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Open Trade and Skilled and Unskilled Labor Productivity in Developing Countries: A Panel Data Analysis

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ABSTRACT
This paper examines the effect of trade openness on the productivity of skilled and unskilled labor in a group of 36 developing countries using panel data and fixed effect approach. We have developed and utilized an empirical model that readily lends itself to testing the hypothesis posed. Our results support the hypothesis that trade openness has a positive and significant impact on labor productivity for both skilled and unskilled labor in the sample countries. We also observe that the beneficial effect of trade openness is relatively stronger for the skilled labor than the unskilled labor. We conclude that contrary to the claim made by Mayda and Rodrik (2001), skilled workers in developing countries may oppose protectionism. When adjusting for the purchasing power parity, the impact of trade openness on labor productivity, although positive and significant, is not as pronounced as it is for other definitions of openness.

KEY WORDS: Trade openness, productivity, skilled labor, unskilled labor, developing countries, panel data

Introduction
Recent developments in trade negotiations and the signing of new international trade agreements have resulted in an intense debate over the issues of trade openness and globalization and their impacts on different countries and their economies. Volumes are written on the merits or demerits of such developments. Some scholars argue that exposure to trade will stimulate domestic economy and promote efficiency while others...
concentrate on the possible adverse effects that trade openness may have on the power of the nation-states and loss of national sovereignty.\textsuperscript{2}

When it comes to the impact of trade on different macroeconomic variables, labor productivity has received special attention in the recent literature. Some studies are country or region specific (Andersson, 2001; Abizadeh & Grant, 1999). Others have looked at larger sample of countries to investigate the effect of trade openness on labor productivity in general (Edwards, 1998; Alcala & Ciccone, 2004).

At the same time, past studies have either looked at total factor productivity (Miller & Upadhyay, 2000; Andersson, 2001) or total labor productivity (Abizadeh & Grant, 1999; Alcala & Ciccone, 2004). Some studies have looked at the effect of trade on total labor productivity in different groups of developed countries (Miller & Upadhyay, 2000) while some others focused on less developed countries (Weinhold & Rauch, 1999).

Meanwhile, recent international trade literature has tried to answer a policy-related question of whether skilled or unskilled labor will oppose or defend trade openness. In light of this question, there are studies that conclude that skilled labor is more likely to oppose protectionism than unskilled labor (Baldwin & Magee, 2000; Scheve & Slaughter, 2001a, b) and Beaulieu (2000a and 2002b). Other studies contend that skilled labor may behave differently toward trade in developed as opposed to developing countries. Mayda and Rodrik (2001) argue that skilled workers in developed countries may oppose protectionism while their counterparts in the developing countries may support it.

Using the above controversy as a springboard for our theoretical and empirical analysis we develop a model to test for the effect of trade openness on both skilled and unskilled labor productivity in the group of developing countries. It is hypothesized that freer trade can lead to economies of scale in those countries that expand their trade by increasing their exports and imports relative to their GDP. The economies of scale, in turn, lead to improved labor productivity as trade volume is expanded.

The main objective of this paper is to develop a sound theoretical model that can readily lend itself to an empirical investigation and evaluation of our hypothesis. We propose that the effect of freer trade on labor productivity can be captured by an openness measure.

What distinguishes this paper from past studies is that first it uses a comprehensive panel data and second it utilizes three alternative definitions of openness as different measures to represent trade openness. In particular, it uses, among others, the openness definition developed by Alcala and Ciccone (2004) based on the purchasing power parity. This paper also differs from those in the past in that it separates the total labor force into skilled and unskilled labor and then analyzes the effect of trade on their respective productivities.

The empirical model will use annual panel data from 36 developing countries from 1988 to 1999 to investigate the effect of increased trade on labor productivity.\textsuperscript{3} The remainder of this paper is organized as follows. The next
section develops the theoretical model as a base for generating our empirical model. The section after presents our empirical model and the fourth section focuses on the empirical results of our investigation using a two-way fixed effects procedure. The fifth section gives a brief summary and conclusion.

