>0.650</td>
<td>1.207</td>
</tr>
<tr>
<td>West Germany</td>
<td>0.818</td>
<td>1.118</td>
<td>0.802</td>
<td>0.912</td>
</tr>
<tr>
<td>France</td>
<td>0.818</td>
<td>1.091</td>
<td>0.666</td>
<td>1.126</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.727</td>
<td>0.891</td>
<td>0.808</td>
<td>1.011</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.608</td>
<td>0.741</td>
<td>0.735</td>
<td>1.115</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.606</td>
<td>1.031</td>
<td>0.545</td>
<td>1.078</td>
</tr>
<tr>
<td>Japan</td>
<td>0.587</td>
<td>1.119</td>
<td>0.797</td>
<td>0.658</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.433</td>
<td>0.868</td>
<td>0.538</td>
<td>0.926</td>
</tr>
<tr>
<td>Argentina</td>
<td>0.418</td>
<td>0.953</td>
<td>0.676</td>
<td>0.648</td>
</tr>
<tr>
<td>U.S.S.R.</td>
<td>0.417</td>
<td>1.231</td>
<td>0.724</td>
<td>0.468</td>
</tr>
<tr>
<td>India</td>
<td>0.086</td>
<td>0.709</td>
<td>0.454</td>
<td>0.267</td>
</tr>
<tr>
<td>China</td>
<td>0.060</td>
<td>0.891</td>
<td>0.632</td>
<td>0.106</td>
</tr>
<tr>
<td>Kenya</td>
<td>0.056</td>
<td>0.747</td>
<td>0.457</td>
<td>0.165</td>
</tr>
<tr>
<td>Zaire</td>
<td>0.033</td>
<td>0.499</td>
<td>0.408</td>
<td>0.160</td>
</tr>
<tr>
<td>Average, 127 countries:</td>
<td>0.296</td>
<td>0.853</td>
<td>0.565</td>
<td>0.516</td>
</tr>
<tr>
<td>Standard deviation:</td>
<td>0.268</td>
<td>0.234</td>
<td>0.168</td>
<td>0.325</td>
</tr>
<tr>
<td>Correlation with Y/L (logs)</td>
<td>1.000</td>
<td>0.624</td>
<td>0.798</td>
<td>0.889</td>
</tr>
<tr>
<td>Correlation with A (logs)</td>
<td>0.889</td>
<td>0.248</td>
<td>0.522</td>
<td>1.000</td>
</tr>
</tbody>
</table>

The elements of this table are the empirical counterparts to the components of equation (3), all measured as ratios to the U. S. values. That is, the first column of data is the product of the other three columns.

For example, according to this table, output per worker in Canada is about 94 percent of that in the United States. Canada has about the same capital intensity as the United States, but only 91 percent of U. S. human capital per worker. Differences in inputs explain lower Canadian output per worker, so Canadian productivity is about the same as U. S. productivity. Other OECD economies such as the United Kingdom also have

9. A complete set of results is available from the web site listed in the acknowledgment footnote.
tion of contracts. Our GADP variable is an equal-weighted average of these five variables, each of which has higher values for governments with more effective policies for supporting production. The index is measured on a scale from zero to one.

The second element of our measure of social infrastructure captures the extent to which a country is open to international trade. Policies toward international trade are a sensitive index of social infrastructure. Not only does the imposition of tariffs divert resources to the government, but tariffs, quotas, and other trade barriers create lucrative opportunities for private diversion. In addition, policies favoring free trade yield benefits associated with the trade itself. Trade with other countries yields benefits from specialization and facilitates the adoption of ideas and technologies from those countries. 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 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 social infrastructure. The Sachs-Warner index measures the fraction of years during the period 1950 to 1994 that the economy has been open and is measured on a [0,1] scale. 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.

In most of the results that we present, we will impose (after testing) the restriction that the coefficients for these two proxies for social infrastructure are the same. Hence, we focus primarily on a single index of social infrastructure formed as the average of the GADP and openness measures.

B. Identification

To examine the quantitative importance of differences in social infrastructure as determinants of incomes across countries, we hypothesize the following structural model:

\[
\log \frac{Y}{L} = \alpha + \beta S + \epsilon,
\]
(5) \[ S = \gamma + \delta \log Y/L + X \theta + \eta, \]
where \( S \) denotes social infrastructure and \( X \) is a collection of other variables.

Several features of this framework deserve comment. First, we recognize explicitly that social infrastructure is an endogenous variable. Economies are not exogenously endowed with the institutions and incentives that make up their economic environments, but rather social infrastructure is determined endogenously, perhaps depending itself on the level of output per worker in an economy. Such a concern arises not only because of the general possibility of feedback from the unexplained component of output per worker to social infrastructure, but also from particular features of our measure of social infrastructure. For example, poor countries may have limited ability to collect taxes and may therefore be forced to interfere with international trade. Alternatively, one might be concerned that the experts at Political Risk Services who constructed the components of the GADP index were swayed in part by knowledge of income levels.

