# Measuring and Explaining Country Efficiency in Improving Health and Education Indicators

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CHAPTER 2

# MEASURING AND EXPLAINING COUNTRY EFFICIENCY IN IMPROVING HEALTH AND EDUCATION INDICATORS

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## Introduction

Governments aiming to improve the education and health status of their populations can increase the level of public spending allocated to these sectors, or improve the efficiency of public spending.[1] Since increasing spending is often difficult due to the limited tax base of most developing countries, improving the efficiency of public spending becomes crucial. In order to improve this efficiency, governments have at least two options. The first consists of changing the allocation mix of public expenditures. For example, Murray et al. (1994) argue that by reallocating resources to cost-effective interventions, Sub-Saharan African countries could improve health outcomes dramatically. The second option is more ambitious; it consists of implementing wide-ranging institutional reforms in order to improve variables such as the overall level of bureaucratic quality and corruption in a country, with the hope that this will improve the efficiency of public spending for the social sectors, among other things.

While many papers have been published on the measurement of efficiency in agricultural and industrial economics, applications to social sector indicators remain few. They include Kirjavainen and Loikkanen (1998) for education, and Grosskopf and Valdmanis (1987) and Evans et al. (2000) for health. In this paper, we use stochastic production frontier estimation methods to compare the impact of the level of public spending on education and health outcomes on the one hand, and the efficiency in spending on the other hand, using life expectancy and net enrolment in primary school as outcome indicators. The paper by Evans et al. (2000), used in a recent report of the World Health Organization, is closest to ours, since it analyzes the efficiency in improving disability adjusted life expectancy in 191 countries.

Apart from the fact that we use a different estimation technique and that we apply the technique to two social indicators instead of one, our analysis goes beyond the work by Evans et al. (2000) because we also consider the determinants of efficiency. That is, after estimating efficiency measures

1. There are other options, such as improving economic growth, but these fall beyond the scope of this paper.

at the country level, we analyze in a second step how the quality of the bureaucracy, corruption, and urbanization affect efficiency. We find that urbanization, and to some extent the quality of the bureaucracy are strong determinants of the efficiency of countries in improving education and health outcomes, while the impact of corruption is not statistically significant. Together, these three variables alone explain up to half of the variation in efficiency measures between countries.

While the impact of bureaucratic quality is not surprising, we conjecture that the importance of urbanization may stem from the fact that it is typically cheaper to provide access to education and health services in urban than in rural areas (due to dispersion in rural areas). There could, however, also be other reasons why efficiency would be better in urban areas.[2] It may be easier to monitor performance (easier access by supervisors, possibly more communications among parents/patients and staff, given not only proximity but also ease of contact). It may also be easier to attract quality inputs, especially teachers and health personnel in urban areas. Also, in the case of education outcomes, it may be that urban living provides more environmental reinforcement of good educational performance and student completion, such as more access to reading material and to jobs requiring schooling, more social encouragement for girls to pursue options requiring schooling, and etc.

In terms of the estimation method, as noted by Christiaensen et al. (2002), both deterministic and stochastic techniques have been used to estimate production frontiers. Two common deterministic methods are the Free Disposal Hull, which provides a piece-wise linear envelope connecting best performers, and the Data Envelopment Analysis, whereby linear programming is used to construct the frontier.[3] The main advantage of deterministic methods is that they impose no or few restrictions on the production technology. Their disadvantage is that they do not take into account random factors which may affect outputs. In order to account for the fact that some deviations from the observed maximum output may be due to random shocks, one can use stochastic approaches. There are two main estimation strategies here. Following Aigner et al. (1977), the first strategy is to assume that the error term has two components, one for random errors and one non-negative component for technical inefficiency (error components model). The second strategy is the fixed effect approach used by Evans et al. (2000), whereby the country with the highest intercept is considered as best performer, and efficiency is computed by comparing the intercepts of the other countries with that of the best performer (possibly adjusting for a minimal level of efficiency).

In this chapter, we rely on an extension of the error component approach of Aigner et al. (1977) proposed by Battese and Coelli (1992, 1995). The rest of the chapter is organized as follows. The maximum likelihood estimation procedure for the production frontier is explained in the next section. That section also describes the seemingly unrelated regressions (SUR) approach used in the second step of the empirical work devoted to the analysis of efficiency determinants. The third section contains a description of the data used and the empirical results. A conclusion follows.

## Methodology

A stochastic frontier method is used to estimate production frontiers for health and education outcomes. The estimation is in the spirit of Battese and Coelli (1992, 1995). Specifically, the estimation uses the maximum likelihood program provided by Coelli (1996).

Let $Y_{it}$ represent the health (education) social indicator for country $i$ at time $t$. The factors or inputs influencing the health (education) outcome are depicted by $X_{it}$. We consider three main inputs, namely per capita GDP level, per capita expenditures on health (education) and the adult literacy rate.[4] We also add a time trend to capture progress over time, and we enable the produc-

2. These reasons were suggested to us by Christine Fallert Kessides.

3. On the Free Disposal Hull, see for example Deprins, Simar and Tulkens (1984) and Fakin and de Crombrugghe (1997). On Data Envelopment Analysis, see Charnes, Cooper and Rhodes (1978), Coelli (1995), Tulkens and Vanden Eeckhaut (1995), and Gupta et al. (1997).

