Assessment of Public Spending Efficiency On Education Distribution: Evidence From Developing Countries

Jean-François BRUN[a, b] and Constantin COMPAORE[*c]

[a]Associate Professor , Université Clermont–Auvergne, CNRS, IRD, CERDI, F-63000 clermont-Ferrand, France

[b]Associated Researcher , Fundaçao Getulio Vargas, FGV Growth and Development, Rio de Janeiro, Brazil

[c]PhD Student in Economics , Université Clermont–Auvergne, CNRS, IRD, CERDI, F-63000 clermont-Ferrand, France

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[*]Corresponding author
Email:constantin.compaore@etu.uca.fr

Abstract

The paper assesses the efficiency of public spending in improving the distribution of education in developing countries over the period 1980–2010. For this purpose, we use partial frontier estimator to compute output and input efficiency scores. Moreover, we analyze the determinants of education output efficiency by using Exponential Fractional Regression Models (EFRM).

Our results show that in average, developing countries can reduce their education inequality by 29% without changing their education public spending. They also improved their output efficiency over our study period. However, their input efficiency decreased relatively on the last period. The results also provide that GDP squared, urbanization, and government stability are the main determinants of education output efficiency for both logit and Cloglog specifications. But, when we include taxation variables only urbanization government stability and democracy impact positively and significantly output efficiency. This result may due to the lack of data on taxation.

Keywords: *Public Spending, Efficiency, Education Inequality, Partial Frontier Method, FRM, Taxation*

1 INTRODUCTION

Education, one of the fundamental human and children rights is essential for sustainable development and ending poverty. Economists recognized the role played by education in economic growth and well-being. Thus, the human capital theory (Becker, 1985) highlighted the importance of education in individual productivity. Following this study, the endogenous growth theory (Romer, 1986, 1990; Lucas, 1988)[1] identified education as the engine of economic growth[2].

However, neoclassical and endogenous growth theories ignored any impact which the distribution of human capital might have on the growth process (Sauer and Zagler, 2014). Yet, the distribution of education is harmful for growth and economic development. In fact, education inequality may affect negatively economic growth via the demographic mechanisms (greater inequality in the distribution of education is related to greater fertility, lower life expectancy, and lower rates of investment in human capital) or credit Market constraints (human capital inequality coupled with credit market constraints may also influence investment and growth)[3]. Moreover many empirical works (Castelló and Doménech, 2002; Castelló-Climent, 2010a,b; Checchi, 2000; Fan et al., 2001) have highlighted the negative impact on economic performance and poverty. This interest of economic literature underlines the importance of education inequality on growth, development and reducing poverty.

Over the last decades, education has expanded dramatically in most developing countries. In some countries, this expansion has been at historically unprecedented rates (The World Bank, 2017). This period is also characterized by the decrease of education inequality (Castelló-Climent and Doménech, 2014). Though, the level of education inequality remains high in many developing countries particularly in South Asia and Sub Saharan Africa[4].

To attain equitable distribution of education, governments can increase the level of public funding allocated to this sector or improve the efficiency of public spending. The increase of public spending is difficult due to the limited tax base of most developing countries. Moreover, increase public expenditures mostly financed though taxation can create distortion in the allocation of resources and constraint economic growth. The Improvement of public spending efficiency becomes crucial. Public spending efficiency is defined as the ability of the government to maximize its economic activities given a level of spending, or the ability of the government to minimize its spending given a level of economic activity (Chan and Karim, 2012). In other words, efficiency of a producer (non-profit or profit organizations) consist in doing a comparison between observed and optimal value of its outputs and inputs. Inputs refer to the monetary and non-monetary resources employed to produce outputs. Outputs are those results that are achieved immediately after implementing

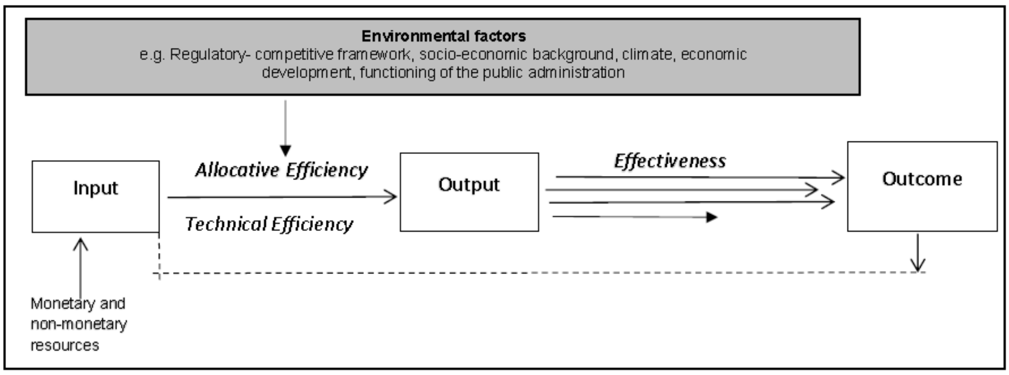
[1] See Sauer and Zagler (2014)
[2] Sauer and Zagler (2012)
[3] Galor and Zeira (1993)
[4] See Castelló-Climent and Doménech (2014, p.8)

an activity (products). In other words, they are goods or services produced by the government. Outcomes, which can be considered as mid-term results, are the difference made by the outputs (Moreno-Enguix and Lorente Bayona, 2017). In other words, they are the final objectives to achieve and often linked to welfare or growth objectives (Mandl et al., 2008). In the case of public sector, outcomes are the goals that the government wants to achieve with the outputs.

Economic efficiency has technical and allocative components. Technical efficiency is defined as the capacity and willingness of an economic unit to produce the maximum possible output from a given bundle of inputs and a technology[5] (or uses minimal inputs for the production of a given level of output). It refers to the ability to avoid waste. As for allocative efficiency, it is defined as the ability and willingness of an economic unit to equate its specific marginal value product with its marginal cost (Kalirajan and Shand, 1999). In others words, The allocative efficiency in economic theory measures a Decision Making Unit's (DMU) success in choosing an optimal set of inputs with a given set of input prices[6]. According to Mandl et al. (2008), allocative efficiency reflects the link between the optimal combination of inputs taking into account costs and benefits and the output achieved. It is the ability to combine inputs and/or outputs in optimal productions in light of prevailing prices[7]. Optimal proportions satisfy the first–order conditions for the optimization problem assigned to the production unit. The measurement of allocative efficiency requires information on input prices. The measurement of allocative efficiency is controversial.

Efficiency can be measured in output orientation or input orientation. Output-oriented efficiency expresses the efficiency of a DMU under a given level of inputs while on the other hand input-oriented efficiency represents the efficiency of a DMU by a given level of output. Thus, countries with low input-oriented efficiency could reduce their expenditures without lowering their performance while countries with low output-oriented efficiency might increase their performance without increasing their expenditures (Christl et al., 2018).

Figure 1: Conceptual framework of efficiency and effectiveness



Source: Mandl et al. (2008, p.3)

[5] Kalirajan and Shand (1999, p.149)
[6] see Daraio and Simar (2007)
[7] Fried et al. (2008, p.20)

Many reasons justify the interest of economic studies and international organizations (e.g. International Monetary Fund and The World Bank) to public spending efficiency. First, as measure per se, it facilitates comparison across similar economic units, i.e. it indicates relative efficiency. Second, where measurement reveals variations in efficiency among economic units, further analysis can be undertaken to identify the factors causing such variations. Third, such analyses bear policy implications for the improvement of efficiency (Kalirajan and Shand, 1999). In fact, studies that measure public spending efficiency, contribute to highlight best practices, learn concerning causes of performance differences among governments, and the impact of public sector reforms as well as determining, the actions that need to be focused on[8]. In a context of macroeconomic constraints (which limit countries' scope for expenditure increases) and fiscal discipline required by the Stability and Growth Pacts (for the countries belonging to economic and monetary unions), public spending efficiency could be used as an indicator to evaluate the effectiveness of government policy implementation on administration, education, health, income distribution, and economic stability. Finally, improving public spending efficiency can improve redevability.

Many empirical studies were interested in education public spending measurement (Gupta and Verhoeven, 2001; Christiaensen et al., 2002; Afonso and Aubyn, 2006; Afonso et al., 2005, 2010b; Herrera and Pang, 2005; Fonchamnyo and Sama, 2016; Gavurova et al., 2017). These studies offer several techniques to measure efficiency (specifically technical efficiency). These methods are classified into parametric and non-parametric. Some of these studies were also focused on the determinants of efficiency. However, these studies have given to education distribution limited attention. That is why we assess empirically in this paper technical efficiency of public spending in improving the distribution of education in developing countries. In fact, technical efficiency permits to identify opportunities for improvements in the ways resources are converted into outputs, and to identify inefficiencies in the mix of production factors. To assess our efficiency scores, we use nonparametric partial frontier estimator which is more robust than the previous estimators (e.g. Data Envelopment Analysis and Free Disposal Hull). We also analyze the determinants of our output–oriented efficiency scores using fractional regression models (FRM) which is the most natural way of modelling bounded, proportional response variables.

The paper is structured as follow. In section2 a review of the relevant literature in the education public spending efficiency field is provided. In section3, we present the methods used for measuring efficiency and the originality of our estimator. Section4 discuss our data and results analysis. The last section concludes.

[8]see Moreno-Enguix and Lorente Bayona (2017, p.7)

2 Literature Review

The theme of efficiency has been analysed since Adam Smith's pin factory and before (Daraio and Simar, 2007). However, the first rigorous analytical approach to the measurement of efficiency in production originated with the work of Koopmans (1951) and Debreu (1951) and empirically applied by Farrell (1957). An important contribution to the development of efficiency and productivity analysis has been done by Shephard's models of technology and his distance functions[9].

There is a abundant literature on the efficiency of education public expenditures. These studies are mostly quantitative relying on parametric and nonparametric approach. Thus, Clements (2002) assessed the efficiency of education public spending in European Union. He applied Free Disposal Hull (FDH) method by comparing countries of European Union to the "best practices" observed in the OECD[10]. His study used expenditure per student (in purchasing parity adjusted dollar) and teacher to student ratio as input variables and international standardized test (TIMSS, Trend in International Mathematics and Science Study) as output variable. He found that 25 percent of education spending is wasteful in European Union relative to the "best practices". This result showed that educational performance could be improved without necessarily increasing educational public spending. Eugéne (2007) by using the same method assessed the efficiency of the Belgian general government in health care, education, public order and safety and general public services. He concluded that Belgian education system is more expensive but lead to better results than the European average. FDH was also used by Gupta and Verhoeven (2001) to assess the efficiency of government expenditure on education (measured by per capita education spending in purchasing power parity (PPP)) and health[11] in 37 African countries, both in relation to each other and in comparison with countries in Asia and the Western Hemisphere. This study covered the period 1984–1995. The authors showed that on average, governments in African countries are less efficient in the provision of education (primary school enrolment, secondary school enrolment, and adult illiteracy) and health (life expectancy, infant mortality, and immunizations against measles and DPT[12]) services than countries in Asia and the Western Hemisphere. But education and health spending in Africa have become more efficient during this period. The results also suggests that improvements in educational attainment and health output in African countries require more than higher budgetary allocations.

Some authors adopted the Data Envelopment Analysis (DEA) method to assess public expenditures on education. Thus, Kirjavainen and Loikkanent (1998) used the nonparametric DEA method to study the efficiency among 291 Finnish senior secondary schools. They also explained the degree of inefficiency (lOO - efficiency score) by a statistical Tobit model. Their results showed that private schools were inefficient relative to public schools. They

[9] Daraio and Simar (2007, p.16)
[10] Organisation for Economic Co-operation and Development
[11] measured by per capita health spending in PPP
[12] Diphtheria–Pertussis–Tetanus

also highlighted that school size does not affect efficiency. Following the same methodology, Afonso and Aubyn (2006) addressed the efficiency of expenditure in education provision by comparing the output (PISA[13] Indicators) from the educational system of 25 mostly OECD countries with resources employed (teachers per student, time spent at school) during the period 2000-2002. They estimated a semi-parametric model of the education production process using a two-stage procedure. By regressing DEA output scores on nondiscretionary variables, both using Tobit and a single and double bootstrap procedure. They showed that inefficiency was strongly related to GDP per capita and adult educational attainment. Gavurova et al. (2017) by using DEA compared the relative efficiency of government expenditures on secondary education, in selected European countries in 2015. They found that average efficiency (output-oriented) was 0.955 and highlighted a relative high efficiency in evaluated countries. DEA was also employed by Yogo (2015) for public spending assessment (precisely input oriented technical efficiency) of 77 developing countries in health, education and infrastructure over the period 1996–2012. He also examined the effect of ethnic diversity (fractionalization and polarization measures) on the efficiency of public spending by using a censored Tobit regression model. Two main findings have been drawn. First, barely 12% of the sample of countries under study makes an efficient use of public expenditures. Second, no matters the level of aggregation, ethnic polarization is positively associated with higher efficiency. Fonchamnyo and Sama (2016), in an article analysing the efficiency of public spending in the education and health sectors in three selected Central Africa countries (Cameroon, Central African Republic and Chad) applied DEA approach to compute efficiency scores. They used in a second stage panel data Tobit and fractional logit regression to determine the institutional and economic factors on public spending efficiency in education and health sectors. They showed that Cameroon is the most efficient country in public spending in education and health. Their results also indicated that budgetary and financial management impacts positively and significantly efficiency scores while corruption has a negative and significant effect. Yotova and Stefanova (2017) in a study on efficiency of tertiary education expenditure used the DEA method. Their study covered nine European Union member States from Central and Eastern Europe (Bulgaria, the Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, and Slovenia). They employed tertiary educational attainment (age group 25-34 years), employment rate of population with tertiary education (age group 25-29 years) and population with tertiary education not at risk of poverty and social exclusion (age group 25-49) as output indicators and total expenditure on tertiary education[14] as input indicator. The authors concluded that Latvia is the most efficient country in comparative perspective in the area of the tertiary education expenditure and achieved direct and indirect output results.