The Theoretical Model

Starting from an aggregate production function, we adopt a Cobb–Douglas type function for the purpose of looking at labor productivity. In light of our main objective to investigate properly the impact of trade on skilled and unskilled labor productivity separately, and based on the widely held views in the international trade literature making a clear distinction between these two groups of labor, our general form of production function is expressed as follows.4

\[ Y = AK^\alpha L^\beta L^\delta, \ 0 < \alpha < 1, \ 0 < \beta < 1, \ 0 < \delta < 1 \]

where \( Y \) is real output (GDP), \( K \) is the total capital stock, \( L^\alpha \) is the number of skilled workers in the labor force, \( L^\beta \) is the number of unskilled workers in the labor force and \( A \) represents total factor productivity. Our aggregate production function is assumed to display increasing and decreasing returns to scale allowing for \((\alpha + \beta + \delta)\) assuming values equal to, less than or greater than one. In addition, \( L^\alpha + L^\beta = L \), where \( L \) is equal to the total number of workers in the labor force.

Next, we define labor productivity \( PR \) as

\[ PR^\alpha = Y^\alpha / L^\alpha \] (2a)

for skilled and

\[ PR^\beta = Y^\beta / L^\beta \] (2b)

for unskilled labor and where \( Y^\alpha \) and \( Y^\beta \) are the share of total output attributed to skilled and unskilled labor, respectively.

Thus, we will have the following relationships for skilled and unskilled labor productivity, respectively:

\[ Y^\alpha / L^\alpha = (AK^\alpha L^\beta L^\delta) / L^\alpha \] (3a)

and

\[ Y^\beta / L^\beta = (AK^\alpha L^\beta L^\delta) / L^\beta \] (3b)

Equations (3a) and (3b) in logarithmic forms are:

\[ \ln(Y^\alpha / L^\alpha) = \ln A + \alpha \ln K + \beta \ln L^\alpha + \delta \ln L^\beta - \ln L^\alpha \] (4a)

and

\[ \ln(Y^\beta / L^\beta) = \ln A + \alpha \ln K + \beta \ln L^\alpha + \delta \ln L^\beta - \ln L^\beta \] (4b)
Simplify equations (4a) and (4b) and set \( \theta^a = (\beta - 1) \) and \( \theta^b = (\delta - 1) \) to arrive at:

\[
\ln\left(\frac{Y^a}{L^a}\right) = \ln A + z \ln K + \theta^a \ln L^s + \delta \ln L^u \tag{5a}
\]

and

\[
\ln\left(\frac{Y^u}{L^u}\right) = \ln A + z \ln K + \theta^b \ln L^s + \delta \ln L^u \tag{5b}
\]

Introducing a matrix of exogenous variables \((X_i)\) effecting labor productivity we can rewrite equations (5a) and (5b) as:

\[
\ln\left(\frac{Y^a}{L^a}\right) = \ln A + z \ln K + \theta^a \ln L^s + \delta \ln L^u + \lambda^a_i \ln X_i \tag{6a}
\]

and

\[
\ln\left(\frac{Y^u}{L^u}\right) = \ln A + z \ln K + \theta^b \ln L^s + \delta \ln L^u + \lambda^b_i \ln X_i \tag{6b}
\]

The general forms of equations (6a) and (6b) establish the framework of this study for the estimation of skilled and unskilled labor productivity.

**The Empirical Model**

The empirical model designed here will readily lend itself to the analysis of the impact of trade openness on the productivity of both skilled and unskilled labor. Coefficients \( \lambda^a_i \) and \( \lambda^b_i \) in equations (5a) and (5b) are the critical coefficients in our models, given the hypothesis posed. We use employment in the service sector as a proxy for the skilled labor force while employment in industry and agriculture are used a proxy for the unskilled labor force. Defining labor productivity for skilled and unskilled labor as the value added in their sector divided by their respective labor force obtains two distinct productivity measures for skilled and unskilled labor \((PR^s\text{ and } PR^u)\). Accordingly, based on the theoretical equations (6a) and (6b) developed above, our empirical models can be written as:

\[
\ln\left(\frac{Y^a}{L^a}\right)_{it} = \ln A + z_i \ln K_{it} + \theta^a_i \ln L^s_{it} + \delta_i \ln L^u_{it} + \lambda^a_i \ln X_{it} + f^a_i + \phi^a_i + \epsilon^a_{it} \tag{7a}
\]

and

\[
\ln\left(\frac{Y^u}{L^u}\right)_{it} = \ln A + z_i \ln K_{it} + \beta_i \ln L^s_{it} + \delta_i \ln L^u_{it} + \lambda^b_i \ln X_{it} + f^b_i + \phi^b_i + \epsilon^b_{it} \tag{7b}
\]