4. Evans et al. (2000) also used expenditures on health, together with years of schooling. There is a risk of endogeneity in the use of expenditures as determinants of outcomes, for example if expenditures are increased

tion frontier to vary by region (hence the efficiency benchmarks to assess country efficiency are regional, rather than worldwide). This is done by including regional dummy variables for Asia ($D_{ASIA}$), Europe and Central Asia ($D_{ECA}$), Latin America and the Caribbean ($D_{LAC}$), and the industrial countries ($D_{Industrial}$). Africa is the omitted region. For each of the health and education indicators, three separate models are estimated. Model I includes all three input variables along with the time and regional dummies as independent variables. Model II includes per capita expenditure on health (education), adult literacy rate and the time and regional variables, while Model III includes per capita GDP, adult literacy rate and the time and regional dummy variables. We estimate the various models to test for the sensitivity of the estimation results to the choice of the specification, and to ensure that the measures of efficiency used for the second stage regressions are not affected much by changes in specification. The functional form of the production frontiers for either social indicator can be presented as below:

$$Y_{it} = \alpha + X_{it}\beta + \gamma_1 D_{ASIA} + \gamma_2 D_{ECA} + \gamma_3 D_{LAC} + \gamma_4 D_{Industrial} + (v_{it} - u_i) \qquad (1)$$
$$i = 1, \dots, N, \qquad t = 1, \dots, T$$

The error term in (1), $(v_{it} - u_i)$, consists of two components. The random noise term, $v_{it} \sim N(0, \sigma_v^2)$, accounts for random shocks and measurement errors. This term is independent of the non-negative term, $u_i \sim |N(\mu, \sigma_u^2)|$, which measures the deviation from the optimal (best practice) outcome, and is used to derive the measures of efficiency.[5] Denoting by $N$ the number of countries, $T_i$ the number of available observations for country $i$, and $\Phi(.)$ the cumulative standard normal distribution function, the log likelihood function incorporating all the information derived from the distributional assumptions on the inefficiency term ($u_i$) and the random noise ($v_{it}$) is:

$$\begin{aligned}
\ln(L) = & -\frac{1}{2}\sum_{i=1}^{N} T_i\left[\ln(2\pi) + \ln(\sigma_u^2 + \sigma_v^2)\right] - \frac{1}{2}\sum_{i=1}^{N}(T_i - 1)\ln\left(\frac{\sigma_v^2}{\sigma_u^2 + \sigma_v^2}\right) \\
& - \frac{1}{2}\sum_{i=1}^{N}\ln\left(\frac{\sigma_v^2 + T_i\sigma_u^2}{\sigma_u^2 + \sigma_v^2}\right) - N\ln\left(1 - \Phi\left(\frac{-\mu}{\sigma_u}\right)\right) - \frac{N}{2}\left(\frac{\mu}{\sigma_u}\right)^2 \\
& + \sum_{i=1}^{N}\ln\left(1 - \Phi\left(\frac{-\mu\sigma_v^2 + \sigma_u^2\sum_{t=1}^{T_i}\left(y_{it} - \alpha - x_{it}\beta - \sum\gamma_k D_{ik}\right)}{\sigma_u\sigma_v\sqrt{\sigma_v^2 + T_i\sigma_u^2}}\right)\right) \\
& + \frac{1}{2}\sum_{i=1}^{N}\left(\frac{\mu\sigma_v^2 - \sigma_u^2\sum_{t=1}^{T_i}\left(y_{it} - \alpha - x_{it}\beta - \sum\gamma_k D_{ik}\right)}{\sigma_u\sigma_v\sqrt{\sigma_v^2 + T_i\sigma_u^2}}\right)^2 \\
& - \frac{1}{2\sigma_v^2}\sum_{i=1}^{N}\sum_{t=1}^{T_i}\left(y_{it} - \alpha - x_{it}\beta - \sum\gamma_k D_{ik}\right)^2
\end{aligned} \qquad (2)$$

when outcome targets are not reached. It is likely, however, that this risk is lower with aggregate country data than in a micro household setting because due to fiscal constraints, governments tend to have limited opportunities to increase expenditures quickly when outcomes are deficient. Furthermore, we have tested for the robustness of the efficiency measures obtained to the choice of variables included in the estimation of the production frontier, and overall, the efficiency measures are highly robust to changes in specification.

5. Kumbhakar and Lovell (2000) show that efficiency rankings appear to be robust to the choice of the distribution.

Consistent estimates are obtained by maximizing (2) with respect to the parameters $\alpha$, $\beta$, $\gamma_i$, and the mean and variances of the $u_i$ and $v_{it}$ terms ($\mu$, $\sigma_u^2$ and $\sigma_v^2$).

The measures of technical efficiency for each country are calculated as follows:

$$Efficiency_i = \frac{E(Y_{it}|X_{it}, D_i, u_i)}{E(Y_{it}|X_{it}, D_i, u_i = 0)} \qquad i = 1, \ldots, N \tag{3}$$

The observed outcome (expected value) given at a level of input use $X_{it}$ in region $D_i$ is depicted by the numerator $E(Y_{it} | X_{it}, D_i, u_i)$. The denominator, $E(Y_{it} | X_{it}, D_i, u_i = 0)$, represents the optimal (or best practice) outcome that can be attained with input use $X_{it}$ in region $D_i$, which implies no inefficiency ($u_i = 0$).