Some research used both FDH and DEA methods to compute efficiency scores. For instance, Afonso and St Aubyn (2004) address the efficiency in education and health sectors

[13] Program for International Student Assessment

[14] Total expenditure on tertiary education is calculated as the sum of public expenditure and private expenditure of households

for a sample of OECD countries by applying nonparametric FDH and DEA methods. They used the performance of 15-year-olds on the PISA (reading, mathematics and science literacy scales) in 2000 as output indicator. As for inputs measures they used the annual expenditures on secondary education per student in 1999. The results suggest that the average input efficiency in education sector varies between 0.520 and 0.610, depending on method used[15]. They used the same methodology to assess efficiency in health and education in an article published in 2005. In the educational case, they employed physical input indicators (the total intended instruction time in public institutions in hours per year for the 12 to 14-year-olds and the number of teachers per student in public and private institutions for secondary education). As an output, they used PISA indicators. The results showed that the average input efficiency vary between 0.859 and 0.886, depending on method used.

Herrera and Pang (2005) estimated the efficiency frontiers for nine education output indicators (gross and net primary school enrolment, gross and net secondary school enrolment, literacy of youth, average years of school, first level complete, second level complete, and learning scores) and four health output indicators (life expectancy at birth, immunization against DPT and measles, disability-adjusted life expectancy) based on a sample of 140 countries from 1996 to 2002. In the case of education, they used public spending per capita on education (in constant 1995 US PPP dollars) and non-monetary factors of production such as the ratio of teachers to students. They also applied nonparametric FDH and DEA methods to compute efficiency scores and sought to identify empirical regularities that explain cross-country variation in the efficiency scores by using a Tobit panel approach. Their results showed that higher expenditure levels, larger wage bill, income inequality, HIV/AIDS and aid are negatively associated with efficiency scores. In contrast, urbanization is positively associate to efficiency score.

Moreno-Enguix and Lorente Bayona (2017) designed Public Expenditures Efficiency Indexes (PEEI), both for general government and its functions (including education), by using single synthetic indicators. These indexes was developed for 35 developed countries in 2012. The Public Expenditures Efficiency Index by function is computed mathematically as the ratio between Public sector performance in function (PSP) and government functional expenditure (in percentage of GDP) in this function. Performance on Education is a synthetic index of primary (average of two normalized scores[16]) and higher (average of two normalized scores) education. Their results showed that corruption and democracy do not influence efficiency in education. Their study follow Afonso et al. (2005) who used the same methodology to compute Public Sector Performance and Public Sector Efficiency (PSE) indicators comprising a composite and seven sub-indicators (administrative, education[17], health, public infrastructure, distribution, stability and economic performance), for 23 industrialized countries.

Parametric method was also used for evaluating educational public spending efficiency.

[15]The output average efficiency varies between 0.942 (FDH) and 0.966 (DEA)

[16]Primary education enrolment rate and Quality of primary education

[17]This index contains secondary school enrolment and educational attainment indicators

Indeed, Jayasuriya and Wodon (2003) assessed efficiency in education and health spending using stochastic frontier estimator on a sample of 76 countries from 1990 to 1998. Per capita GDP, per capita expenditures on education and adult literacy rate employed as input variables. As for education output variable, they used net primary enrolment rate.The production frontiers are allowed to vary by region. In a second stage the authors used explained efficiency by bureaucracy quality, corruption and urbanization. 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 (education and health). An analysis of the determinants of the efficiency measures suggests that bureaucratic quality and urbanization both have strong positive impacts on efficiency while the impact of corruption is not statistically significant.

In sum, there is a great interest of literature for public spending efficiency in education. This literature employs several methods to compute efficiency scores and also analyse its determinants.

3 Methods for Measuring Efficiency

There is two types of public spending efficiency measurement:
Macro measurements which aim to evaluate the efficiency of total public spending. They attempt to measure, or rather to get some ideas of the benefits from higher public spending. Micro measurements aim at measuring the efficiency of particular categories of public spending. They attempt to determine the relationship between spending and benefits in a particular budgetary function or even sub-function (i.e., health spending or the efficiency of spending in hospitals, or spending for protection against malaria, aids, etc.)[18].

Numerous techniques have been developed to compute efficiency scores. These methods are based on the concept of efficiency frontier (productivity possibility frontier). In other words the method consist on estimating a production, cost or profit function. Efficiency scores of Decision Making Units (DMUs) are measured by their distance to an estimated production function (the frontier). A production function is a mathematical representation of the technology that transforms inputs into outputs. The two most widely used catalog methods into parametric or non-parametric, and into stochastic or deterministic.

3.1 The parametric methods

The parametric approach assumes a specific functional form for the relationship between the inputs and the outputs as well as for the inefficiency term incorporated in the deviation of the observed values from the frontier (Herrera and Pang, 2005). It assumes that a function giving maximum possible output as a function of certain inputs (or minimum cost of producing that output given the prices of the inputs). This approach can be either deterministic

[18]See Afonso et al. (2010b)

or stochastic.

A very common parametric method is the Stochastic Frontier Analysis (SFA) approaches. There are two main estimation strategies here. The first strategy is based on a error components model which assumes that the error term has two components, one for random errors (assumed to follow a normal distribution) and one non negative represents the technical inefficiency (Aigner et al., 1977; Meeusen and van Den Broeck, 1977). Initially applied to cross-section data, the SFA was extended to panel data with Battese and Coelli (1992, 1995); Kumbhakar and Wang (2005); Kumbhakar et al. (2014) etc. The second strategy is the fixed effect approach used by Evans et al. (2000). In this method, frontier intercept[19] is represented by a constant and the non negative component of the error term are the country-specific inefficiencies. The country with the highest intercept is considered as best performer and taken as the reference country (the frontier) and the distance from this maximum, gives a measure of technical efficiency (Evans et al., 2000; Jayasuriya and Wodon, 2003).

SFA offers the possibility to find out whether the deviation of a DMU's actual output from its potential output is mainly because it did not use the best practice techniques or is due to external random factor (Kalirajan and Shand, 1999). It permits to test statistically various hypotheses concerning technology's modelling and characteristics of DMU–specific efficiency measures[20]. According to Harold et al. (1993), SFA offers flexibility in modeling various specific aspects of production such as production and marketing risk. SFA facilitates decomposition of economic efficiency into technical and allocative efficiency. SFA also takes care of potential bias introduced by extreme observations (Christiaensen et al., 2002). However, it imposes a parametric structure on the production function and on the distribution of efficiency which potentially introduces other bias.

Other methods was used to estimate a frontier via resolving a linear or quadratic programming (Aigner and Chu, 1968), corrected ordinary least square (Richmond, 1974) or maximum likelihood (Afriat, 1972). These methods are named the parametric deterministic approach or "full frontier models". This approach assumes that inefficiency is explained by all deviations from the frontier[21] (Herrera and Pang, 2005; Fried et al., 2008). Since this method is deterministic, the results are sensitive to outliers. The principal drawback of parametric method is the possibility of imposing a inappropriate structure on the technology. (Hollingsworth et al., 1999).

3.2 Nonparametric methods

The nonparametric approach calculates the frontier directly from the data without imposing specific functional restrictions on the production technology. This approach was pioneered by Farrell (1957). This method is generally dominated by deterministic approach and use an

[19] constant – non negative component of the error term
[20] Kalirajan and Shand (1999, p.168)
[21] The distance of a DMU from the frontier

outer envelope that encompasses all observations is constructed. In other words under the nonparametric approach, a best practice frontier is constructed from the observed inputs and outputs as a piecewise linear technology (Grosskopf, 1986). In this approach the restrictions placed on the technology vary widely, but can be less restrictive than those used to date in the parametric approach.

One common nonparametric method to establish the production frontier is the Free Disposal Hull (FDH) approach. This approach is defined as a piecewise linear reference technology, constructed on the basis of observed input-output combinations that satisfie the following axioms:
The first states that a semi-positive output cannot be obtained from a null input vector — thus excluding free production — and that any non-negative input results at least in a zero output. The second implies that finite inputs cannot produce infinite outputs. The third (Known as strong free disposability or positive monotonicity assumption) guarantees that an increase in inputs cannot result in a decrease in outputs. The fourth axiom is postulated for mathematical convenience which cannot be contradicted by any empirical observation. The last axiom implies that any reduction in outputs remains producible with the same amount of inputs. This assumption allows for variable returns to scale (De Borger et al., 1994). In this method technical efficiency is measure as the distance between an observed production unit and the postulated production frontier (the isoquant). This method was first proposed by Deprins, Simar and Tulkens (1984). FDH requires minimal assumptions with respect to the production technology (e.g. absence of convexity). It allows for a direct measurement of the relative efficiency of government spending among countries (Gupta and Verhoeven, 2001). From a managerial viewpoint, the major advantage of the FDH is that the resulting efficiency measures are related to an observed production unit[22]. But its main drawback is due to the partial ordering based on the vector dominance reasoning. This implies that the approach may be sensitive both to the number and distribution of the observations in the data set, and to the number of input and output dimensions considered (De Borger et al., 1994). FDH does not permit to make a distinction between random factors that may affect production (for example, rainfall in agricultural production) and actual inefficiency (Christiaensen et al., 2002). Finally the method is not robust to outliers or extreme data points.

Data Envelopment Analysis (DEA) is another common non parametric deterministic approach to estimating production frontiers. In this approach, linear programming methods are used to construct a linear envelope to bind the data (construct the frontier) relative to which efficiency measures can be calculated. In contrast to FDH, DEA assumes convexity of the production possibility set implying that linear combinations of best-observed production results lie on or below the production possibility frontier (Christiaensen et al., 2002; Herrera and Pang, 2005). According to Aragon et al. (2005), the convexity assumption is widely used in economics but is not always valid. DEA also assumes the free disposability of the production frontier. This technique, originating from Farrell's (1957) seminal work and

[22] De Borger et al. (1994, p.657)

popularized by Charnes et al. (1978) was initially born in operations research for measuring and comparing the relative efficiency of a set of DMUs[23]. DEA permits to analyse each DMU separately and to measure relative efficiency with respect to the entire set being evaluated. It also solves problems using standard techniques of linear programming (Seiford, 1996). However, DEA is sensitive to extreme values and outliers (an atypical observation or a data point outlying the cloud of data points).

An alternative nonparametric estimator of the "efficiency frontier" which is more robust to extreme values, noise or outliers than the standard DEA and FDH was proposed by the literature (Cazals et al., 2002; Aragon et al., 2005; Daraio and Simar, 2005; Daouia and Ruiz-Gazen, 2006; Daouia and Simar, 2007; Daouia and Gijbels, 2011; Tauchmann, 2012; Christl et al., 2018). The underlying idea of this method is to estimate a partial frontier well inside the cloud of data points but near the upper frontier[24] (Daouia and Gijbels, 2011). Two alternatives have been used to estimate partial frontier:
The order-m estimator (or conditional order-m estimator) introduced by Cazals et al. (2002) is based on the concept of expected minimum production function (or expected maximum production function). This estimator generalizes FDH by adding a layer of randomness to the computation of efficiency scores. Rather than benchmarking a DMU by the best performing peer in the sample at hand, order-m is based on the idea of benchmarking the DMU by expected best performance in a sample of m peers[25]. In other words the method consist to estimate a frontier of a discrete $order - m \in N^{*}$[26] (instead of estimating the full frontier), which increases with respect to m to achieve the efficient frontier φ when $m \to \infty$[27]. This estimator shares the same asymptotic properties as the FDH estimator but is less sensitive to outliers and/or extreme values (Daouia and Simar, 2007; Daouia and Ruiz-Gazen, 2006).

The quantile-frontier of order-α (or order-α estimator) suggested by Aragon et al. (2005) is also a generalization of FDH. The idea is to replace the concept of "discrete" order-m partial frontier by a "continuous" order-α partial frontier where $\alpha \in]0,1]$ corresponds to the level of an appropriate non standard conditional quantile frontier (Daouia and Simar, 2007). From an economic point of view, α gives the production threshold exceeded by $100(1-\alpha)\%$ all production units using less than x as inputs. The order-α estimator is very fast to compute, very easy to interpret, can be useful in terms of practical efficiency analysis. It does not envelop all the observed data points and has at least the same statistical properties as the order-m estimator. Moreover according to Daouia and Ruiz-Gazen (2006) and Aragon et al. (2005) order-α has better robust property than order-m. Note that there exists a relationship

[23] Murillo-Zamorano (2004)
[24] In contrast to envelopment methods (DEA and FDH) which envelop all the data
[25] Tauchmann (2012, p.463)
[26] a set of all integers $m \geq 1$
[27] Daouia and Ruiz-Gazen (2006, p.1234–1235)

between α and m[28] such that

$$\alpha(m) = \frac{1}{2}^{\frac{1}{m}} \tag{1}$$

Partial frontiers and related measures of efficiency show some nice statistical properties together with several "appealing" economic features that deserve some comments (Daraio and Simar, 2007).