In equations (7a) and (7b) the coefficients of interest are \( \lambda^a_i \) and \( \lambda^b_i \) which represent the relationship between labor productivity and our control variables to be defined shortly, \( f^a_i \) and \( f^b_i \) represent the unobservable country specifics, time-invariant effects, \( \phi^a_i \) and \( \phi^b_i \) represent unobservable time specific effects, and \( \epsilon^a_i \) and \( \epsilon^b_i \) represent time-variant unsystematic effects and
are i.i.d. $X_\theta$ is a matrix that includes all remaining control variables where $\lambda^a_j$ and $\lambda^b_j$ ($j = 1, \ldots, n$) are vectors of coefficients. All variables except any dummies used are logged.

One of the key and controversial control variables used in the past studies to represent the degree of trade openness, and thus examine the impact of freer trade on productivity, is openness. There are three distinct definitions of openness that researchers have used in the past. First is the traditional definition of openness, which is expressed as follows:

$$OP^A = (X + M)/Y$$  \hspace{1cm} (8)

where $OP^A$ is the traditional measure of openness, $X$ equals to total exports and $M$ is total imports.\(^5\)

Second is a modified definition of openness that claims to capture better the degree of openness by excluding net exports from GDP. This is defined as:

$$OP^B = (X + M)/((Y - (X - M))$$  \hspace{1cm} (9)

where $OP^B$ is the modified version of openness.\(^6\)

The third definition of openness is given by Alcala and Ciccone (2004) and is called ‘real openness’. These authors argue that ‘... an increase in the degree of specialization affects openness in two opposite ways. Holding the price of nontradable goods constant, a higher degree of specialization raises openness as more specialization necessarily implies a larger volume of imports,’ (Alcala & Ciccone, 2004: 617). However, they show that, at the same time, a higher degree of specialization will raise the price of non-tradeables leading to lower openness (Alcala & Ciccone, 2004: 617). Accordingly, based on ‘sound theoretical reasons’, they conclude that the traditional openness ‘... may result in misleading picture of the productivity gains due to trade’ (Alcala & Ciccone, 2004: 613). Alcala and Ciccone’s definition of ‘real openness’ is given by:

$$OP^C = (X + M)/(Y_{PPP})$$  \hspace{1cm} (10)

where $OP^C$ is real openness, $X$ and $M$ are in US dollars and $Y_{PPP}$ is a measure of GDP in purchasing power parity US$.\(^7\)

While these measures of openness are widely used in the literature, they are all aggregate measures and therefore imperfect. One could get a more accurate picture of openness by decomposing total trade flows ($X + M$) into its components such as the distribution of bilateral trade flows between country $A$ and its individual trading partners or the weights of consumer and producer goods within trade flows. However, the ratio of the sum of exports and imports to an economic base, such as the gross domestic product, appears to be the only common openness indicator available, particularly for panel data analysis.
We use letter ‘T’ in our empirical models to represent openness in general. Another variable that can affect labor productivity is the level of investment in education. We hypothesize that increased investment expenditures on education can lead to improvements in productivity of labor. We introduce and utilize real per capita expenditures on education \((E)\) as a proxy for this variable.

Including the above two control variables in equations (7a) and (7b) we get:

\[
\ln \left( \frac{Y^s}{L^s} \right)_{it} = \ln A + \alpha_i \ln K_{it} + \theta_i^a \ln L_{it}^s + \delta_i \ln L_{it}^u + \lambda_i^{a1} \ln T_{it} + \lambda_i^{a2} \ln E_{it} \\
+ f_i^a + \phi_i^a + \epsilon_i^a 
\]  

(11a)

and

\[
\ln \left( \frac{Y^u}{L^u} \right)_{it} = \ln A + \alpha_i \ln K_{it} + \beta_i \ln L_{it}^u + \theta_i^b \ln L_{it}^u + \lambda_i^{b1} \ln T_{it} + \lambda_i^{b2} \ln E_{it} \\
+ f_i^b + \phi_i^b + \epsilon_i^b 
\]  

(11b)

Equations (11a) and (11b) form the basis of our empirical investigation.