The efficiency measures obtained from (3) are then used as dependent variables in a second step to analyze the determinants of efficiency. Linear models as presented in equation (4) are estimated in this analysis. Initially, each equation is estimated individually using the robust ordinary least squares (robust OLS) procedure with the Huber/White estimator of the variance covariance matrix used to ensure consistent standard errors. Next, the seemingly unrelated regression (SUR) method is used to estimate (4). The use of SUR enables us to test for differences in the impact of the exogenous variables on the efficiency in reaching better education and health outcomes. The second step regressions are as follows:

$$\begin{cases} Efficiency\ for\ Net\ Primary\ Educ_i = \delta_E + Z_i\theta_E + \zeta_{Ei} \\ Efficiency\ for\ Life\ Expectancy_i = \delta_L + Z_i\theta_L + \zeta_{Li} \end{cases} \qquad i = 1, \ldots, N \tag{4}$$

In (4), three independent variables and their squared values (to account for the possibility of nonlinearity in the variables' impact on efficiency) are included in the vector $Z_i$. They are a country's level of bureaucratic quality, the degree of absence in corruption, and the level of urbanization. The variables are detailed in the next section.

## Data and Results

A panel data set consisting of 76 countries over the period 1990 to 1998 is used. Two groups of variables are included: those used in estimating the production frontiers for health and education outcomes, and those used in the analysis for the determinants of efficiency.

The first group of variables consists of the two outcome measures (life expectancy and net primary enrolment rate) and the three input variables (per capita GDP level, per capita expenditure on education or health, and the adult literacy rate). The World Development Indicators (WDI) database at the World Bank is the primary data source. Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout her life. Net primary enrolment rate is the ratio of the number of children of official school age (as defined by the national education system) who are enrolled in primary education to the population of the corresponding official school age. As defined by the International Standard Classification of Education of 1976 (ISCED76), primary education provides children with basic reading, writing, and mathematics skills along with an elementary understanding of such subjects as history, geography, natural science, social science, art, and music. Per capita GDP (constant 1995 US$) was obtained from the WDI database. As in Evans et al. (2000), per capita health expenditures (constant 1995 US$) include both public and private expenditures. Per capita expenditures on education (constant 1995 US$) are calculated in a similar manner. Adult illiteracy measures the percentage of the population aged 15 years and above who cannot, with understanding, read and write a short, simple statement on their everyday life.

The second group of variables consists of institutional variables and data on urbanization. The institutional variables, corruption and bureaucratic quality indices, were obtained from the International Country Risk Guide (ICRG) published by Political Risk Services

**TABLE 2-1: SUMMARY STATISTICS**

| | N | Mean | Min | Max | Std Dev |
|---|---|---|---|---|---|
| **Variables used in the first stage regressions** | | | | | |
| Life expectancy (years) | 314 | 64.53 | 42.48 | 78.67 | 10.30 |
| Net primary enrolment rate | 301 | 83.57 | 20.40 | 104.50 | 18.19 |
| GDP, per capita (constant 1995 US$) | 507 | 3772.89 | 84.72 | 25684.75 | 5055.70 |
| Health expenditure, per capita (constant 1995 US$) | 314 | 211.49 | 3.27 | 1980.86 | 326.55 |
| Education expenditure, per capita (constant 1995 US$) | 301 | 149.42 | 2.16 | 1042.32 | 194.71 |
| Adult literacy rate | 507 | 75.27 | 11.40 | 99.80 | 21.94 |
| **Variables used in the second stage regressions** | | | | | |
| Efficiency measure: Life expectancy (Model I)† | 76 | 81.91 | 62.94 | 99.20 | 7.95 |
| Efficiency measure: Life expectancy (Model II)† | 76 | 81.65 | 62.28 | 99.15 | 8.28 |
| Efficiency measure: Life expectancy (Model III)† | 76 | 82.07 | 62.93 | 99.19 | 7.99 |
| Efficiency measure: Net primary enrolment (Model I)† | 66 | 73.60 | 33.11 | 97.88 | 12.10 |
| Efficiency measure: Net primary enrolment (Model II)† | 66 | 75.09 | 33.57 | 98.56 | 12.29 |
| Efficiency measure: Net primary enrolment (Model III)† | 66 | 74.81 | 33.46 | 98.27 | 12.35 |
| Bureaucratic quality | 86 | 50.55 | 16.67 | 87.04 | 16.11 |
| Corruption | 86 | 53.47 | 0.00 | 83.33 | 14.83 |
| Urbanization | 86 | 53.54 | 12.29 | 100.00 | 22.25 |

*Source:* ICRG and WDI; †Based on authors' estimation.

(PRS).[6] The ICRG indices are subjective assessments based on an analysis by a worldwide network of experts. To ensure coherence and cross country comparability, these indices are subject to a peer review process. The corruption index measures actual or potential corruption within the political system, which distorts the economic and financial environment, reduces government and business efficiency by enabling individuals to assume positions of power through patronage rather than ability, and introduces inherent instability in the political system. The bureaucratic quality index measures the strength and expertise of the bureaucrats and their ability to manage political alterations without drastic interruptions in government services or policy changes. For the corruption index, higher values indicate a decreased prevalence of corruption. For the bureaucratic quality index, higher values indicate the existence of greater bureaucratic quality. The urbanization data, from the World Bank's WDI database, refers to the urban population as a share of the total population. Summary statistics for all variables are presented in Table 2-1.