First of all, partial frontier estimators do not envelop all the data points. Consequently, these robust measures of frontiers and the related efficiency scores are less influenced and hence more robust to extreme values and outliers. This property permits to avoid one of the more important limitation of the traditional nonparametric estimators related to their deterministic nature[29].

Second, as a consequence of their statistical properties these robust estimators do not suffer of the curse of dimensionality shared by most nonparametric estimators and by the DEA/FDH efficiency estimators (Daraio and Simar, 2007). This property is very important for empirical works since it allows to work with samples of moderate size and do not require large samples to avoid imprecise estimation (e.g. large confidence intervals)[30].

Third, and even more important is the economic interpretation of order-m measures of efficiency, and and the appealing notion of order-α in particular α measures of efficiency. Indeed, the parameter m has a dual nature. It is defined as a "trimming" parameter for the robust nonparametric estimation. It defines also the level of benchmark one wants to carry out over the population of firms. Based on this nature, Daraio and Simar (2007) have proposed to to use m in its dual meaning to provide both robust estimations and a potential competitors analysis.

Note that a hybrid method to measuring efficiency was proposed by
Wagstaff and Wang (2011) which blends both DEA and SFA approach.

4 Data and Results Analysis

4.1 Data

We use a panel data set of 65 developing countries[31] over 1980 to 2010. Two groups of variables are considered: those used in estimating the production frontier for education distribution and those used in the analysis for the determinants of efficiency.

The first group of variables includes one output (education Gini index by age and gender for persons aged 15 and over) and one input variable (Per capita education spending by the government in purchasing power parity (PPP)). The education Gini index is from

[28] Daouia and Gijbels (2011, p.149)
[29] Daraio and Simar (2007, p.78)
[30] Daraio and Simar (2007, p.78)
[31] low and middle income countries according to The World Bank

Crespo-Cuaresma et al. (2012, 2013) database. This indicator measures inequality in educational attainment by age and gender at the global level[32]. It captures access to education. This quinquennial index covers 175 countries from 1960 to 2010. It was formulated using IISA/VID (International Institute for Applied Systems Analysis/Vienna Institute of Demography) global database of populations by age, sex, and levels of education. This demographic data set was developed by applying the demographic methodology of multi-state population projection (see Lutz and Samir (2011); Samir et al. (2010); Lutz and Goujon (2001)). The education Gini index by age and sex is computed by applying the following formula:

$$GiniEC_{\alpha,s} = \frac{1}{\bar{y}_{\alpha,s}} \sum_{i=2}^{4} \sum_{j=1}^{i-1} |y_{\alpha,s,i} - y_{\alpha,s,j}| p_{\alpha,s,i} p_{\alpha,s,j} \tag{2}$$

Where $y_{\alpha,s,i}$ is the cumulative duration of schooling for the level of education i in the age group α with sex s and $p_{\alpha,s,i}$ is the corresponding share of the population with that level of education. $\bar{y}_{\alpha,s}$ denotes the mean value of years of schooling, given by

$$\bar{y}_{\alpha,s} = \sum_{i=1}^{n} p_{\alpha,s,i} y_{\alpha,s,i}$$

Four educational attainment levels have been considered: no formal education (i = 1), primary education (i = 2), secondary education (k = 3) and tertiary education (i = 4). The education Gini coefficient is range between 0 to 1. A value of 0 indicates a perfectly equally distributed education structure (This case corresponds to a situation in which the whole population attains the same education level). In the other hand, a value of 1 indicates a perfect unequal distribution (In this case, one person completes for example tertiary education, while the rest of the population does not attain any formal schooling)[33]. As Afonso et al. (2010a), we compute our output variable ($GiniEC^{T}_{\alpha,s}$) by transforming our education Gini index as follow:

$$GiniEC^{T}_{\alpha,s} = 1 - GiniEC_{\alpha,s} \tag{3}$$

This transformation is used to insert increasing outputs as the desired objective.

We used Per capita education spending by the government in purchasing power parity (PPP) as our input measure. This indicator is computed as the product of the shares of education spending in percentage of GDP from IMF[34] database (World Economic Outlook and Government Financial Statistics) and real GDP per capita at chained PPPs in US Dollars[35] from Penn World Table 9.0 (PWT 9.0) data set. In fact, expenditure-side real GDP allows comparison of relative living standards across countries and over time Feenstra et al. (2015). Then, using Per capita PPP public spending on education permits for a more accurate cross-country comparison of the domestic shadow costs of the resource allocation for education than conventional US dollar measures and GDP shares (Gupta and Verhoeven, 2001).

[32] We use the index for both sex men and women

[33] Sauer (2016)

[34] International Monetary Fund

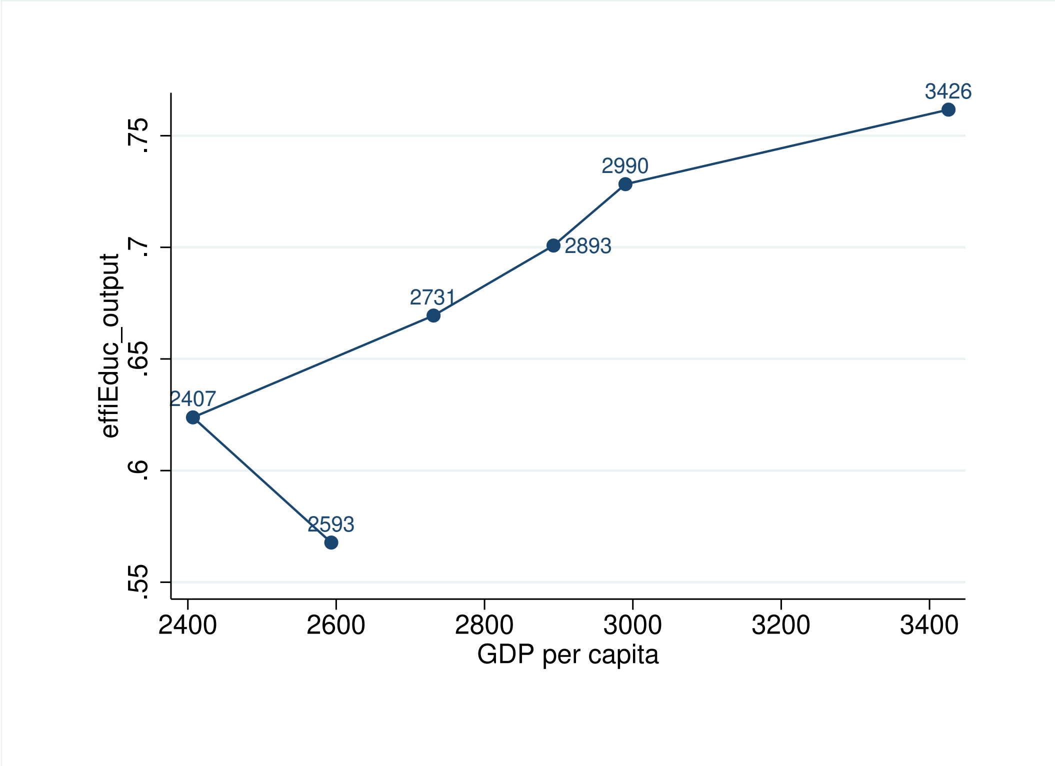
[35] We computed GDP per capita by dividing GDP by population from PWT database

Private expenditures, including activities of Non Governmental Organizations (NGOs), may also be use as an input. But these data are not available. Physical inputs such as the numbers of teachers, pupil-teacher ratio, average class size, number of instruction hours and the use and availability of computers can also be take into account to estimate the production frontier[36]. However, these indicators are either unavailable or contain missing data for many developing countries.

The second group of variables are used in the analysis for the determinants of efficiency score. Such factors may play a relevant role in determining heterogeneity across countries and influence performance and efficiency. They can have an economic or non–economic origin. These variables are called "environmental" variables also known as non–discretionary or "exogenous" inputs. These exogenous factors include: The logarithm of real per capita GDP (at constant 2010 US dollar) from The World Bank's World Development Indicators (WDI) data set. In fact, this variable aims to proxy the physical capital stock which facilitates an efficient production of public goods and services but which may also facilitate monitoring of policy makers (Afonso et al., 2010b). A higher level of public spending efficiency is associated with a higher level of GDP per capita. We also used the logarithm of real per capita GDP squared (logGDPpercapSq). In fact, the relationship between our education's output efficiency score is not linear as show by figure2. We can hypothesize that the increase of efficiency score is explained by the increase of GDP per capita due to the available of resources. But this increase become lower at a GDP per capita threshold ($2990.006) caused by structural problem.

[36]see Afonso and Aubyn (2006); Afonso and St Aubyn (2005)

Figure 2: Relationship between education's output efficiency score and GDP per capita



Source: authors

Urbanization data from WDI, refer to urban population in percentage of total population. Indeed, it is more easier to provide public services (as education) in urban areas rather than in rural. This may be explained by the clustering of public agents. Higher degree of urbanization should reflect in higher efficiency, making positive as the expected sign of the coefficient on this variable.

Trade openness (exports and imports as a share of GDP) from WDI data set. This indicator proxies the degree of international competition over labour and capital (Afonso et al., 2010b). It also measures the level of integration in the world economy. According to (Hauner and Kyobe, 2010), trade openness could increase public spending efficiency by increasing competitive pressure on the domestic economy, including the government, as well as raising more generally exposure to the outside world, including through skills and technology transfer[37].

Financial Development Index (FD) from IMF financial development database. This overall index of financial development is an aggregation of financial institutions and financial markets sub-indices. It takes into account depth (size and liquidity of markets), access (ability of individuals and companies to access financial services) and efficiency (efficiency of financial intermediaries and markets in intermediating resources and facilitating financial transactions) dimension of financial institutions and financial markets (Čihák et al., 2013; Svirydzenka, 2016). A better developed financial system could reduces the possibility to rig

[37] Rayp and Van De Sijpe (2007, p.370)

the financial system, thus putting more pressure on the government to control its budget by working in an efficient manner (Rayp and Van De Sijpe, 2007).

Corruption from the International Country Risk Guide (ICRG) published by Political Risk Services: This variable assess corruption in within the political system (Howell, 2012). Corruption distorts the economic and financial environment, reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability and introduces inherent instability in the political system (Jayasuriya and Wodon, 2003). Moreover, corruption breeds waste of public funds. Higher values of corruption index indicate a decreased prevalence of corruption. A higher values of corruption index indicate a decreased prevalence of corruption. In other words, low level of corruption rises public spending efficiency.

Government stability from the International Country Risk Guide (ICRG) published by Political Risk Services: This variable assess both the government's ability to carry out its declared program(s), and its ability to stay in office. The risk rating assigned is the sum of three subcomponents (Government Unity, Legislative Strength and Popular Support). Each subcomponent has a maximum score of four points and a minimum score of 0 points. A score of 4 points equates to Very Low Risk and a score of 0 points to Very High Risk (Howell, 2012). Political instability can complicate consistent budgetary planning and undermine efficiency (Hauner and Kyobe, 2010).

Democracy measured by the polity2 indicator from the Polity IV database. This index is a combination of democracy and autocracy indicators of polity IV. Additionally to autocracy and democracy, polity2 includes interruption[38], interregnum[39] and transition[40] periods. The polity2 score ranges from -10 (highly autocratic), to 10 (highly democratic) and available since 1800. To make the interpretation easier, we normalized the polity2 score from 0 (highly autocratic) to 1 (highly democratic) by using a Max-Min formula. Indeed, voting is the fundamental link between voters and politicians. A high degree of democratic participation in terms of voter turnout may reduce inefficiencies in public service provision through more efficient monitoring of politicians. In other words, a higher turnout may give politicians incentives to implement policies that improve efficiency and benefit the electorate at large, at the expense of policies benefiting public sector unions and other special interests Borge et al. (2008).

To check our result robustness we use taxation variables such as total taxes (tesc), natural resources (restax) and non natural resources (nonrestaxes) taxes from Brun and Diakite (2016). these variables are in percentage of GDP. Indeed, the improvement of public resources mobilization (such as tax revenue) may increase public expenditures efficiency via the accountability of policy makers.