We use panel data for a group of developing countries to estimate the appropriate coefficients in equations (11a) and (11b). This will allow us to test our hypothesis of the impact of freer trade openness on labor productivity. Fixed-effects and random-effect procedures are the two popular methods used to estimate the appropriate coefficients when employing panel data. A fixed effects model has the advantage of removing the bias from the estimation caused by possible correlation between explanatory variables and time-invariant country specific effects. Here, the countries in the sample are used as controls for themselves. The other important characteristic of the fixed effects approach is that it produces consistent estimates even when the random-effects model is valid.

In order to ensure the relevance and superiority of the fixed effects method over the random effects model, we conduct the Hausman (1978) specification test for random effects to check the robustness of the fixed effects specification. In a random effects model, the assumption is that individual country effects \(f_i^a\) and \(f_i^b\) in equations (11a) and (11b) and all other regressors are uncorrelated. However, if they are correlated then the coefficient estimates of the regressors in a random effects model will be inconsistent and systematically different from those for a fixed effects model, and the fixed effects model is strictly a better choice. Under Hausman’s specification test for the random effects, the null hypothesis is that coefficient estimates of the fixed effects and random effects models are not systematically different from each other. Based on the high values of Chi-Square test statistics for all the models reported in this paper, we rejected the null hypothesis.\(^7\) It is thus concluded that fixed effects specification is clearly a more superior technique for the estimation of these models leading to unbiased and consistent estimates of the coefficients in our empirical models.
Country dummies and year dummies are used to control for the country specific and time specific effects. That is, in order to ensure proper specification of the models we employ a two-way fixed effects method. We also conducted a test for non-stationarity in our panel data and, considering the limitations of data, we found that this is not a concern. Finally, we have found that heteroskedasticity could be a problem in some of the regressions and corrected for it accordingly.

The Results

Our results are reported in Tables 1 and 2 for skilled labor productivity and unskilled labor productivity, respectively. Each column in these tables reports the results based on the alternative definition used for openness. $OP_A$ stands for the traditional definition of openness, $OP_B$ refers to the modified definition of openness, and $OP_C$ is the ‘real openness’ based on the GDP PPP. Capital stock variable ($K$) is lagged by one year in all models. Rodrik (1998) argues that the effect of trade on other economic variables occurs with a rather long lag. This is to ensure that there is enough time allowed for changes in trade to show their impact on different productivity measures. Subsequently, our openness variables are lagged by three years in all three versions reported in Tables 1 and 2.

Looking closely at Tables 1 and 2, we observe consistent and robust results on the estimations of the coefficients. Due to the striking similarities and closeness of these estimated coefficients in all three versions reported, with minimal exceptions, we will interpret the results for these versions as one unit.

<table>
<thead>
<tr>
<th>Variables</th>
<th>$OP_A^{1-3}$</th>
<th>$OP_B^{1-3}$</th>
<th>$OP_C^{1-3}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Stock ($\alpha$)</td>
<td>0.111**</td>
<td>0.109**</td>
<td>0.124**</td>
</tr>
<tr>
<td></td>
<td>(0.020)</td>
<td>(0.020)</td>
<td>(0.021)</td>
</tr>
<tr>
<td>Skilled Labor ($\beta')$</td>
<td>-0.664**</td>
<td>-0.662**</td>
<td>-0.678**</td>
</tr>
<tr>
<td></td>
<td>(0.096)</td>
<td>(0.096)</td>
<td>(0.099)</td>
</tr>
<tr>
<td>Unskilled Labor ($\delta$)</td>
<td>0.373**</td>
<td>0.377**</td>
<td>0.397**</td>
</tr>
<tr>
<td></td>
<td>(0.075)</td>
<td>(0.075)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>Openness ($\lambda_1$)</td>
<td>0.048**</td>
<td>0.051**</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.016)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Education Expenditures ($\lambda_2$)</td>
<td>0.049**</td>
<td>0.048**</td>
<td>0.028*</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.017)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Constant ($\ln A$)</td>
<td>10.14</td>
<td>10.10</td>
<td>9.80</td>
</tr>
<tr>
<td></td>
<td>(2.35)</td>
<td>(2.35)</td>
<td>(2.44)</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>248</td>
<td>248</td>
<td>248</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.58</td>
<td>0.58</td>
<td>0.52</td>
</tr>
</tbody>
</table>

**Notes:**
1. Standard errors are shown in parenthesis.
2. ** Indicates 1% significance levels.
3. * Indicates 5% significance levels.
4. + Indicates 10% significance levels.
As far as the results for skilled labor are concerned, we observe that the estimated coefficients for the capital stock variable, $a$, are positive and statistically significant in all three cases using alternative definitions of openness. The coefficients for the skilled labor variable, $\theta$, are negative, owing to the diminishing marginal productivity, and are statistically significant. Unskilled labor variables carry positive and statistically significant signs confirming complementarity of skilled and unskilled labor.