The production frontier estimation results for life expectancy and net primary enrolment are presented in Table 2-2. GDP per capita is found to have a positive and statistically significant impact on life expectancy, but not on net primary enrolment. Education expenditures per capita do not have a statistically significant impact on net primary enrolment, and the impact of health vanishes when GDP per capita is used as a control variable in the regression. This suggests that spending more is not necessarily the solution for better outcomes: spending better (i.e., improving efficiency) may be as important, if not more important. The adult literacy rate has a strong impact on both outcomes, whichever specification is used. A 10 percent increase in the adult literacy rate results in approximately 1.2 additional years for life expectancy, and a gain of roughly 6.1 to 6.6 percentage points for net primary enrolment. The year effects are small and lack statistical significance for both outcomes. The regional dummy variables are statistically significant for the health outcome, but for the education outcome the difference between some regions and Latin America is not statistically significant. More precisely, for life expectancy, all regions have higher production possibilities frontiers than Africa. For net primary

6. For details, see the Political Risk Services website at http://www.prsgroup.com/icrg/icrg.html

Table 2-2: Production Frontier Coefficients for Health and Education Outcomes

| | Life expectancy | | | Net primary enrolment | | |
|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model III** | **Model I** | **Model II** | **Model III** |
| Constant | 61.29 | 61.57 | 61.10 | 58.37 | 59.50 | 59.92 |
| | (58.86) | (49.28) | (55.48) | (11.30) | (12.22) | (11.45) |
| GDP, | 0.0006 | – | 0.0006 | 0.0003 | – | –0.0001 |
| per capita (constant 1995 US$) | (4.12) | | (4.96) | (0.56) | | (–0.30) |
| Expenditure, | –0.0007 | 0.0030 | – | –0.0179 | –0.0086 | – |
| per capita (constant 1995 US$) | (–0.51) | (2.39) | | (–1.79) | (–1.17) | |
| Adult literacy | 0.1203 | 0.1291 | 0.1235 | 0.6687 | 0.6125 | 0.6054 |
| | (6.80) | (7.15) | (6.97) | (7.16) | (7.74) | (6.87) |
| Year | –0.0114 | –0.0023 | –0.0086 | –0.0094 | 0.0251 | –0.0109 |
| | (–0.24) | (–0.07) | (–0.18) | (–0.06) | (0.18) | (–0.08) |
| Dummy Variables (Africa omitted) | | | | | | |
| Asia | 6.56 | 8.84 | 6.52 | 15.70 | 14.27 | 15.92 |
| | (4.52) | (4.62) | (4.22) | (4.25) | (3.75) | (4.29) |
| Europe & | 6.67 | 6.40 | 6.60 | –6.73 | –4.14 | –3.76 |
| Central Asia | (6.18) | (6.21) | (6.27) | (–0.98) | (–0.62) | (–0.54) |
| Latin America | 8.48 | 8.44 | 7.79 | 0.65 | 3.81 | 3.43 |
| & Caribbean | (6.92) | (6.88) | (7.60) | (0.12) | (0.78) | (0.63) |
| Industrial | 8.79 | 10.51 | 8.82 | 14.79 | 10.27 | 6.63 |
| Countries | (8.31) | (10.88) | (8.43) | (2.10) | (1.50) | (0.98) |
| Number of Observations | 314 | 314 | 314 | 301 | 301 | 301 |

*Source:* Authors' estimation; (t-statistics).

enrolment, Asia and, for some specifications industrial countries, have higher frontiers than Africa, but the Europe and Central Asia, and the Latin America and Caribbean regions do not.

The estimated mean efficiency level for all countries in the sample is higher for life expectancy (81.9 percent) than for net primary enrolment (74.5 percent). This is essentially because some countries have very low levels of efficiency for schooling, and thereby the mean efficiency estimates are lower (the variance is also larger). Remember that in a country with an efficiency score of, say, 0.5, the level of life expectancy or net primary enrolment is only half of what it could be. There is thus ample scope for improvements in efficiency in order to reach education and health targets in the countries with low efficiency.

For life expectancy, we can compare our results to those of Evans et al. (2000). The best point of comparison is our findings for Model II, since Evans et al. do not include GDP per capita in their estimation. Like us, without controlling for per capita GDP, they find positive and statistically significant impacts of per capita expenditures on health and levels of education (measured by the average years of schooling in their paper) on life expectancy. The magnitude of the impacts is broadly similar to our results, although they find somewhat larger positive impacts of per capita