Our input and environmental variables have been averaged over 5 (respectively 1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004 2005-2010) years periods because our

[38] occupation by a foreign country
[39] falling down of political authority
[40] period between two political regimes that are substantially different

output data are quinquennial. Summary statistics for all variables are presented in table1

Table 1: Summary Statistics of key variables

Variables	Definition	mean	sd	min	max	N
Variables used in the first stage regressions						
GiniEC15	Gini index of education 15 year and over	0.46	0.23	0.086	0.95	390
GiniEC15T	Transformed education's Gini index	0.54	0.23	0.053	0.91	390
goveducgdp	Education Spending in percentage of GDP	3.83	2.28	1.21	31.0	390
rgdpepercap	Real GDP per capita at chained PPPs in US Dollars	4385.4	3591.5	253.6	18184.7	390
Variables used in the second stage regressions						
effiEduc_output30	Education's Spending Output Efficiency Score	0.71	0.26	0.075	1.04	390
effiEduc_input30	Education's Spending Input Efficiency Score	0.51	0.39	0.031	2.49	390
ogGDPpercapita	Logarithmof GDP per capita at constant 2010 US Dollars	7.42	1.07	5.01	9.52	376
logGDPpercapitaSq	Logarithmof real per capita GDP squared	56.2	15.9	25.1	90.7	376
Urbanrate	Urban rate	44.8	19.7	8.16	90.5	390
Trade	Trade openness in percentage of GDP	63.3	32.1	12.9	259.9	370
FD	Financial Development	0.18	0.11	0	0.63	390
debt	Debt in percentage of GDP	74.7	67.4	8.62	753.5	366
Corruption	Corruption	2.54	0.96	0	6	379
GovernmentStability	Government Stability	7.04	2.04	1.12	11	379
Democracy	Normalized Polity2 democracy Index	0.55	0.32	0.0100	1	385
tesc	Total tax revenue in percentage of GDP	15.1	6.75	4.30	67.7	269
restax	Ressource taxes in percentage of GDP	1.45	4.23	0	27.2	261
nonrestaxes	Non ressource taxes in percentage of GDP	13.3	5.21	4.07	36.0	262

Source: Authors' calculation

4.2 empirical strategy

We use partial frontier approaches (or conditional efficiency model) in particular the order-m estimator to estimate our production boundary. In fact, as a nonparametric estimator, order-m does not impose specific functional restrictions on the production technology. Moreover, It is more robust to the extreme values and outliers than the other nonparametric estimators particularly, FDH and DEA (see 3.2). Also, it does not suffer from the curse of dimensionality shared by most non-parametric estimators and by the DEA/FDH efficiency estimators. Using order-m estimator we compute efficiency scores for output and input oriented for each period. We set the value of m equal to 30. This value permits to get the lower share of super-efficient DMUs (after stimulated many samples of m DMUs). The method authorizes DMUs to be above the production frontier (i.e. efficiency score higher than 1). We test the sensibility of our order-m estimators (effiEduc_output30 and effiEduc_input30) to other values of m, by using Pearson correlation test (non linear correlation test) and Spearman's rank correlation test between our estimator and other order-m estimators for different values of m (respectively m=16[41] and m=49[42]). In the same vein, we also test the sensibility of our order-m estimator to alternative order-α estimator. A correlation coefficient (or a rank correlation coefficient) close to one and significant means that the DMU's efficiency (or its rank) are not significantly influenced by m values or order-α estimator. The order-m estimator allows some DMUs to lie outside the efficiency frontier (super-efficient countries). Hence, unlike the other methods, the efficiency score in the order-m method can be greater than one.

In the second stage we regress our output efficiency score (effiEduc_output) on a set of exogenous variables (named environmental variables) by using fractional regression models (FRMs). In fact, Fractional responses are variables bounded by 0 and 1. They are a very common type of dependent variable in econometric models. Efficiency scores are examples of such variables. The bounded nature of such variables and in some cases, the possibility of nontrivial probability mass accumulating at one or both boundaries imply that fractional regression models have to be applied in this context. The standard linear regression model is not appropriate since it does not guarantee that the predicted values of the dependent variable are restricted to the unit interval (Ramalho et al., 2010, 2011). Moreover, given that the dependent variable is strictly bounded from above and below, it is in general unreasonable to assume that the effect of any explanatory variable is constant throughout its entire range[43]. Tobit approach is also traditionally used to estimate efficiency score. However, there are some problems with this approach. First, only in the two-limit Tobit model are in fact the predicted values of dependent variable restricted to the unit interval. But that approach can only be applied when we have observations in both limits, which is often not the case. Second, the Tobit model is appropriate to describe censored data in the

[41] corresponding to one fourth of our sample

[42] corresponding to three fourths of our sample

[43] Ramalho et al. (2011)

interval [0, 1] but its application to data defined only in that interval is not easy to justify. Observations at the boundaries of a fractional variable are a natural consequence of individual choices and not of any type of censoring. Finally, the Tobit model is very stringent in terms of assumptions, requiring normality and homoskedasticity of the dependent variable, prior to censoring (Ramalho et al., 2011). Fractional regressions models were first suggested by Papke and Wooldridge (1996). This seminal paper were followed by several extensions (Ramalho et al., 2010, 2011; Ramalho and Ramalho, 2017; Ramalho et al., 2018). Recently, Ramalho et al. (2016, 2018) developed a new class of estimators based on a transformation of logit and complementary loglog (cloglog) fractional regression models into a form of exponential regression (EFRM) with multiplicative individual effects and time-variant heterogeneity from which six alternative GMM estimators (including four alternative GMM fixed-effects estimators) have been proposed. These estimators are robust to heterogeneity (time-variant and time-invariant) and can accommodate endogenous explanatory variables. In this paper we use the pooled fixed-effects (GMMpfe) estimator allowing explanatory variables and individual effects to be correlated. On the basis of that above we use the following econometric specification:

$$y_{it} = G(x_{it}\theta + \alpha_i + \upsilon_{it}) \tag{4}$$

Where υ_{it} denotes time-varying unobserved heterogeneity and G is assumed to have a logit ($G(\cdot) = \frac{\exp(\cdot)}{1+\exp(\cdot)}$) or cloglog ($G(\cdot) = 1 - \exp\exp(\cdot)$) specification. y_{it} is the dependent variable and x_{it} the matrix of explanatory variables. α_i is the vector of individual-specific intercepts and θ denotes the vector of parameters.

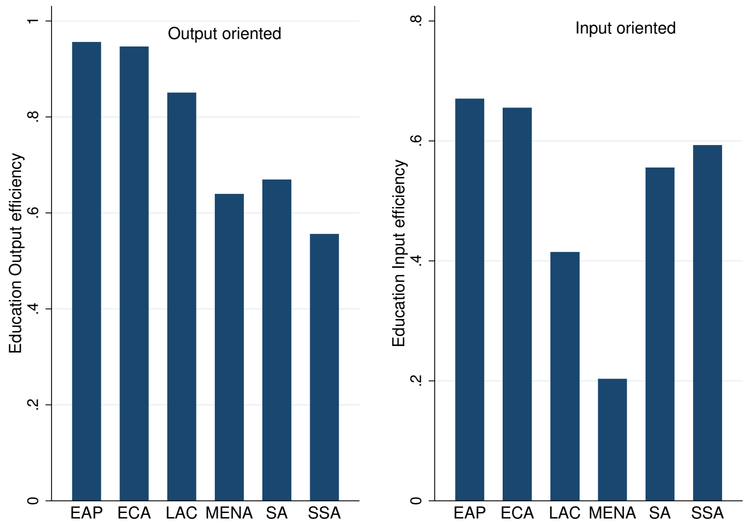
4.3 Results Analysis

4.3.1 Efficiency scores

AppendixF provides output and input efficiency scores for each country and each period. The analysis of efficiency scores provides the following results:
The average output technical efficiency score is relatively high (0.71). This suggests that developing countries might increase their output (then reduce their education inequality) by 29% without changing their education public spending. East Asia and Pacific (EAP), Europe and central Asia (ECA) and Latin America and Caribbean (LAC) have the highest levels of output efficiency scores over our study period. As for Sub-Saharan Africa (SSA), its output efficiency score is the lowest (0.56). However its input efficiency score (0.59) is higher than the average input efficiency score (0.51) and its output efficiency score. Middle East and North Africa's (MENA) countries have the lowest input efficiency score (0.2). In most of geographic areas (except Sub-Saharan Africa) the output efficiency score is higher than the input efficiency score (see figure3[44]).

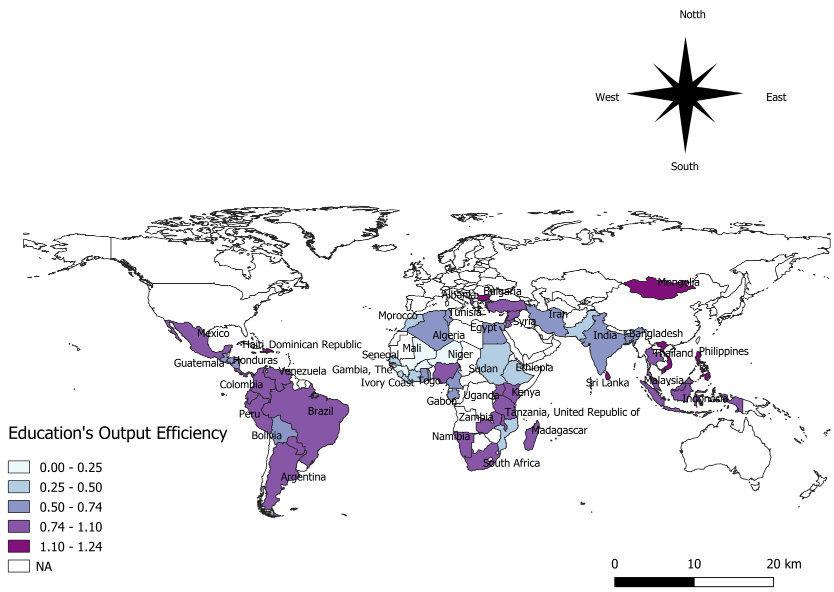
[44] SA: South Asia

Figure 3: Average score of efficiency by regional sub-sample



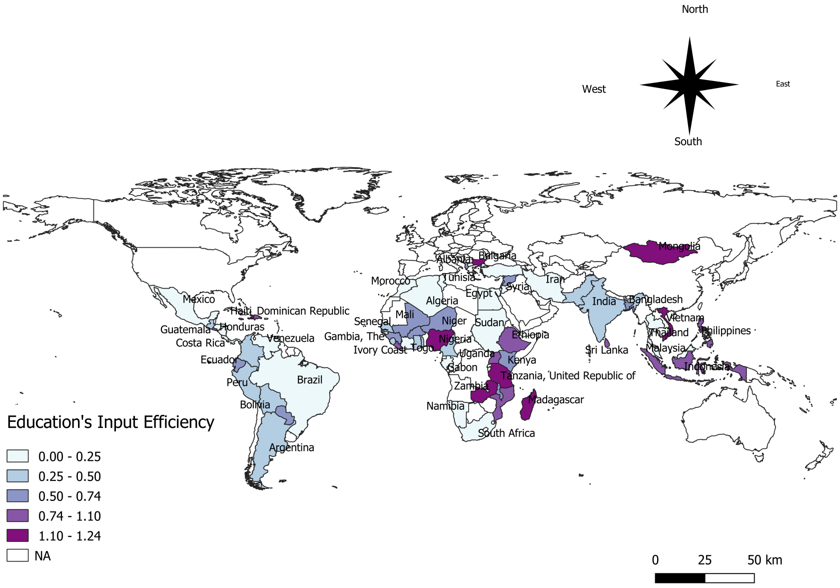
Source: authors

Figure 4: Geographical representation of education's output efficiency



Source: authors

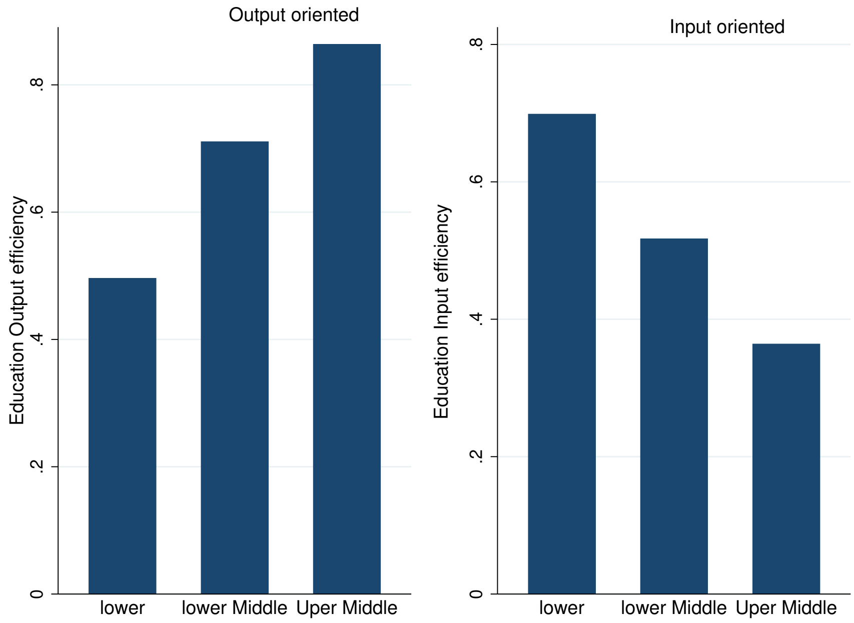
Figure 5: Geographical representation of education's input efficiency



Source: authors

Low income countries have the lowest level of output efficiency (0.2). However they are the highest level of input efficiency (0.70). In the same vain, upper middle income countries have the highest level of output efficiency (0.86) but the lowest level of input efficiency (0.37). Figure6 provides the average output and input efficiency score by income group.