Second, our specification for the determination of incomes in equation (4) is parsimonious, reflecting our hypothesis that social infrastructure is the primary and fundamental determinant of output per worker. We allow for a rich determination of social infrastructure through the variables in the \( X \) matrix. Indeed, we will not even attempt to describe all of the potential determinants of social infrastructure; we will not estimate equation (5) of the structural model. The heart of our identifying assumptions is the restriction that the determinants of social infrastructure affect output per worker only through social infrastructure and not directly. We test the exclusion below.

Our identifying scheme includes the assumption that \( EX'\epsilon = 0 \). Under this assumption, any subset of the determinants of social infrastructure constitute valid instruments for estimation of the parameters in equation (4). Consequently, we do not require a complete specification of that equation. We will return to this point in greater detail shortly.

Finally, we augment our specification by recognizing, as discussed in the previous section, that we do not observe social infrastructure directly. Instead, we observe a proxy variable \( S \) computed as the sum of GADP and the openness variable, normalized to a \([0,1]\) scale. This proxy for social infrastructure is
related to true social infrastructure through random measurement error:

\[ S = \psi S + \nu, \]

where \( \nu \) is the measurement error, taken to be uncorrelated with \( S \) and \( X \). Without loss of generality, we normalize \( \psi = 1 \); this is an arbitrary choice of units since \( S \) is unobserved. Therefore,

\[ S = \hat{S} - \nu. \]

Using this measurement equation, we rewrite equation (4) as

\[ \log \frac{Y}{L} = \alpha + \beta \tilde{S} + \tilde{\epsilon}, \]

where

\[ \tilde{\epsilon} = \epsilon - \beta \nu. \]

The coefficient \( \beta \) will be identified by the orthogonality conditions \( EX\tilde{\epsilon} = 0 \). Therefore, both measurement error and endogeneity concerns are addressed. The remaining issue to discuss is how we obtain valid instruments for GADP and our openness measure.

C. Instruments

Our choice of instruments considers several centuries of world history. One of the key features of the sixteenth through nineteenth centuries was the expansion of Western European influence around the world. The extent of this influence was far from uniform, and thus provides us with identifying variation which we will take to be exogenous. Our instruments are various correlates of the extent of Western European influence. These are characteristics of geography such as distance from the equator and the extent to which the primary languages of Western Europe—English, French, German, Portuguese, and Spanish—are spoken as first languages today.

Our instruments are positively correlated with social infrastructure. Western Europe discovered the ideas of Adam Smith, the importance of property rights, and the system of checks and balances in government, and the countries that were strongly influenced by Western Europe were, other things equal, more likely to adopt favorable infrastructure.

That the extent to which the languages of Western Europe are spoken as a mother tongue is correlated with the extent of
tion is that national boundaries do not limit the areas where ideas are applied.

The seventh specification considers a measure of the density of economic activity, computed following the methods of Ciccone and Hall [1996].\textsuperscript{24} 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. Here, however, 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.

The results for the eighth specification are unexpected. This specification adds an indicator variable taking the value of one for countries that are categorized as capitalist or mixed-capitalist by the Freedom House [Finn 1994]. The odd result is that the regression coefficient implies that capitalist countries produce substantially less output per worker than otherwise similar noncapitalist countries. In part, this reflects the particular definition of capitalism employed by the Freedom House. According to their classification, a number of sub-Saharan African economies are classified as capitalist.

The final specification of Table VI adds a list of continent dummies to the instrument set.\textsuperscript{25} As with the other specifications, the coefficient on social infrastructure is unchanged by the addition of the continents to the instrument list. However, the overidentification test now rejects the restrictions, in part because African economies have lower output per worker than otherwise similar economies on other continents.

VII. Conclusion

Countries produce high levels of output per worker in the long run because they achieve high rates of investment in physical capital and human capital and because they use these inputs with

\begin{equation}
D_i = \frac{1}{N_i} \sum_{s \in S_i} n_s a_s^{(y-1)},
\end{equation}

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 provinces, and $a_s$ is the area of provinces. We use a value of $y = 1.058$, as estimated by Ciccone and Hall. This value implies that doubling density increases $D_i$ by about 6 percent.

\textsuperscript{24} The Ciccone-Hall measure for country $i$ is given by

\textsuperscript{25} The continents are North America (including Central America), South America, Africa, Asia (plus Oceania), and Europe.
a high level of productivity. Our empirical analysis suggests that success on each of these fronts is driven by social infrastructure. A country’s long-run economic performance is determined primarily by the institutions and government policies that make up the economic environment within which individuals and firms make investments, create and transfer ideas, and produce goods and services.

Our major findings can be summarized by the following points:

1. Many of the predictions of growth theory can be successfully considered in a cross-section context by examining the levels of income across countries.

2. The large variation in output per worker across countries is only partially explained by differences in physical capital and educational attainment. Paralleling the growth accounting literature, levels accounting finds a large residual that varies considerably across countries.

3. Differences in social infrastructure across countries cause large differences in capital accumulation, educational attainment, and productivity, and therefore large differences in income across countries.

4. The extent to which different countries have adopted different social infrastructures is partially related to the extent to which they have been influenced by Western Europe. Using distance from the equator and language data, we conclude that our finding that differences in social infrastructure cause large differences in income is robust to measurement error and endogeneity concerns.

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References