**TABLE 2-3: CORRELATION BETWEEN HEALTH AND EDUCATION EFFICIENCY MEASURES**

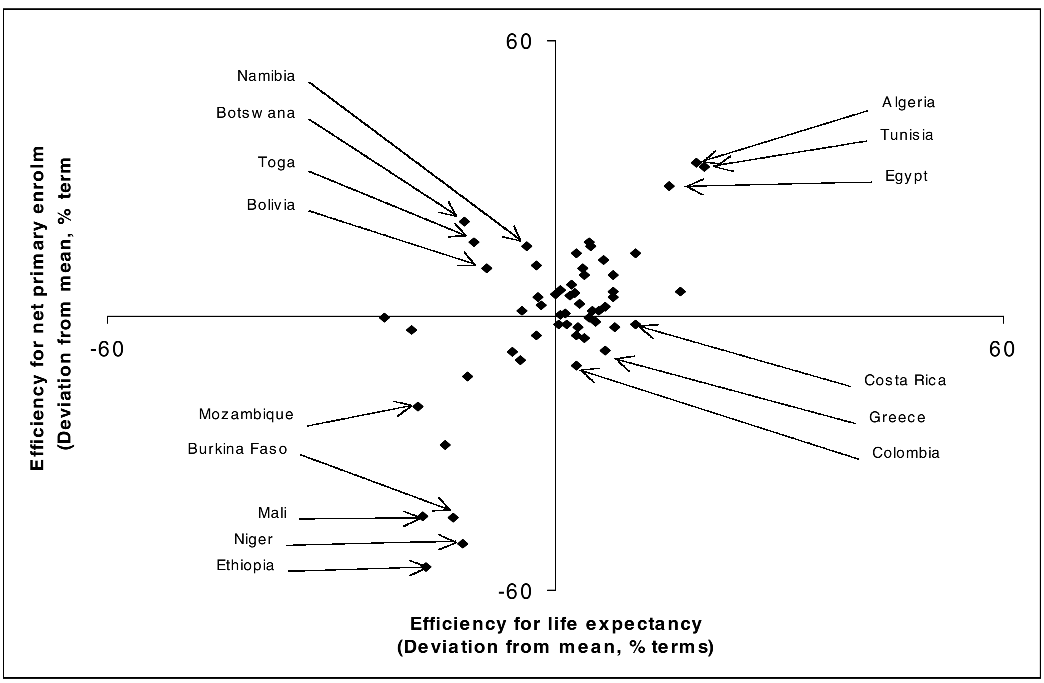
| | | Life expectancy | | | Net primary enrolment | | |
|---|---|---|---|---|---|---|---|
| | | Model I | Model II | Model III | Model I | Model II | Model III |
| Life expectancy | Model I | 1 | | | | | |
| | Model II | 0.9796 | 1 | | | | |
| | Model III | 0.9993 | 0.9789 | 1 | | | |
| Net primary enrolment | Model I | 0.6196 | 0.6046 | 0.6166 | 1 | | |
| | Model II | 0.6239 | 0.6137 | 0.6185 | 0.9945 | 1 | |
| | Model III | 0.6274 | 0.6139 | 0.6229 | 0.9926 | 0.9978 | 1 |

*Source:* Authors' estimation.

health spending (but again, this may vanish when per capita GDP is used as an input in the production frontier estimation). What is more relevant for the second stage estimation discussed below is that the correlation between our efficiency measures at the country level and theirs is high, at 0.82. The correlations between the efficiency measures obtained with our three specifications in Table 2-2 are also high for both health and education (Table 2-3). This suggests that the results which form the basis of the second stage estimation are robust.

The countries with the lowest efficiency levels for life expectancy include Malawi, Zambia, Mozambique, Mali, Ethiopia, Tanzania, Burkina Faso and Niger. The countries with the lowest efficiency levels for schooling include Ethiopia, Niger, Burkina Faso, Mali, Tanzania, Mozambique and Ivory Coast. Figure 2-1 presents a scatter plot of the two efficiency measures (or more precisely,

**FIGURE 2-1: CORRELATION BETWEEN EFFICIENCY MEASURES (USING MODEL II ESTIMATES)**




*Source:* Authors.

TABLE 2-4: DETERMINANTS OF EFFICIENCY FOR HEALTH AND EDUCATION OUTCOMES (ROBUST OLS)

| | Life expectancy | | | Net primary enrolment | | |
|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model III** | **Model I** | **Model II** | **Model III** |
| Constant | 0.4742 | 0.5193 | 0.4808 | 0.1987 | 0.2144 | 0.1989 |
| | (7.06) | (8.11) | (7.13) | (0.90) | (0.95) | (0.89) |
| Bureaucratic | 0.7060 | 0.5647 | 0.7002 | 0.5709 | 0.5268 | 0.5379 |
| quality | (3.19) | (2.55) | (3.13) | (0.98) | (0.89) | (0.91) |
| Bureaucratic | −0.5973 | −0.4564 | −0.5987 | −0.4243 | −0.3541 | −0.3744 |
| quality^2 | (−3.01) | (−2.26) | (−2.98) | (−0.81) | (−0.67) | (−0.71) |
| Corruption | −0.0148 | −0.1025 | −0.0276 | −0.0359 | −0.0503 | −0.0635 |
| (decrease in) | (−0.10) | (−0.79) | (−0.19) | (−0.06) | (−0.08) | (−0.10) |
| Corruption | 0.0349 | 0.1278 | 0.0414 | −0.0142 | 0.0102 | 0.0226 |
| (decrease in)^2 | (0.25) | (0.95) | (0.28) | (−0.03) | (0.02) | (0.04) |
| Urbanization | 0.5289 | 0.4788 | 0.5351 | 1.394 | 1.399 | 1.474 |
| | (3.23) | (3.00) | (3.25) | (3.87) | (3.77) | (4.01) |
| Urbanization^2 | −0.3749 | −0.2830 | −0.3743 | −1.083 | −1.085 | −1.158 |
| | (−2.79) | (−2.10) | (−2.77) | (−3.92) | (−3.81) | (−4.09) |
| Number of Observations | 76 | 76 | 76 | 66 | 66 | 66 |
| $R^2$ | 0.36 | 0.43 | 0.36 | 0.39 | 0.40 | 0.41 |
| F statistic | 11.39 | 17.10 | 11.10 | 3.65 | 3.76 | 4.05 |

*Source:* Authors' estimation; (t-statistics).

of the country deviations from the mean level of efficiency in percentage terms) for the sample of countries for which both measures have been estimated (we used model II for the scatter plot, but the figure would be very similar for models I or III). Not surprisingly, there is a high degree of correlation between the two efficiency measures. But there are also some countries which have a better efficiency than the average for one indicator, and at the same time a lower efficiency than the average for the other indicator. For example, Botswana, Bolivia, Namibia and Togo do comparatively better than the average for net primary enrolment, but worse than the average for life expectancy. In contrast, Colombia, Costa Rica and Greece do comparatively better than the average for life expectancy, but worse for net primary enrolment.