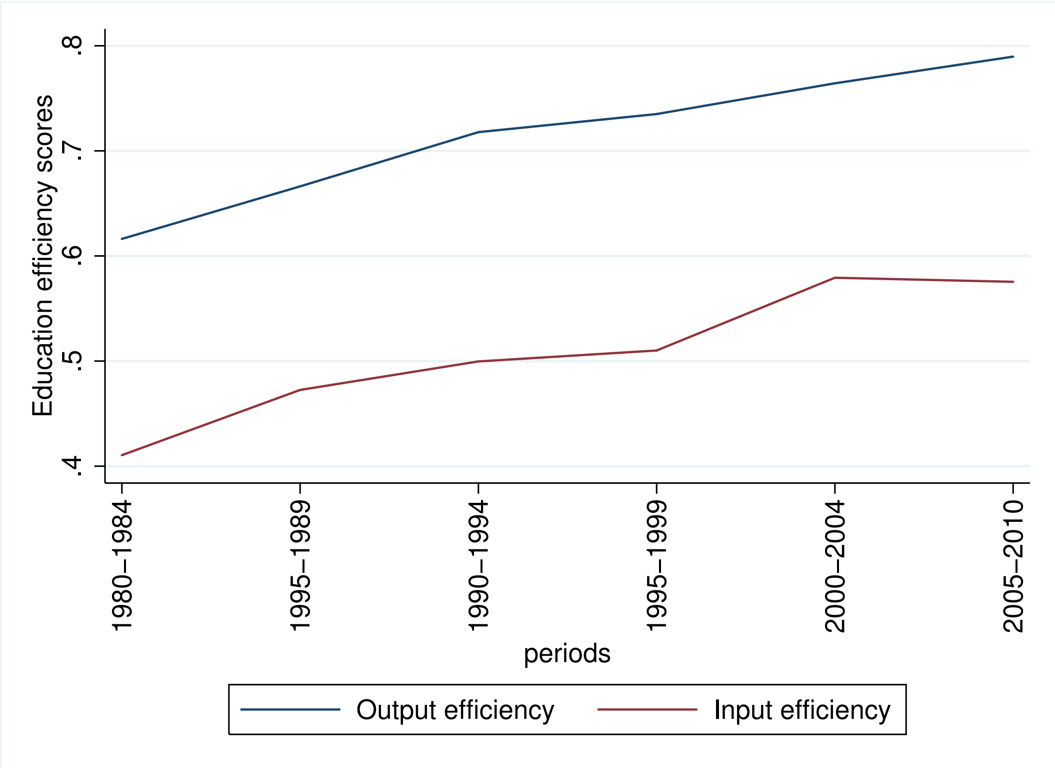
Figure 6: Average score of efficiency by income group



Source: authors

Table2 and table3 provide the evolution of output and input efficiency scores over our study period. The results show that the output efficiency score have increased over the period (figure7 and table2. As far as input efficiency is concerned, we notice an improvement of efficiency from 1980 to 2004 and a relative decreasing from 2005 to 2010 (see figure7 and table3).

Figure 7: Evolution of Output and Input efficiency score



Source: authors

Table 2: Evolution of efficiency scores output oriented

Periods	mean	p50	sd	cv	min	max	p25	p75	iqr
1980-1984	0.62	0.65	0.3	0.48	0.075	1.04	0.41	0.86	0.45
1985-1989	0.67	0.72	0.28	0.42	0.13	1.03	0.49	0.9	0.41
1990-1994	0.72	0.81	0.27	0.38	0.16	1.04	0.54	0.96	0.42
1995-1999	0.74	0.83	0.25	0.34	0.17	1.04	0.61	0.91	0.3
2000-2004	0.76	0.84	0.23	0.3	0.19	1.04	0.68	0.92	0.23
2005-2010	0.79	0.85	0.22	0.28	0.21	1.04	0.73	0.93	0.2
Average	0.71	0.8	0.26	0.37	0.075	1.04	0.54	0.92	0.38
N	390								

Source: Authors

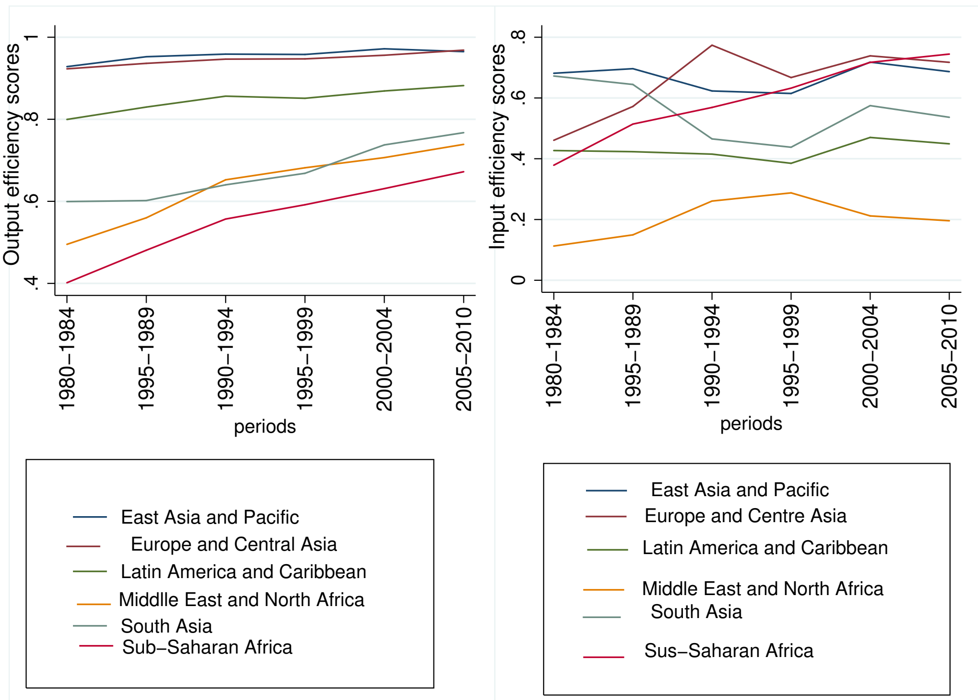
Table 3: Evolution of efficiency scores input oriented

Periods	mean	p50	sd	cv	min	max	p25	p75	iqr
1980-1984	0.41	0.27	0.37	0.89	0.031	1.45	0.14	0.7	0.56
1985-1989	0.47	0.33	0.37	0.77	0.054	1.36	0.16	0.8	0.65
1990-1994	0.5	0.34	0.4	0.8	0.056	1.67	0.18	0.77	0.59
1995-1999	0.51	0.38	0.44	0.87	0.043	2.49	0.21	0.69	0.49
2000-2004	0.58	0.48	0.38	0.65	0.054	1.78	0.27	0.9	0.63
2005-2010	0.58	0.5	0.38	0.66	0.051	1.88	0.28	0.82	0.54
Average	0.51	0.37	0.39	0.77	0.031	2.49	0.21	0.8	0.59
N	390								

Source: Authors' calculation

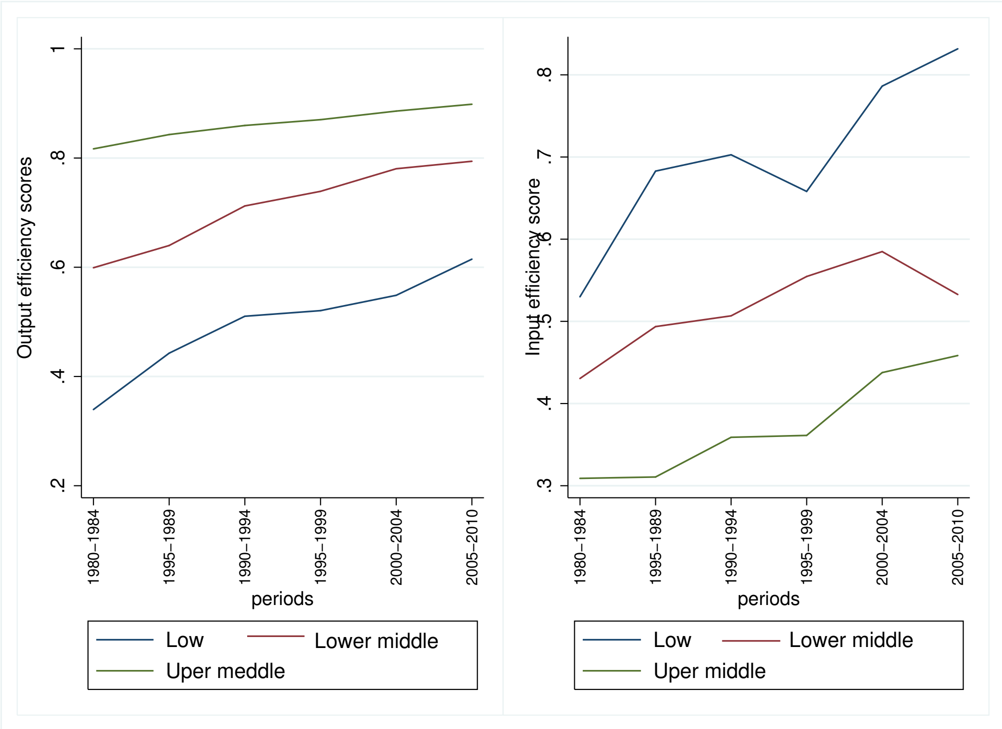
Sub-Saharan Africa, South Asia and Europe and Central Asia have improved their output efficiency score during out study period (see figure8). We also observe an improvement of output efficiency in lower and upper middle income countries over our study period (see figure9)

Figure 8: Evolution of output and input efficiency by region



Source: authors

Figure 9: Evolution of output and input efficiency by icome group



Source: authors

The sensibility tests (Pearson and Spearman's rank correlation tests) of our order-m estimators (effiEduc_output30 and effiEduc_input30) to other value of m and to order-α estimators (EffiEducalpha_output98 and EffiEducalpha_input98) are significant (at 1%) and close to 1 (see table4 and 5. Consequently, our output and input orderm-m estimators are robust (DMU's efficiency score (or its rank) are not significantly influenced by the values of m or order-α estimator).

Table 4: Sensibility of output efficiency score to other values of m and orderalpha estimator

	Pearson correlation test			
	effiEduc_output30	effiEduc_output16	effiEduc_output49	EffiEducalpha_output98
effiEduc_output30	1.0000			
effiEduc_output16	0.9993*	1.0000		
effiEduc_output49	0.9998*	0.9987*	1.0000	
EffiEducalpha_output98	0.9992*	0.9976*	0.9996*	1.0000
	Spearman correlation test			
	effiEduc_output30	effiEduc_output16	effiEduc_output49	EffiEducalpha_output98
effiEduc_output30	1.0000			
effiEduc_output16	0.9983*	1.0000		
effiEduc_output49	0.9993*	0.9970*	1.0000	
EffiEducalpha_output98	0.9967*	0.9935*	0.9979*	1.0000

Source Authors'calculation.
Note: *p< 0.01

Table 5: Sensibility of input efficiency score to other values of m and to orderalpha estimator

	Pearson correlation test			
	effiEduc_input30	effiEduc_input16	effiEduc_input49	EffiEducalpha_input98
effiEduc_input30	1.0000			
effiEduc_input16	0.9760*	1.0000		
effiEduc_input49	0.9910*	0.9438*	1.0000	
EffiEducalpha_input98	0.9442*	0.8701*	1.0000	1.0000
	Spearman correlation test			
	effiEduc_input30	effiEduc_input16	effiEduc_input49	EffiEducalpha_input98
effiEduc_input30	1.0000			
effiEduc_input16	0.9885*	1.0000		
effiEduc_input49	0.9951*	0.9758*	1.0000	
EffiEducalpha_input98	0.9813*	0.9608*	0.9850*	1.0000

Source Authors'calculation.

Note: *p< 0.01

4.4 Determinants of Education's output efficiency score

Table6 shows the main determinants of education spending's output efficiency for logit and CLoglog specifications. These results provide the following observations:
The logarithm of real GDP per capita has a positive effect on public spending efficiency for logit and Cloglog specifications. However this effect is not significant. The logarithm of real per capita GDP squared and debt lower significantly education public spending efficiency for logit specification. But, debt has non significant impact in Cloglog specification. Urban rate, financial development and government stability impact positively and significantly public spending on education for logit specification. However the impact of financial development is not significant for Cloglog specification. Corruption has a non significant impact on education public spending efficiency for both specifications. Moreover its effect is negative and non significant for the complementary loglog specification. Democracy has a positive and significant on education output efficiency for the Cloglog specification.