Investment in education can play a significant role in improving labor productivity. Our results confirm this. The coefficient for this variable, $\lambda^{a2}$, has a positive and statistically significant sign in all three versions.

Regarding the central variable (openness) in our study, we observe that the coefficients for all three versions of openness are positive and statistically significant. However, when openness is adjusted for purchasing power parity, we observe that both the coefficient and standard error for skilled labor, although they assume lower values compared with the other two definitions used for openness, are nonetheless statistically significant. This leads us to conclude that alternative definitions of openness have varying degrees of impact on productivity of skilled labor. It follows that, at least in the case of developing countries, regardless of the way openness is defined, trade openness has a positive and significant impact on the productivity of skilled labor. This conclusion leads us to believe that, contrary to the assertion made in Mayda and Rodrik (2001), skilled workers in developing countries may logically oppose protectionism if they feel that freer trade can lead to higher productivity and thus increased real wages for them.

<table>
<thead>
<tr>
<th>Variables</th>
<th>$OP_{1-3}^A$</th>
<th>$OP_{1-3}^B$</th>
<th>$OP_{1-3}^C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Stock ($a$)</td>
<td>0.088**</td>
<td>0.086**</td>
<td>0.101**</td>
</tr>
<tr>
<td></td>
<td>(0.029)</td>
<td>(0.029)</td>
<td>(0.029)</td>
</tr>
<tr>
<td>Skilled Labor ($\theta$)</td>
<td>0.661**</td>
<td>0.666**</td>
<td>0.585**</td>
</tr>
<tr>
<td></td>
<td>(0.137)</td>
<td>(0.137)</td>
<td>(0.128)</td>
</tr>
<tr>
<td>Unskilled Labor ($\delta$)</td>
<td>-0.313**</td>
<td>-0.308**</td>
<td>-0.356**</td>
</tr>
<tr>
<td></td>
<td>(0.099)</td>
<td>(0.099)</td>
<td>(0.094)</td>
</tr>
<tr>
<td>Openness ($\lambda^1$)</td>
<td>0.051*</td>
<td>0.054**</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.025)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Education</td>
<td>0.058**</td>
<td>0.058**</td>
<td>0.062*</td>
</tr>
<tr>
<td>Expenditures ($\lambda^{a2}$)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>Constant (ln $A$)</td>
<td>0.840</td>
<td>0.75</td>
<td>2.33</td>
</tr>
<tr>
<td></td>
<td>(3.84)</td>
<td>(3.87)</td>
<td>(3.60)</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>245</td>
<td>245</td>
<td>245</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.71</td>
<td>0.71</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Notes:
1. Standard errors are shown in parenthesis.
2. ** Indicates 1% significance levels.
3. * Indicates 5% significance levels.
Looking at the results reported in Table 2, it is observed that the estimated coefficients are very similar to those reported for the skilled labor models earlier. For consistency and ease of comparison we have lagged all three versions of openness variable by three years here as well.

The results indicate that increased use of capital and skilled labor plus higher expenditure in education have a positive and statistically significant influence on unskilled labor productivity. These results are consistent with received economic theory. The coefficient for unskilled labor, \( \delta \), carries a negative sign and is statistically significant. This, again demonstrate the law of diminishing marginal productivity.

For the trade variable, we observe that the coefficients for the first two versions (\( OP^A \) and \( OP^B \)) carry positive and statistically significant coefficients confirming the positive impact that expanded trade can exert on the productivity of unskilled labor in developing countries. As far as the third version of openness (\( OP^C \)) is concerned, the coefficient is not statistically significant and, similar to the results for skilled labor, both the coefficient and standard error are much lower that the ones for other definitions of openness. However, if this variable is lagged by four years, its coefficient becomes statistically significant at the 5 per cent level. This led us to conclude that, regardless of how openness is defined, trade openness has a positive influence on the productivity of unskilled as well as skilled labor over time.