Tables 2-4 (robust OLS estimation) and 2-5 (SUR estimation) present the results for the determinants of efficiency in improving education and health outcomes. We have three estimations, since we use the efficiency measures from the three models in Table 2-2. The results obtained with the three specifications are very similar, which is not surprising given the high correlation between the dependent variables. Urbanization has a strong positive and highly significant impact on efficiency for both net primary enrolment and life expectancy. On the other hand, bureaucratic quality has a positive impact only for life expectancy (the impact on net primary enrolment is not statistically significant). Furthermore, corruption does not appear to have a statistically significant impact on any of the two indicators. At the mean of the sample, controlling for corruption and urbanization, a 10 percentage point improvement in bureaucratic quality leads to an increase of about 0.4 percentage points in efficiency for life expectancy, while controlling for bureaucratic quality and corruption (at the sample mean), a 10 percentage point increase in urbanization leads to an increase of about 0.9 percentage points in life expectancy efficiency, and an increase of about 1.2 percentage points in net primary education efficiency. The values change slightly depending on the model chosen for the estimation.

**TABLE 2-5: DETERMINANTS OF EFFICIENCY FOR HEALTH AND EDUCATION OUTCOMES (SUR ESTIMATION)**

| | Life expectancy | | | Net primary enrolment | | |
|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model III** | **Model I** | **Model II** | **Model III** |
| Constant | 0.6203 | 0.6562 | 0.6272 | 0.3327 | 0.3490 | 0.3342 |
| | (5.08) | (5.29) | (5.12) | (1.69) | (1.77) | (1.72) |
| Bureaucratic | 0.7034 | 0.5270 | 0.7037 | 0.7013 | 0.6880 | 0.7330 |
| quality | (2.12) | (1.56) | (2.11) | (1.31) | (1.28) | (1.39) |
| Bureaucratic | –0.6052 | –0.4152 | –0.6132 | –0.4983 | –0.4493 | –0.5059 |
| quality^2 | (–1.97) | (–1.33) | (–1.99) | (–1.01) | (–0.90) | (–1.03) |
| Corruption | –0.7158 | –0.7138 | –0.7356 | –0.6587 | –0.6940 | –0.7230 |
| (decrease in) | (–1.77) | (–1.74) | (–1.81) | (–1.01) | (–1.06) | (–1.12) |
| Corruption | 0.6096 | 0.6216 | 0.6229 | 0.4427 | 0.4816 | 0.5063 |
| (decrease in)^2 | (1.74) | (1.75) | (1.77) | (0.79) | (0.85) | (0.91) |
| Urbanization | 0.7134 | 0.6395 | 0.7193 | 1.458 | 1.452 | 1.508 |
| | (4.18) | (3.69) | (4.20) | (5.30) | (5.26) | (5.55) |
| Urbanization^2 | –0.4959 | –0.3943 | –0.4947 | –1.132 | –1.128 | –1.175 |
| | (–3.33) | (–2.60) | (–3.30) | (–4.71) | (–4.68) | (–4.95) |
| Number of Observations | 56 | 56 | 56 | 56 | 56 | 56 |
| $R^2$ | 0.48 | 0.51 | 0.49 | 0.48 | 0.49 | 0.51 |
| $\chi^2$ statistic | 52.72 | 59.38 | 53.02 | 51.16 | 53.57 | 57.57 |

*Source:* Authors' estimation; (t-statistics).

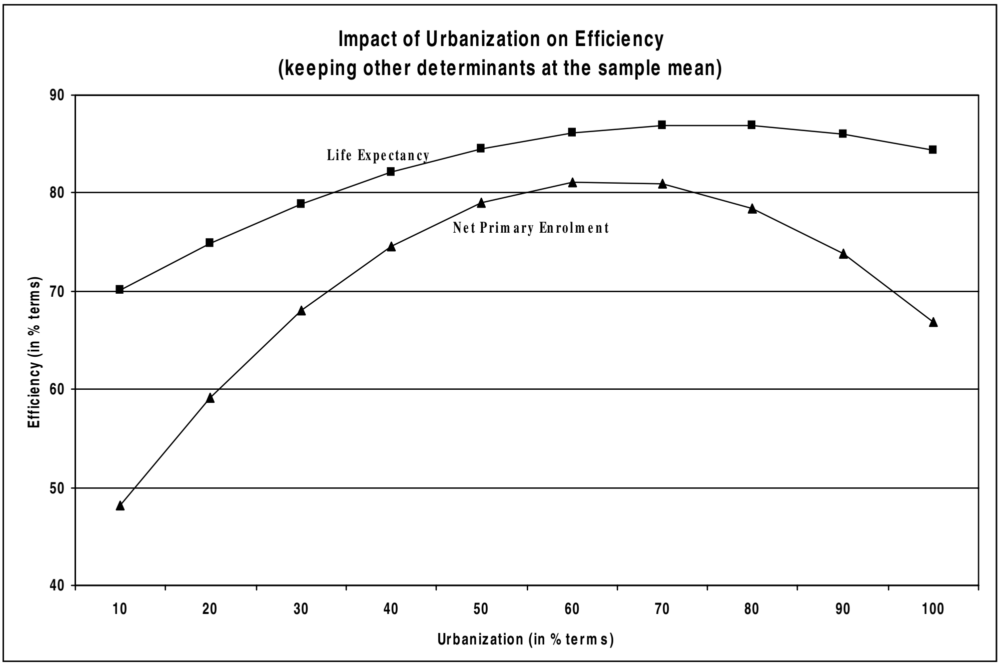
One reason for the importance of urbanization may be related to lower per capita costs of providing health and education services. But there could also be other reasons why efficiency would be better in urban areas.[7] Monitoring performance may be easier in urban areas (better access by supervisors, possibly more communications among parents/patients and staff, given not only proximity but also ease of contact). Attracting quality inputs, especially teachers and health personnel, may also be easier in an urban setting. Another possibility, at least for education, could be that urban living provides better reinforcement for good educational performance and student completion, thanks to better access to reading material and jobs requiring higher levels of schooling, more social encouragement for girls to pursue options requiring schooling, etc.