Table7 reports the determinants of education output efficiency including taxation. Our results show that only urbanization government stability and democracy have a positive and significant impact on education output efficiency. Trade has a positive and significant effect on education efficiency for logit specification. The impact of taxation variables (total tax revenue, resources and non resources taxes) are negligible. These results may be due to the number of observation. In fact there is great decrease of observations between our previous (281 observations) and our last regression (188 observation)

Table 6: Determinant of education output efficiency

	Logit	Cloglog
logGDPpercap	2.417	1.177
	(1.651)	(0.971)
logGDPpercapSq	-0.233**	-0.113*
	(0.115)	(0.065)
Trade	0.337	0.032
	(0.294)	(0.139)
Urbanrate	0.052***	0.028***
	(0.009)	(0.005)
FD	1.769 *	0.651
	(0.929)	(0.496)
debt	-0.109**	-0.027
	(0.045)	(0.029)
Corruption	0.001	-0.019
	(0.050)	(0.024)
GovernmentStability	0.040***	0.042***
	(0.020)	(0.010)
Democracy	0.203	0.170 *
	(0.202)	(0.092)
Number of observations	281	281
Number of Countries	59	59

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7: Determinant of education output efficiency including taxation variables

	Logit				Cloglog			
logGDPpercap	0.445	0.424	0.513	0.573	0.248	0.280	0.294	0.322
	(1.873)	(1.830)	(1.778)	(1.795)	(1.098)	(1.114)	(1.023)	(1.036)
logGDPpercapSq	-0.118	-0.115	-0.119	-0.123	-0.057	-0.059	-0.058	-0.060
	(0.123)	(0.120)	(0.117)	(0.118)	(0.071)	(0.072)	(0.066)	(0.067)
Trade	0.456*	0.501*	0.521*	0.502*	0.132	0.122	0.180	0.170
	(0.272)	(0.289)	(0.288)	(0.288)	(0.120)	(0.114)	(0.115)	(0.113)
Urbanrate	0.049***	0.049***	0.049***	0.050***	0.031***	0.031***	0.031***	0.031***
	(0.010)	(0.011)	(0.010)	(0.011)	(0.006)	(0.006)	(0.006)	(0.006)
FD	0.781	0.825	0.925	0.954	0.038	0.056	0.139	0.155
	(0.837)	(0.867)	(0.901)	(0.900)	(0.475)	(0.479)	(0.488)	(0.489)
debt	-0.056	-0.070	-0.049	-0.032	0.013	0.023	0.017	0.026
	(0.147)	(0.146)	(0.144)	(0.150)	(0.082)	(0.086)	(0.079)	(0.082)
Corruption	-0.029	-0.030	-0.036	-0.038	-0.014	-0.015	-0.019	-0.020
	(0.042)	(0.042)	(0.041)	(0.041)	(0.023)	(0.023)	(0.022)	(0.022)
GovernmentStability	0.056***	0.058***	0.061***	0.060***	0.043***	0.043***	0.047***	0.046***
	(0.020)	(0.022)	(0.021)	(0.021)	(0.011)	(0.011)	(0.011)	(0.012)
Democracy	0.381**	0.369**	0.357**	0.359**	0.240***	0.241***	0.222**	0.223**
	(0.169)	(0.174)	(0.174)	(0.172)	(0.091)	(0.090)	(0.093)	(0.092)
tesc		-0.008						
		(0.016)						
restax				0.009		0.005		0.004
				(0.015)		(0.011)		(0.010)
nonrestaxes			-0.018	-0.017			-0.013	-0.013
			(0.020)	(0.020)			(0.011)	(0.011)
Number of observations	188	188	188	188	188	188	188	188
Number of Countries	46	46	46	46	46	46	46	46

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 CONCLUSION

Developing countries face to relative high education inequality. Facing with the limited resources to reduce it, assessment of public spending efficiency Is crucial in these countries. Based on this, the paper assesses the efficiency of public spending in improving the distribution of education in developing countries from 1980 to 2010. . For this purpose, we use nonparametric partial frontier estimator to compute output and input technical efficiency scores. This method is more robust to extreme values or outliers than the other nonparametric estimators (specifically, FDH and DEA). We also used exponential Fractional Regression Model (EFRM) to analyze the determinants of our education output efficiency.

Our results show that in average developing countries might reduce their education inequality by 29% without changing their education public spending. Education output efficiency is very low in sub-Saharan Africa and low-income countries. We also notice that developing countries have achieve significant progress. As far as education input efficiency is concerned, our results indicate that developing countries could reduce their education public expenditures by 49% to achieve the same results. Education input efficiency has been improved from 1980 to 2004 but has known a relative decreasing from 2005 to 2010. We also highlight the robustness of our estimators via Pearson and Spearman's correlation tests.

From EFRM results we find that GDP squared, urbanization, and institutional quality (government stability) are the main determinant of education output efficiency for logit and complementary loglog specifications. However, when we take taxation variables into account, only urbanization, government stability and democracy are statistically significant. This later result may be due to lack of data on taxation.

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Appendix

A Descriptive statistics of education output efficiency scores by region

Regions	mean	p50	sd	cv	min	max	p25	p75	iqr
East Asia and Pacific	0.96	0.98	0.077	0.08	0.78	1.04	0.89	1.02	0.14
Europe and Central Asia	0.95	0.99	0.1	0.11	0.74	1.04	0.88	1.03	0.15
Latin America and Caribbean	0.85	0.86	0.12	0.14	0.42	1.03	0.8	0.93	0.14
Middle East and North Africa	0.64	0.66	0.18	0.28	0.25	1	0.52	0.79	0.27
South Asia	0.67	0.64	0.22	0.34	0.32	1.01	0.51	0.85	0.33
Sub-Saharan Africa	0.56	0.54	0.3	0.54	0.075	1.02	0.28	0.84	0.56
Average	0.71	0.8	0.26	0.37	0.075	1.04	0.54	0.92	0.38
N	390								

Source Authors'calculation

B Descriptive statistics of education input efficiency scores by region

Regions	mean	p50	sd	cv	min	max	p25	p75	iqr
East Asia and Pacific	0.67	0.82	0.39	0.58	0.057	1.14	0.21	1	0.79
Europe and Central Asia	0.66	0.73	0.34	0.51	0.14	1	0.3	1	0.7
Latin America and Caribbean	0.43	0.28	0.33	0.77	0.05	1.45	0.2	0.65	0.45
Middle East and North Africa	0.2	0.12	0.23	1.11	0.043	1.17	0.074	0.25	0.18
South Asia	0.56	0.49	0.28	0.51	0.21	1	0.3	0.82	0.53
Sub-Saharan Africa	0.59	0.48	0.43	0.73	0.031	2.49	0.27	0.83	0.56
Average	0.51	0.37	0.39	0.77	0.031	2.49	0.21	0.8	0.59
N	390								

Source Authors'calculation

C Descriptive statistics of education output efficiency scores by income level

Income groups	mean	p50	sd	cv	min	max	p25	p75	iqr
Low income	0.5	0.38	0.31	0.63	0.075	1	0.21	0.82	0.61
Lower middle income	0.71	0.72	0.24	0.34	0.16	1.04	0.54	0.92	0.38
Uper middle income	0.86	0.87	0.12	0.14	0.43	1.04	0.81	0.95	0.14
Averge	0.71	0.8	0.26	0.37	0.075	1.04	0.54	0.92	0.38
N	390								

Source Authors'calculation

D Descriptive statistics of education input efficiency scores by income level

Income groups	mean	p50	sd	cv	min	max	p25	p75	iqr
low income	0.70	0.66	0.34	0.49	0.18	1.72	0.42	0.97	0.55
lower middle income	0.52	0.32	0.43	0.83	0.03	2.49	0.21	0.82	0.61
uper middle income	0.37	0.26	0.31	0.84	0.04	1.02	0.14	0.53	0.39
Average	0.51	0.37	0.39	0.77	0.03	2.49	0.21	0.80	0.59
N	390								

Source Authors'calculation

E list of country used

Country for which efficiency score is computed	**Output efficiency is rage between 0 and 1**	**First Regression**	**Second Regression (including taxation)**
Country for which efficiency score is computed	**Output efficiency is rage between 0 and 1**	**First Regression**	**Second Regression (including taxation)**
Albania	Albania	Albania	Albania
Algeria	Algeria	Algeria	Argentina
Argentina	Argentina	Argentina	Bolivia
Bangladesh	Bangladesh	Bangladesh	Brazil
Bolivia	Bolivia	Bolivia	Burkina Faso
Brazil	Brazil	Brazil	Cameroon
Bulgaria	Burkina Faso	Burkina Faso	Colombia
Burkina Faso	Cameroon	Cameroon	Costa Rica

Country for which efficiency score is computed	Output efficiency is rage between 0 and 1	First Regression	Second Regression (including taxation)
Cameroon	Colombia	Colombia	Côte d'Ivoire
Colombia	Costa Rica	Costa Rica	Dominican Republic
Costa Rica	Côte d'Ivoire	Côte d'Ivoire	Ecuador
Côte d'Ivoire	Dominican Republic	Dominican Republic	El Salvador
Dominican Republic	Ecuador	Ecuador	Gabon
Ecuador	Egypt	Egypt	Gambia
Egypt	El Salvador	El Salvador	Ghana
El Salvador	Ethiopia	Gabon	Guatemala
Ethiopia	Gabon	Gambia	Guinea
Gabon	Gambia	Ghana	Honduras
Gambia	Ghana	Guatemala	India
Ghana	Guatemala	Guinea	Jamaica
Guatemala	Guinea	Haiti	Jordan
Guinea	Haiti	Honduras	Kenya
Haiti	Honduras	India	Madagascar
Honduras	India	Indonesia	Malawi
India	Indonesia	Iran (Islamic Republic of)	Mali
Indonesia	Iran (Islamic Republic of)	Jamaica	Mexico
Iran (Islamic Republic of)	Jamaica	Jordan	Morocco

Country for which efficiency score is computed	**Output efficiency is rage between 0 and 1**	**First Regression**	**Second Regression (including taxation)**
Jamaica	Jordan	Kenya	Mozambique
Jordan	Kenya	Lebanon	Namibia
Kenya	Lebanon	Liberia	Niger
Lebanon	Liberia	Madagascar	Nigeria
Liberia	Madagascar	Malawi	Pakistan
Madagascar	Malawi	Malaysia	Panama
Malawi	Malaysia	Mali	Paraguay
Malaysia	Mali	Mexico	Peru
Mali	Mexico	Morocco	Romania
Mexico	Morocco	Mozambique	Senegal
Mongolia	Mozambique	Namibia	Sierra Leone
Morocco	Namibia	Nicaragua	South Africa
Mozambique	Nicaragua	Niger	Thailand
Namibia	Niger	Nigeria	Togo
Nicaragua	Nigeria	Pakistan	Turkey
Niger	Pakistan	Panama	Uganda
Nigeria	Panama	Paraguay	United Republic of Tanzania
Pakistan	Paraguay	Peru	Venezuela
Panama	Peru	Philippines	Viet Nam

Paraguay	Philippines	Senegal	
Peru	Romania	Sierra Leone	
Philippines	Senegal	South Africa	
Romania	Sierra Leone	Sri Lanka	
Senegal	South Africa	Sudan	
Sierra Leone	Sri Lanka	Thailand	
South Africa	Sudan	Togo	
Sri Lanka	Syrian Arab Republic	Tunisia	
Sudan	Thailand	Turkey	
Syrian Arab Republic	Togo	Uganda	
Thailand	Tunisia	United Republic of Tanzania	
Togo	Turkey	Venezuela	
Tunisia	Uganda	Viet Nam	
Turkey	United Republic of Tanzania		
Uganda	Venezuela		
United Republic of Tanzania	Viet Nam		
Venezuela	Zambia		
Viet Nam			
Zambia			
Total = 65	Total = 63	Total = 59	Total = 46

Source: Authors' calculation

F Education Efficiency Scores

Country	**id**	**code**	**period**	**Output efficiency**	**Input efficiency**
Country	id	code	year	Output efficiency	Input efficiency
Albania	1	ALB	1980-1984	0.936904669	0.30494979
Albania	1	ALB	1985-1989	0.955996692	0.305873126
Albania	1	ALB	1990-1994	1.011498451	1
Albania	1	ALB	1995-1999	0.984068334	0.77450043
Albania	1	ALB	2000-2004	1.002596617	0.966671646
Albania	1	ALB	2005-2010	1.030608058	1
Algeria	2	DZA	1980-1984	0.425112307	0.045602422
Algeria	2	DZA	1985-1989	0.515994489	0.066885889
Algeria	2	DZA	1990-1994	0.597665966	0.079126343
Algeria	2	DZA	1995-1999	0.663461685	0.074523166
Algeria	2	DZA	2000-2004	0.702233791	0.136619449
Algeria	2	DZA	2005-2010	0.746936142	0.137037501
Argentina	3	ARG	1980-1984	0.992442906	0.69576019
Argentina	3	ARG	1985-1989	1.001588583	0.460963428
Argentina	3	ARG	1990-1994	0.957878768	0.466602832
Argentina	3	ARG	1995-1999	0.94031173	0.280630231
Argentina	3	ARG	2000-2004	0.934341192	0.364783019
Argentina	3	ARG	2005-2010	0.930572987	0.38702777
Bangladesh	4	BGD	1980-1984	0.623249769	0.959137022
Bangladesh	4	BGD	1985-1989	0.635415614	0.98600775
Bangladesh	4	BGD	1990-1994	0.639518499	0.596423805
Bangladesh	4	BGD	1995-1999	0.653231323	0.478211135
Bangladesh	4	BGD	2000-2004	0.697421372	0.728322744