When comparing the overall effect of trade openness on labor productivity, and given our statistical results, we can conclude that the beneficial effect of trade openness is relatively stronger for the skilled labor than the unskilled labor. Such finding can further support the view that, skilled workers are more pro trade than their unskilled counterparts. In the meantime, we observe that the results for both the traditional and modified versions of openness are very similar while those for the real openness yield both lower coefficients and standard errors. It is thus speculated that, once we adjust for the purchasing power parity, the impact of trade openness, although positive and significant, is not as pronounced as it would be in the absence of such adjustment.

**Summary and Conclusions**

Given recent interest in trade openness and globalization, a number of researchers have become interested in the effect of such developments on various macro-economic variables. One such variable is productivity in general and labor productivity in particular. Although studies that have concerned themselves with the attitudes of labor towards freer trade have tried to answer their empirical question by separating the group of skilled and unskilled labor and their support, or lack there of, for trade openness, we are not aware of any study that tries to separate the effect of openness on skilled and unskilled labor productivity.
The theoretical and empirical models developed here are designed to allow for the above distinction and the testing of the effect of trade openness on both skilled and unskilled labor productivity in the group of developing countries. It is hypothesized that freer trade can lead to economies of scale in those countries that expand their trade by increasing their exports and imports relative to their GDP. That is, the effect of freer trade on labor productivity can be captured by an openness measure.

Using comprehensive annual panel data from 36 developing countries from 1988 to 1999 and three alternative definitions of openness as different measures of trade openness, we determine the impact of freer trade on labor productivity.

Given the robust statistical results reported in this study, we can unequivocally conclude that, at least in the case of developing countries, regardless of the way openness is defined, trade openness has a positive and significant impact on the productivity of skilled and unskilled labor over time. In addition, when comparing the overall effect of trade openness on labor productivity, we can conclude that the beneficial effect of trade openness is relatively stronger for the skilled labor than the unskilled labor. Accordingly, contrary to the claim made by Mayda and Rodrik (2001), skilled workers in developing countries may logically oppose protectionism if they feel that freer trade can lead to higher productivity and thus increased real wages for them.

Although results for both the traditional and modified versions of openness are very similar, those for the real openness yield both lower coefficients and standard errors. It is thus speculated that, once we adjust for the purchasing power parity, the impact of trade openness, although positive and significant, is not as pronounced as it would be in the absence of such adjustment.

Notes

1 See, Held and McGrew (2000) and Jones (2000) regarding these debates.
2 See, Weiss (1999) for an excellent discussion on this debate.
3 See Appendix for the complete list of countries used in our sample (Table A1), detailed definition of variables used and their sources of data.
4 This form of CES production function is based on the theoretical model presented in Layard and Walters (1978). According to these authors, when it comes to this type of production function, ‘there is no difficulty in introducing a third factor, by, say, distinguishing between skilled labor S and unskilled labor N.’ (Layard & Walters, 1978: 275).
5 Recent studies by Andersson (2001) and Dar and Amirkhalkhali (2003), among others, have used this definition.
6 Abizadeh and Grant (1999) are among those who have used this definition in their analysis.
7 Chi-Square test statistics are 193.84, 195.03 and 202.74, respectively for the regressions reported in Table 1, and 84.31, 86.57 and 129.28, respectively for the regressions reported in Table 2.
8 For this we used the Levin-Lin-Chu panel unit root test as explained in Levin et al. (2002). Baltagi (2001: 236 – 238) also explains an earlier version of this test. The test was conducted in
STATA using the command ‘levinlin’. This test requires a balanced panel. Hence the panel sample was reduced to 21 countries and the period from 1991 to 1998. To give an example, the calculated adjusted t-statistics for the two dependent variables (skilled labor productivity and unskilled labor productivity) were $-151.53$ and $-13.52$, respectively, which suggests rejection of the Null Hypothesis of non-stationarity in these two series. We found that heteroskedasticity is a problem in all three regressions in Table 2. We used robust standard errors in those regressions.

References


Appendix I: Definitions of Variables and Data Sources

1(a) GDP \((Y)\) in constant 1995 US$

Dollar figures for GDP are converted from domestic currencies using 1995 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Source:
World Bank national accounts data, and OECD National Accounts data files.

1(b) GDP \((PPP US$)\)

Source:
Alan Heston, Robert Summers and Bettina Aten, Peon World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002.

http://pwt.econ.upenn.edu/php_site/pwt61_form.php

2) Exports \((X)\) in constant 1995 US$

Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments.