The impact of urbanization and a better bureaucracy are decreasing at the margin (the coefficients for the quadratic terms are negative). Yet, even when the quality of the bureaucracy reaches a high value (the maximum value is 100 percent), the gains for life expectancy still tend to be positive, albeit smaller. The same is true for the impact of urbanization on life expectancy. However, for very high rates of urbanization, further increases in urbanization may lead to a decrease in efficiency for net primary enrolment (see Figure 2-2; unless urbanization reaches extremely high levels however, the decrease is not statistically significant).

Table 2-6 presents test results used to determine if the impacts of corruption, bureaucratic quality, and urbanization are the same for the efficiency in reaching net primary education and life expectancy outcomes. A test that the joint impact of the three variables and their quadratic terms is the same for both efficiency measures cannot be rejected at a 5 percent level of significance for all three models (P-values 0.142, 0.068 and 0.077 for Models I, II and III respectively). A $\chi^2$ test cannot reject the hypothesis that bureaucratic quality affects the two efficiency measures in a similar man-

7. These reasons were suggested to us by Christine Fallert Kessides.

FIGURE 2-2: IMPACT OF URBANIZATION ON EFFICIENCY MEASURES (USING MODEL II ESTIMATES)




*Source:* Authors.

ner (P-values 0.612, 0.552 and 0.450 for Models I, II and III respectively), and a similar conclusion holds for corruption (P-values 0.493, 0.470 and 0.569 for Models I, II and III respectively). However, the impact of urbanization on the two efficiency measures is found to be different at a 5 percent level of significance (P-values 0.026, 0.010 and 0.016 for Models I, II and III respectively). As mentioned earlier, this may be due to the fact that for high rates of urbanization, an increase in urbanization seems to lead to a loss in efficiency for net primary enrolment (this is not observed for life expectancy).

## Conclusion

Using a worldwide panel data set for the period 1990–98, we have measured the efficiency of countries in improving health and education outcomes for their population. The method relies on the estimation of production functions for net primary enrolment and life expectancy using stochastic frontier methods. The inputs used in the estimation are per capita GDP, per capita expenditures on the respective social sectors, and the adult literacy rate. The production frontiers are allowed to vary by region. The results suggest large differences among countries (and among regions) in efficiency, and a substantial correlation in the efficiency measures obtained for the two indicators. Still, there are some countries which have a better efficiency than average for one indicator, and a lower efficiency than average for the other.

An analysis of the determinants of the efficiency measures suggests that bureaucratic quality and urbanization both have strong positive impacts on efficiency, albeit decreasing at the margin. In contrast, corruption does not appear to have the same impact. The policy conclusion of the paper is that while better indicators can be achieved through an expansion in the use of inputs (while keeping efficiency levels constant), an improvement in efficiency levels (while keeping input

**TABLE 2-6: $\chi^2$ TESTS TO STUDY THE IMPACT OF DETERMINANT VARIABLES ON EFFICIENCY**

| | | | |
|---|---|---|---|
| **Test:** | Do the determinant variables jointly have a similar impact on education efficiency vis a vis health efficiency<br>$H_0: \theta_E = \theta_L$<br>$H_a$: not all equal | | |
| | **Model I** | **Model II** | **Model III** |
| | $\chi^2_6$ statistic = 9.61 | $\chi^2_6$ statistic = 11.74 | $\chi^2_6$ statistic = 11.41 |
| | P-value = 0.1419 | P-value = 0.0679 | P-value = 0.0766 |
| **Test:** | Does bureaucratic quality have a similar impact on education efficiency vis a vis health efficiency<br>$H_0: \theta_{E,\ Bureaucratic\ Quality} = \theta_{L,\ Bureaucratic\ Quality}$<br>$H_a$: not all equal | | |
| | **Model I** | **Model II** | **Model III** |
| | $\chi^2_2$ statistic = 0.98 | $\chi^2_2$ statistic = 1.19 | $\chi^2_2$ statistic = 1.60 |
| | P-value = 0.6115 | P-value = 0.5515 | P-value = 0.4497 |
| **Test:** | Does corruption have a similar impact on education efficiency vis a vis health efficiency<br>$H_0: \theta_{E,\ Corruption} = \theta_{L,\ Corruption}$<br>$H_a$: not all equal | | |
| | **Model I** | **Model II** | **Model III** |
| | $\chi^2_2$ statistic = 1.42 | $\chi^2_2$ statistic = 1.51 | $\chi^2_2$ statistic = 1.13 |
| | P-value = 0.4928 | P-value = 0.4699 | P-value = 0.5689 |
| **Test:** | Does urbanization have a similar impact on education efficiency vis a vis health efficiency<br>$H_0: \theta_{E,\ Urbanization} = \theta_{L,\ Urbanization}$<br>$H_a$: not all equal | | |
| | **Model I** | **Model II** | **Model III** |
| | $\chi^2_2$ statistic = 7.30 | $\chi^2_2$ statistic = 9.16 | $\chi^2_2$ statistic = 8.23 |
| | P-value = 0.0260 | P-value = 0.0103 | P-value = 0.0164 |

*Source:* Authors' estimation.

use constant) is clearly an alternative strategy. Some of the improvement in efficiency may come quasi automatically with urbanization (perhaps because it is cheaper to provide access to school and health centers in urban areas). But efforts to improve the bureaucratic quality of countries would also lead to gains in efficiency. In contrast, a decrease in corruption might not lead to a dramatic increase in the efficiency measures for the two indicators.