Country	id	code	period	Output efficiency	Input efficiency
Bangladesh	4	BGD	2005-2010	0.734275281	0.659936607
Bolivia	5	BOL	1980-1984	0.618969977	0.214088649
Bolivia	5	BOL	1985-1989	0.667653918	0.430560648
Bolivia	5	BOL	1990-1994	0.720981896	0.301945359
Bolivia	5	BOL	1995-1999	0.741517842	0.279827625
Bolivia	5	BOL	2000-2004	0.784333706	0.279210567
Bolivia	5	BOL	2005-2010	0.854011297	0.255598277
Brazil	6	BRA	1980-1984	0.785562396	0.143551305
Brazil	6	BRA	1985-1989	0.800108194	0.129014224
Brazil	6	BRA	1990-1994	0.813263178	0.171136022
Brazil	6	BRA	1995-1999	0.816173494	0.166277617
Brazil	6	BRA	2000-2004	0.843701661	0.272878379
Brazil	6	BRA	2005-2010	0.839385033	0.275658906
Bulgaria	7	BGR	1980-1984	1.036768198	1
Bulgaria	7	BGR	1985-1989	1.03253293	1
Bulgaria	7	BGR	1990-1994	1.028594851	1
Bulgaria	7	BGR	1995-1999	1.027989268	1
Bulgaria	7	BGR	2000-2004	1.028382897	1
Bulgaria	7	BGR	2005-2010	1.023425341	1
Burkina Faso	8	BFA	1980-1984	0.126959532	0.880245388
Burkina Faso	8	BFA	1985-1989	0.149487272	0.803153336
Burkina Faso	8	BFA	1990-1994	0.170442164	0.542364061
Burkina Faso	8	BFA	1995-1999	0.177064672	0.467419773
Burkina Faso	8	BFA	2000-2004	0.203789666	0.516003251
Burkina Faso	8	BFA	2005-2010	0.231444359	0.441074222
Cameroon	9	CMR	1980-1984	0.535983026	0.207828343
Cameroon	9	CMR	1985-1989	0.57390672	0.252853185
Cameroon	9	CMR	1990-1994	0.691373467	0.327234685
Cameroon	9	CMR	1995-1999	0.852913439	0.379893899
Cameroon	9	CMR	2000-2004	0.879703462	0.477055997

Country	id	code	period	Output efficiency	Input efficiency
Cameroon	9	CMR	2005-2010	0.908646166	0.667468786
Colombia	10	COL	1980-1984	0.826842785	0.143107861
Colombia	10	COL	1985-1989	0.849954844	0.195072085
Colombia	10	COL	1990-1994	0.826281309	0.206052199
Colombia	10	COL	1995-1999	0.835529447	0.292036027
Colombia	10	COL	2000-2004	0.841755211	0.32330665
Colombia	10	COL	2005-2010	0.848095238	0.396137297
Costa Rica	11	CRI	1980-1984	0.907475233	0.15091835
Costa Rica	11	CRI	1985-1989	0.900942624	0.090858087
Costa Rica	11	CRI	1990-1994	0.892965019	0.106652439
Costa Rica	11	CRI	1995-1999	0.873493254	0.15051803
Costa Rica	11	CRI	2000-2004	0.870829046	0.20966877
Costa Rica	11	CRI	2005-2010	0.888520539	0.283636212
Côte d'Ivoire	12	CIV	1980-1984	0.237461135	0.093900368
Côte d'Ivoire	12	CIV	1985-1989	0.287797004	0.123813957
Côte d'Ivoire	12	CIV	1990-1994	0.331952393	0.111849442
Côte d'Ivoire	12	CIV	1995-1999	0.377972513	0.13322708
Côte d'Ivoire	12	CIV	2000-2004	0.433643758	0.244954497
Côte d'Ivoire	12	CIV	2005-2010	0.529197276	0.290067673
Dominican Republic	13	DOM	1980-1984	1.016626835	1
Dominican Republic	13	DOM	1985-1989	1.013507366	1
Dominican Republic	13	DOM	1990-1994	1.033675075	1.01461339
Dominican Republic	13	DOM	1995-1999	1.018753767	1.00583601
Dominican Republic	13	DOM	2000-2004	0.999465942	0.865670919
Dominican Republic	13	DOM	2005-2010	0.992684901	0.727308512
Ecuador	14	ECU	1980-1984	0.828739941	0.107165575
Ecuador	14	ECU	1985-1989	0.861071825	0.221968025
Ecuador	14	ECU	1990-1994	0.882484436	0.337871104
Ecuador	14	ECU	1995-1999	0.911525309	0.639136136
Ecuador	14	ECU	2000-2004	1.026859164	1.024969697

Country	id	code	period	Output efficiency	Input efficiency
Ecuador	14	ECU	2005-2010	0.948248625	0.928504705
Egypt	15	EGY	1980-1984	0.408800364	0.228160694
Egypt	15	EGY	1985-1989	0.45738709	0.213365227
Egypt	15	EGY	1990-1994	0.517321765	0.169193789
Egypt	15	EGY	1995-1999	0.561364889	0.118973345
Egypt	15	EGY	2000-2004	0.626180112	0.127479583
Egypt	15	EGY	2005-2010	0.713397026	0.111044906
El Salvador	16	SLV	1980-1984	1	1.446907878
El Salvador	16	SLV	1985-1989	1	1.358930707
El Salvador	16	SLV	1990-1994	0.951505721	0.952943027
El Salvador	16	SLV	1995-1999	0.897552788	0.513653755
El Salvador	16	SLV	2000-2004	0.917676032	0.699861765
El Salvador	16	SLV	2005-2010	0.827661216	0.49509424
Ethiopia	17	ETH	1980-1984	0.161420152	0.761736989
Ethiopia	17	ETH	1985-1989	0.286837131	0.896621287
Ethiopia	17	ETH	1990-1994	0.347478658	0.641738176
Ethiopia	17	ETH	1995-1999	0.363389313	0.726453304
Ethiopia	17	ETH	2000-2004	0.53373611	1.108499169
Ethiopia	17	ETH	2005-2010	0.48428309	0.755035877
Gabon	18	GAB	1980-1984	0.548168242	0.046605479
Gabon	18	GAB	1985-1989	0.619949281	0.072193854
Gabon	18	GAB	1990-1994	0.68848592	0.110725023
Gabon	18	GAB	1995-1999	0.752601743	0.176414281
Gabon	18	GAB	2000-2004	0.783897519	0.266515523
Gabon	18	GAB	2005-2010	0.84344399	0.320201457
Gambia	19	GMB	1980-1984	0.316476315	0.176870674
Gambia	19	GMB	1985-1989	0.348163962	0.25415501
Gambia	19	GMB	1990-1994	0.430532753	0.227509737
Gambia	19	GMB	1995-1999	0.562876463	0.246794015
Gambia	19	GMB	2000-2004	0.611700535	0.563194096

Country	id	code	period	Output efficiency	Input efficiency
Gambia	19	GMB	2005-2010	0.650360167	0.72033602
Ghana	20	GHA	1980-1984	0.480300188	0.267347753
Ghana	20	GHA	1985-1989	0.494925112	0.328011096
Ghana	20	GHA	1990-1994	0.574383378	0.306327015
Ghana	20	GHA	1995-1999	0.635173142	0.27014944
Ghana	20	GHA	2000-2004	0.764067948	0.335428655
Ghana	20	GHA	2005-2010	0.799193025	0.25434801
Guatemala	21	GTM	1980-1984	0.532765865	0.267287582
Guatemala	21	GTM	1985-1989	0.590311587	0.391377419
Guatemala	21	GTM	1990-1994	0.634756207	0.33688283
Guatemala	21	GTM	1995-1999	0.671612859	0.244156227
Guatemala	21	GTM	2000-2004	0.684564829	0.271421582
Guatemala	21	GTM	2005-2010	0.711691916	0.192072675
Guinea	22	GIN	1980-1984	0.114614904	0.279353589
Guinea	22	GIN	1985-1989	0.137953967	0.401397377
Guinea	22	GIN	1990-1994	0.195090681	0.366987258
Guinea	22	GIN	1995-1999	0.222704515	0.379028827
Guinea	22	GIN	2000-2004	0.354988962	0.917839408
Guinea	22	GIN	2005-2010	0.317745537	1.103327632
Haiti	23	HTI	1980-1984	0.415807456	0.79127425
Haiti	23	HTI	1985-1989	0.664216995	0.951280296
Haiti	23	HTI	1990-1994	1	1.296035528
Haiti	23	HTI	1995-1999	0.779751956	0.980110884
Haiti	23	HTI	2000-2004	0.852863193	1.080651999
Haiti	23	HTI	2005-2010	0.910636008	0.931601465
Honduras	24	HND	1980-1984	0.624097586	0.262720406
Honduras	24	HND	1985-1989	0.661606133	0.312103987
Honduras	24	HND	1990-1994	0.695837915	0.228157669
Honduras	24	HND	1995-1999	0.736908615	0.204492673
Honduras	24	HND	2000-2004	0.766492188	0.22286199

Country	id	code	period	Output efficiency	Input efficiency
Honduras	24	HND	2005-2010	0.803984046	0.200286448
India	25	IND	1980-1984	0.454399049	0.433711082
India	25	IND	1985-1989	0.492898375	0.4979195
India	25	IND	1990-1994	0.536383152	0.284026116
India	25	IND	1995-1999	0.578844011	0.218339443
India	25	IND	2000-2004	0.699861586	0.297177166
India	25	IND	2005-2010	0.734441996	0.26341626
Indonesia	26	IDN	1980-1984	0.860718369	0.692077816
Indonesia	26	IDN	1985-1989	0.915322006	0.819737911
Indonesia	26	IDN	1990-1994	0.949920475	0.652547657
Indonesia	26	IDN	1995-1999	0.97640115	0.668901265
Indonesia	26	IDN	2000-2004	0.983629704	0.929432452
Indonesia	26	IDN	2005-2010	0.954597712	0.825935483
Iran (Islamic Republic of)	27	IRN	1980-1984	0.445205778	0.074388385
Iran (Islamic Republic of)	27	IRN	1985-1989	0.536632419	0.147029832
Iran (Islamic Republic of)	27	IRN	1990-1994	0.590795159	0.110450648
Iran (Islamic Republic of)	27	IRN	1995-1999	0.669174254	0.082040139
Iran (Islamic Republic of)	27	IRN	2000-2004	0.69893539	0.12545985
Iran (Islamic Republic of)	27	IRN	2005-2010	0.733467877	0.108143978
Jamaica	28	JAM	1980-1984	1.01721704	1
Jamaica	28	JAM	1985-1989	1.006245971	0.986136019
Jamaica	28	JAM	1990-1994	0.998668313	0.666718721
Jamaica	28	JAM	1995-1999	0.997172117	0.514987946
Jamaica	28	JAM	2000-2004	0.987380683	0.665015578
Jamaica	28	JAM	2005-2010	0.991237581	0.815514147
Jordan	29	JOR	1980-1984	0.650536835	0.073802106
Jordan	29	JOR	1985-1989	0.720692098	0.100239426
Jordan	29	JOR	1990-1994	0.77985394	0.176776752
Jordan	29	JOR	1995-1999	0.828593671	0.275204778
Jordan	29	JOR	2000-2004	0.864857793	0.296308935

Country	id	code	period	Output efficiency	Input efficiency
Jordan	29	JOR	2005-2010	0.876347363	0.272949517
Kenya	30	KEN	1980-1984	0.650797367	0.197506711
Kenya	30	KEN	1985-1989	0.726876795	0.29450497
Kenya	30	KEN	1990-1994	0.783441961	0.304509282
Kenya	30	KEN	1995-1999	0.839587033	0.601674974
Kenya	30	KEN	2000-2004	0.914478779	0.833010256
Kenya	30	KEN	2005-2010	1.015903234	1.039678335
Lebanon	31	LBN	1980-1984	0.734021068	0.172418579
Lebanon	31	LBN	1985-1989	0.791572571	0.205214083
Lebanon	31	LBN	1990-1994	0.831343532	0.385662824
Lebanon	31	LBN	1995-1999	0.828424752	0.480475575
Lebanon	31	LBN	2000-2004	0.847187459	0.39741686
Lebanon	31	LBN	2005-2010	0.86726284	0.477496475
Liberia	32	LBR	1980-1984	0.103886545	0.285585999
Liberia	32	LBR	1985-1989	0.127987519	0.421942919
Liberia	32	LBR	1990-1994	0.276276052	1.010403752
Liberia	32	LBR	1995-1999	0.279720813	1.364951015
Liberia	32	LBR	2000-2004	0.28822273	1.002755761
Liberia	32	LBR	2005-2010	1	1.246625423
Madagascar	33	MDG	1980-1984	0.733722031	0.657413065
Madagascar	33	MDG	1985-1989	0.761516869	0.964084089
Madagascar	33	MDG	1990-1994	1.003420711	1.255132675
Madagascar	33	MDG	1995-1999	1.000165701	1.112994194
Madagascar	33	MDG	2000-2004	0.89271754	0.969876707
Madagascar	33	MDG	2005-2010	1	1.724657774
Malawi	34	MWI	1980-1984	0.575289667	0.419059902
Malawi	34	MWI	1985-1989	0.62109375	0.585716128
Malawi	34	MWI	1990-1994	0.843618453	0.666300416
Malawi	34	MWI	1995-1999	0.817717969	0.527516961
Malawi	34	MWI	2000-2004	0.840866446	0.874981344