Source:
World Bank national accounts data, and OECD National Accounts data files.

3) Imports \((M)\) in constant 1995 US$

Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments.
(4) **Population**

Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship – except for refugees not permanently settled in the country of asylum, which are generally considered part of the population of their country of origin.

Source:
World Bank staff estimates from various sources including the United Nations Statistics Division’s Population and Vital Statistics Report, country statistical offices, and Demographic and Health Surveys from national sources and Macro International.

(5) **Gross capital formation (K) in constant 1995 US$**

Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and ‘work in progress.’ According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.

Source:
World Bank national accounts data, and OECD National Accounts data files.

(7) **Per capita expenditures on education**

The variable ‘education per capita’ (\(E\)) was calculated by taking public spending on education divided by population.

Definition:
Public expenditure on education consists of public spending on public education plus subsidies to private education at the primary, secondary, and tertiary levels.

Source:
(8) Labor force (L)

Labor force stats were taken from http://laborsta.ilo.org/ in May 2004 where information in Table 1B ‘Economically active population by level of education & age group’ is available for download.

The variable unskilled labor \((L^u)\) was calculated from the above table by adding up the total numbers from levels of education; \(X\), level 1, level 2, level 3 and level? (Unknown level of education) for each country. In other words, if there was a value in the level? column, this was taken as unskilled labor.

The variable skilled labor \((L^s)\) is the total of the figures reported under level 4/5 level 5A, level 5B, and level 6/9. (All of these levels represent some form of post secondary education although the exact reporting criteria differ between countries; for example, some countries include individuals in a category if they are enrolled in a program while other countries require a student to have graduated from a program before counting them in the category.)

(9) Agriculture value added (constant 1995 US$)

Agriculture corresponds to ISIC divisions 1–5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Data are in constant 1995 US dollars.

Source:
World Bank national accounts data, and OECD National Accounts data files.

(10) Industry value added (constant 1995 US$)

Definition:
Industry corresponds to ISIC divisions 10–45 and includes manufacturing (ISIC divisions 15–37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Data are in constant 1995 U.S. dollars.
Source:
World Bank national accounts data, and OECD National Accounts data files.

(11) Services value added (constant 1995 US$)

Definition:
Services correspond to ISIC divisions 50–99. They include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Data are in constant 1995 US dollars.

Source:
World Bank national accounts data, and OECD National Accounts data files

(12) Employment in services

Employment in services is the number of laborers recorded as working in the services sector. Employees are people who work for a public or private employer and receive remuneration in wages, salary, commission, tips, piece rates, or pay in kind. Services include wholesale and retail trade and restaurants and hotels; transport, storage, and communications; financing, insurance, real estate, and business services; and community, social, and personal services—corresponding to divisions 6–9 (ISIC revision 2) or tabulation categories G-P (ISIC revision 3).

Source:
International Labour Organization, Key Indicators of the Labour Market database.

(13) Employment in agriculture

Employment in agriculture is the number of laborers recorded as working in the agricultural sector. Employees are people who work for a public or private employer and receive remuneration in wages, salary, commission, tips, piece rates, or pay in kind. Agriculture includes hunting, forestry, and
fishing, corresponding to major division 1 (ISIC revision 2) or tabulation categories A and B (ISIC revision 3).

Source:
International Labour Organization, Key Indicators of the Labour Market database.

(14) Employment in industry

Employment in industry is the number of laborers recorded as working in the industrial sector. Employees are people who work for a public or private employer and receive remuneration in wages, salary, commission, tips, piece rates, or pay in kind. Industry includes mining and quarrying (including oil production), manufacturing, electricity, gas and water, and construction, corresponding to major divisions 2–5 (ISIC revision 2) or tabulation categories C-F (ISIC revision 3).

Source:
International Labour Organization, Key Indicators of the Labour Market database.

(15) Skilled labor/productivity

Employment in services was used as a proxy for skilled labor. The value for skilled labor productivity is measured by taking services value added/skilled labor.

(16) Unskilled labor/productivity

Employment in agriculture and industry was used as a proxy for unskilled labor. The value for unskilled labor productivity is measured by taking (agriculture value added + industry value added)/unskilled labor.

Table A1. List of sample countries used

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<tr>
<th>Argentina</th>
<th>Barbados</th>
<th>Belize</th>
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<th>Chile</th>
<th>Colombia</th>
<th>Costa Rica</th>
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