## References

Aigner, D. J., C. A. K. Lovell, and P. Schmidt. 1977. "Formulation and Estimation of Stochastic Frontier Production Function Models." *Journal of Econometrics* 6: 21–37.

Battese, G. E., and T. J. Coelli. 1995. "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data." *Empirical Economics.* 20: 325–32.

———. 1992. "Frontier Production Functions, Technical Efficiency and Panel Data: With Applications to Paddy Farmers in India." *Journal of Productivity Analysis* 3: 153–69.

Battese, G. E. 1992. "Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics." *Agricultural Economics* 7: 185–208.

Charnes, A., W. W. Cooper, and E. Rhodes. 1978. "Measuring the Efficiency of Decision Making Units." *European Journal of Operational Research* 2(6): 429–44.

Chirikos, T. N., and A. M. Sear. 2000. "Measuring Hospital Efficiency: A Comparison of Two Approaches." *Health Services Research* 34(6): 1389–408.

Christiaensen, L., C. Scott, and Q. Wodon. 2002. "Development Targets and Costs." In J. Klugman, ed., *A Sourcebook for Poverty Reduction Strategies, Volume 1: Core Techniques and Cross-Cuting Issues.* Washington, DC: World Bank.

Coelli, T. J. 1995. "Recent Developments in Frontier Modeling and Efficiency Measurement." *Journal of Agricultural Economics* 39(3): 219–45.

———. 1996. "A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation." CEPA Working Paper 96/07. New South Wales, Australia.

Deprins, D., L. Simar, and H. Tulkens. 1984. "Measuring Labor-Efficiency in Post Offices." In Marchand, M., P. Pestieau, and H. Tulkens, eds., *The Performance of Public Enterprises: Concepts and Measurement*. Amsterdam: North-Holland.

Evans, D. B., A. Tandon, C. J. L. Murray, and J. A. Lauer. 2000. "The Comparative Efficiency of National Health Systems in Producing Health: An Analysis of 191 Countries." GPE Discussion Paper Series 29. World Health Organization, Geneva.

Fakin, B., and A. de Crombrugghe. 1997. "Fiscal Adjustments in Transition Economies—Transfers and the Efficiency of Public Spending: A Comparison with OECD Countries." World Bank Policy Research Paper 1803. World Bank, Washington, DC.

Fried, H. O., C. A. K. Lovell, and S. Schmidt. 1993. *The Measurement of Productive Efficiency: Techniques and Applications*. London: Oxford University Press.

Grossman, P. J., P. Mavros, and R. W. Wassmer. 1999. "Public Sector Technical Inefficiency in Large U.S. Cities." *Journal of Urban Economics* 46(2): 278–99.

Grosskopf, S., and V. Valdmanis. 1987. "Measuring Hospital Performance: A Non-Parametric Approach." *Journal of Health Economics* 6(2): 89–107.

Gupta, S., K. Honjo, and M. Verhoeven. 1997. "The Efficiency of Government Expenditure: Experiences from Africa." IMF Working Paper 97/15. International Monetary Fund, Washington, DC.

Kaufmann, D., A. Kraay, and P. Zoido-Lobaton. 2000. "Governance Matters, from Measurement to Action." *Finance and Development, A Quarterly Publication of the International Monetary Fund (International)* 37(2): 10–13.

Keefer, P., and S. Knack. 1997. "Why Don't Poor Countries Catch Up? A Cross-National Test of An Institutional Explanation." *Economic Inquiry* 35: 590–602.

Kirjavainen, T., and H. A. Loikkanen. 1998. "Efficiency Differences of Finnish Senior Secondary Schools: An Application of DEA and Tobit Analysis." *Economics of Education Review* 17(4): 377–94.

Kumbhakar, S. C., and C. A. K. Lovell. 2000. *Stochastic Frontier Analysis*. Cambridge: Cambridge University Press.

Mirmirani, S., and H-C. Li. 1995. "Health Care Efficiency Measurement: An Application of Data Envelopment Analysis." *Rivista Internazionale di Scienze Economiche Commerciali* 42(3): 217–29.

Murray, C., J. Kreuser, and W. Whang. 1994. "Cost-Effectiveness Analysis and Policy Choices: Investing in Health Systems." *Bulletin of the World Health Organization* 74(4): 663–74.

PRS Group Inc. 1998. *International Country Risk Guide (ICRG)*. New York: PRS Group Inc.

Tulkens, H. 1993. "On FDH Analysis: Some Methodological Issues and Applications to Retail Banking, Courts and Urban Transit." *Journal of Productivity Analysis* 4: 183–210.

Tulkens, H., and P., Vanden Eeckhaut. 1995. "Non-Parametric Efficiency, Progress and Regress Measures for Panel Data: Methodological Aspects." *European Journal of Operational Research* 80: 474–99.

World Bank. 2001. *World Development Indicators*. Washington, DC: World Bank.

Zere, E. 2000. "Hospital Efficiency in Sub-Saharan Africa: Evidence From South Africa." UNU World Institute for Development Economics Research Working Paper 187, United Nations University, Helsinki, Finland.