Country	id	code	period	Output efficiency	Input efficiency
Malawi	34	MWI	2005-2010	0.881485462	0.686608493
Malaysia	35	MYS	1980-1984	0.779523611	0.056918386
Malaysia	35	MYS	1985-1989	0.82522887	0.079138152
Malaysia	35	MYS	1990-1994	0.849169314	0.077314369
Malaysia	35	MYS	1995-1999	0.880906641	0.089814298
Malaysia	35	MYS	2000-2004	0.897524774	0.104161084
Malaysia	35	MYS	2005-2010	0.912908435	0.136771068
Mali	36	MLI	1980-1984	0.107303239	0.831685603
Mali	36	MLI	1985-1989	0.17127417	0.782269359
Mali	36	MLI	1990-1994	0.180289313	0.507160902
Mali	36	MLI	1995-1999	0.172330454	0.372828275
Mali	36	MLI	2000-2004	0.188996553	0.490874857
Mali	36	MLI	2005-2010	0.209727719	0.453204006
Mexico	37	MEX	1980-1984	0.766485929	0.053228095
Mexico	37	MEX	1985-1989	0.8125	0.091809593
Mexico	37	MEX	1990-1994	0.825640917	0.10103859
Mexico	37	MEX	1995-1999	0.828912735	0.145945013
Mexico	37	MEX	2000-2004	0.843260109	0.159992576
Mexico	37	MEX	2005-2010	0.851197422	0.209856391
Mongolia	38	MNG	1980-1984	1.017717123	1
Mongolia	38	MNG	1985-1989	1.029700875	1
Mongolia	38	MNG	1990-1994	1.03721714	1
Mongolia	38	MNG	1995-1999	1.041301847	1
Mongolia	38	MNG	2000-2004	1.044209003	1
Mongolia	38	MNG	2005-2010	1.02291584	1
Morocco	39	MAR	1980-1984	0.252278209	0.098609664
Morocco	39	MAR	1985-1989	0.291738689	0.089422949
Morocco	39	MAR	1990-1994	0.332965106	0.056252368
Morocco	39	MAR	1995-1999	0.376699448	0.054979555
Morocco	39	MAR	2000-2004	0.420280725	0.09369456

Country	id	code	period	Output efficiency	Input efficiency
Morocco	39	MAR	2005-2010	0.45849067	0.09668494
Mozambique	40	MOZ	1980-1984	0.159278169	0.811294734
Mozambique	40	MOZ	1985-1989	1	1.328588247
Mozambique	40	MOZ	1990-1994	0.375482529	1.060758948
Mozambique	40	MOZ	1995-1999	0.391301721	1.06331718
Mozambique	40	MOZ	2000-2004	0.32989046	0.777419269
Mozambique	40	MOZ	2005-2010	0.337503672	0.642567456
Namibia	41	NAM	1980-1984	0.679805815	0.162415996
Namibia	41	NAM	1985-1989	0.717566013	0.155883566
Namibia	41	NAM	1990-1994	0.759288847	0.184626639
Namibia	41	NAM	1995-1999	0.782951832	0.204917341
Namibia	41	NAM	2000-2004	0.815484285	0.242274746
Namibia	41	NAM	2005-2010	0.84073931	0.284815788
Nicaragua	42	NIC	1980-1984	0.579006493	0.099315867
Nicaragua	42	NIC	1985-1989	0.619778633	0.129923999
Nicaragua	42	NIC	1990-1994	0.651012778	0.220800593
Nicaragua	42	NIC	1995-1999	0.753032804	0.22595115
Nicaragua	42	NIC	2000-2004	0.751515388	0.268545449
Nicaragua	42	NIC	2005-2010	0.873546243	0.247994825
Niger	43	NER	1980-1984	0.074586637	0.420666337
Niger	43	NER	1985-1989	0.135920018	0.675039768
Niger	43	NER	1990-1994	0.164873317	0.535057724
Niger	43	NER	1995-1999	0.187956229	0.537002206
Niger	43	NER	2000-2004	0.274130106	1.019149065
Niger	43	NER	2005-2010	0.254230112	0.86465776
Nigeria	44	NGA	1980-1984	0.37812078	0.133905724
Nigeria	44	NGA	1985-1989	0.471717179	0.736542761
Nigeria	44	NGA	1990-1994	1	1.673667431
Nigeria	44	NGA	1995-1999	1	2.49353075
Nigeria	44	NGA	2000-2004	1	1.326064467

Country	id	code	period	Output efficiency	Input efficiency
Nigeria	44	NGA	2005-2010	0.758934677	0.50021857
Pakistan	45	PAK	1980-1984	0.315175563	0.294063807
Pakistan	45	PAK	1985-1989	0.319681793	0.297613174
Pakistan	45	PAK	1990-1994	0.398139477	0.209373429
Pakistan	45	PAK	1995-1999	0.4396061	0.207619056
Pakistan	45	PAK	2000-2004	0.544721663	0.37606898
Pakistan	45	PAK	2005-2010	0.585956633	0.323150545
Panama	46	PAN	1980-1984	0.856601	0.063815162
Panama	46	PAN	1985-1989	0.865009069	0.106826089
Panama	46	PAN	1990-1994	0.871890247	0.129118785
Panama	46	PAN	1995-1999	0.859134376	0.175678045
Panama	46	PAN	2000-2004	0.866576791	0.238332063
Panama	46	PAN	2005-2010	0.882747948	0.279175013
Paraguay	47	PRY	1980-1984	1.018350005	1.005324721
Paraguay	47	PRY	1985-1989	0.941607654	0.39031294
Paraguay	47	PRY	1990-1994	0.94730103	0.369037449
Paraguay	47	PRY	1995-1999	0.907501221	0.385275662
Paraguay	47	PRY	2000-2004	0.894132793	0.483451039
Paraguay	47	PRY	2005-2010	0.948436975	0.54726541
Peru	48	PER	1980-1984	0.812303901	0.192467019
Peru	48	PER	1985-1989	0.850226879	0.280364215
Peru	48	PER	1990-1994	0.874561667	0.447799891
Peru	48	PER	1995-1999	0.910115182	0.475574672
Peru	48	PER	2000-2004	0.916652262	0.653931439
Peru	48	PER	2005-2010	0.929822624	0.651568949
Philippines	49	PHL	1980-1984	1.015254617	1.003988981
Philippines	49	PHL	1985-1989	1.026496649	1.002057433
Philippines	49	PHL	1990-1994	1.003116131	0.76275301
Philippines	49	PHL	1995-1999	0.95573765	0.692739666
Philippines	49	PHL	2000-2004	1.019788146	1

Country	id	code	period	Output efficiency	Input efficiency
Philippines	49	PHL	2005-2010	1.042614341	1.011020541
Romania	50	ROU	1980-1984	0.978598833	0.401711315
Romania	50	ROU	1985-1989	0.978197932	0.81958586
Romania	50	ROU	1990-1994	0.977976322	0.909709454
Romania	50	ROU	1995-1999	0.987182319	0.628547311
Romania	50	ROU	2000-2004	0.992869318	0.691355586
Romania	50	ROU	2005-2010	1.001700282	0.578889906
Senegal	51	SEN	1980-1984	0.191300005	0.36218375
Senegal	51	SEN	1985-1989	0.217096359	0.351265877
Senegal	51	SEN	1990-1994	0.252891332	0.258901447
Senegal	51	SEN	1995-1999	0.321740806	0.250891089
Senegal	51	SEN	2000-2004	0.352548242	0.34890011
Senegal	51	SEN	2005-2010	0.387321055	0.309946656
Sierra Leone	52	SLE	1980-1984	0.20945327	0.435342759
Sierra Leone	52	SLE	1985-1989	0.236870557	0.491833866
Sierra Leone	52	SLE	1990-1994	0.263268828	0.302434802
Sierra Leone	52	SLE	1995-1999	0.353946596	0.270154208
Sierra Leone	52	SLE	2000-2004	0.41237849	0.475197494
Sierra Leone	52	SLE	2005-2010	0.46141696	0.659606159
South Africa	53	ZAF	1980-1984	0.789799094	0.042482655
South Africa	53	ZAF	1985-1989	0.848516166	0.066653617
South Africa	53	ZAF	1990-1994	0.858109653	0.083918333
South Africa	53	ZAF	1995-1999	0.889945269	0.134592026
South Africa	53	ZAF	2000-2004	0.911126614	0.266942233
South Africa	53	ZAF	2005-2010	0.92512238	0.525279284
Sri Lanka	54	LKA	1980-1984	1.004754305	1.002619982
Sri Lanka	54	LKA	1985-1989	0.959515631	0.796376169
Sri Lanka	54	LKA	1990-1994	0.987072825	0.771854043
Sri Lanka	54	LKA	1995-1999	1.001674533	0.84761107
Sri Lanka	54	LKA	2000-2004	1.008129239	0.898135781

Country	id	code	period	Output efficiency	Input efficiency
Sri Lanka	54	LKA	2005-2010	1.014958262	0.899590969
Sudan	55	SDN	1980-1984	0.167461649	0.030722912
Sudan	55	SDN	1985-1989	0.196077153	0.05449998
Sudan	55	SDN	1990-1994	0.220745116	0.072890222
Sudan	55	SDN	1995-1999	0.264794916	0.123359248
Sudan	55	SDN	2000-2004	0.359936804	0.333940923
Sudan	55	SDN	2005-2010	0.387702525	0.557237267
Syrian Arab Republic	56	SYR	1980-1984	0.578563213	0.140856832
Syrian Arab Republic	56	SYR	1985-1989	0.643586695	0.302773952
Syrian Arab Republic	56	SYR	1990-1994	1.00075376	1.050985456
Syrian Arab Republic	56	SYR	1995-1999	0.912479341	1.172607899
Syrian Arab Republic	56	SYR	2000-2004	0.828767002	0.464402735
Syrian Arab Republic	56	SYR	2005-2010	0.810935855	0.312364072
Thailand	57	THA	1980-1984	0.896913588	0.198976621
Thailand	57	THA	1985-1989	0.905887604	0.212595388
Thailand	57	THA	1990-1994	0.875290155	0.19693701
Thailand	57	THA	1995-1999	0.854820251	0.205148429
Thailand	57	THA	2000-2004	0.852908611	0.255336136
Thailand	57	THA	2005-2010	0.871568501	0.317533582
Togo	58	TGO	1980-1984	0.369460404	0.185123011
Togo	58	TGO	1985-1989	0.430712193	0.313198119
Togo	58	TGO	1990-1994	0.533709824	0.323994249
Togo	58	TGO	1995-1999	0.69312185	0.441353202
Togo	58	TGO	2000-2004	0.748370588	0.623591661
Togo	58	TGO	2005-2010	0.778526306	0.701067626
Tunisia	59	TUN	1980-1984	0.466983497	0.067507893
Tunisia	59	TUN	1985-1989	0.52140379	0.070974626
Tunisia	59	TUN	1990-1994	0.568959534	0.05753978
Tunisia	59	TUN	1995-1999	0.614151418	0.042852536
Tunisia	59	TUN	2000-2004	0.664670587	0.053523749

Country	id	code	period	Output efficiency	Input efficiency
Tunisia	59	TUN	2005-2010	0.704334676	0.051101368
Turkey	60	TUR	1980-1984	0.739751518	0.136814758
Turkey	60	TUR	1985-1989	0.778749824	0.163168654
Turkey	60	TUR	1990-1994	0.768528223	0.185477197
Turkey	60	TUR	1995-1999	0.789766312	0.266142517
Turkey	60	TUR	2000-2004	0.800741374	0.297050178
Turkey	60	TUR	2005-2010	0.818409562	0.290754676
Uganda	61	UGA	1980-1984	0.92852819	1.017473817
Uganda	61	UGA	1985-1989	0.929235995	0.938347757
Uganda	61	UGA	1990-1994	1	1.086010695
Uganda	61	UGA	1995-1999	0.848574281	0.758885205
Uganda	61	UGA	2000-2004	0.878213823	0.732874691
Uganda	61	UGA	2005-2010	0.897137642	0.672974706
United Republic of Tanzania	62	TZA	1980-1984	0.665978253	0.396275759
United Republic of Tanzania	62	TZA	1985-1989	0.708374083	0.980662584
United Republic of Tanzania	62	TZA	1990-1994	0.96495688	1.101993442
United Republic of Tanzania	62	TZA	1995-1999	1	1.098664403
United Republic of Tanzania	62	TZA	2000-2004	1	1.401032925
United Republic of Tanzania	62	TZA	2005-2010	0.905176699	1.317119598
Venezuela	63	VEN	1980-1984	0.794150352	0.050089702
Venezuela	63	VEN	1985-1989	0.830127954	0.091606729
Venezuela	63	VEN	1990-1994	0.836565852	0.120762043
Venezuela	63	VEN	1995-1999	0.842494071	0.250803739
Venezuela	63	VEN	2000-2004	0.861255348	0.378405064
Venezuela	63	VEN	2005-2010	0.846980393	0.261731565
Viet Nam	64	VNM	1980-1984	1	1.136435986
Viet Nam	64	VNM	1985-1989	1.012679696	1.065175653
Viet Nam	64	VNM	1990-1994	1.038278222	1.049363971
Viet Nam	64	VNM	1995-1999	1.039158106	1.032702923
Viet Nam	64	VNM	2000-2004	1.033002496	1.019577861

Viet Nam	64	VNM	2005-2010	0.985123158	0.829286158
Zambia	65	ZMB	1980-1984	0.735577583	0.365735114
Zambia	65	ZMB	1985-1989	0.821106732	0.581537724
Zambia	65	ZMB	1990-1994	1.012684464	1.160048723
Zambia	65	ZMB	1995-1999	1.003971338	1.675231814
Zambia	65	ZMB	2000-2004	1.003727794	1.784666538
Zambia	65	ZMB	2005-2010	1	1.875311732

Source: Authors' calculation