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ASSESSING PUBLIC SECTOR EFFICIENCY IN DEVELOPING COUNTRIES WITH DEA AND BOOTSTRAP ANALYSIS

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Absract: *The purpose of this paper is to analyse public sector efficiency of 75 developing countries. In a first step, we have computed Public Sector Performance (PSP) indicators for the period of 2000-2018. Based on these PSPs, we have estimated efficiency scores using Data Envelopment Analysis (DEA). The input-oriented DEA analysis reveals that countries can achieve the same level of performance using 42% less spending. The output-oriented DEA models conclude that developing countries can increase their performance by 33% with the same level of public spending. In a second step, we have examined the determinants of efficiency of public sector by applying a Bootstrap analysis. The empirical explanation of the efficiency scores reveals that the strong institutions can play a crucial role in enhancing the efficiency of public sector. Our findings can be useful for policymakers in order to set out a structural adjustment plan to improve the efficiency level for public sector.*

Keywords: public spending, public sector performance, efficiency, data envelopment analysis, Bootstrap analysis

1. Introduction

Recent challenging global conditions have sparked a renewed interest among academics, policy makers, and international organizations in the examination and quantification of the efficiency of public spending at the aggregate level. Due to the difficult situation often faced by governments and the expensive consequences of fiscal imbalances brought on by excessive accumulation of government debt to finance high spending levels, experienced by a handful of countries in recent decades, the ability of governments to achieve public policy outcomes using the least amount of resources possible has become more important in recent years.

Performance of the public sector has a significant impact on public sector efficiency (PSP). Public sector performance (PSP) is the sum of the performance of various governments' interventions. Public spending is a key indicator of PSP and is referenced in many kinds of literature (Afonso & Kazemi, 2017).

Public sector performance (PSP) is the ability of the government to distribute resources fairly, which can be done by maximizing the efficiency of public spending (Michael et al., 2020). On the other hand, public investment on social capital, infrastructure, and healthcare is directed toward a nation's long-term development (Anup & Yadawananda, 2019). According to Afonso et al. (2005), the unstable environment for capital flaws in developing nations is the reason that globalization puts pressure on the government to allocate resources efficiently. Policymakers advocate for increasing public spending during a nation's early stages of development without paying much regard to efficiency issues. The economy, particularly the low-income segment of the economy, could be negatively impacted by the abrupt fall in this spending. The decrease in these spending has the possibility of damage to the economy and mainly the low-income group of the economy. Rapid and ongoing reduction of public investment may result in decrease of public capital stock and long-run growth performance. Then it is undoubtedly beneficial in knowing that to what extent and how government can productively utilize its existing expanding strategy.

Efficiency analysis has its precedent on the literature quantifying production efficiency of firms or different types of decision-making units.Cherchye and Post (2001) address efficiency of electricity generating plants, Burgess and Wilson (1998) evaluate efficiency of hospitals, and Wheelock and Wilson (2003) of banking institutions. Afonso and Santos (2008) address efficiency of Portuguese Universities and Agasisti (2011) of Universities in the European Union. Other examples are Eugène (2008) for the relative efficiency of Belgian general government as provider of public order and safety, while Aubyn (2008) offers a review of the literature on law and order efficiency measurement.

In the case of public spending efficiency, the wide majority of the related literature has focused the analysis of efficiency in education and health sectors across countries (Fonchamnyo & Sama, 2016; Herrera & Ouedraogo, 2018; Ozana & Margareta, 2018; Richard & Patrizio, 2020; Lilia & Kristina, 2017). A smaller strand of the literature has centered on the evaluation of efficiency of public expendiure at the subnational or aggregate level. Notable examples are Afonso and Fernandes (2008) for the assessment of efficiency of public spending in Belgian local governments, Afonso and Scaglioni (2007) for Italian regions, and D'inverno et al. (2018) for Tuscan municipalities. To the best of our knowledge this is the first attempt in the literature to quantify the efficiency of public sector at aggregate level in the context of developing countries. For this purpose, this study uses non-parametric approach Data Envelopment Analysis (DEA) to estimate efficiency scores of public sector. This technique is a competing methodology to stochastic frontier approach (SFA) and reveals many advantages comparing with SFA, such that: (i) DEA can be applied easily and no distributional assumptions required; (ii) unlike SFA, the main feature of DEA is that it does not require specifying a functional form for production technology; (iii) in the case of production function, the DEA approach can be used in the case of multi-inputs multi-outputs. This is the main advantage vis-à-vis the SFA approach that can be only used when we have one output, or aggregate output. Therefore, in this kind of research, aggregate outputs in one output lead inevitably to misleading results. Furthermore, this research extends to assess what determines divergences in public sector efficiency using DEA-bootstrap approach. This procedure corrects likely biased DEA efficiency scores taking into account that environmental variables are correlated to output and input variables (Simar & Wilson, 2007).

The remainder of the paper is organized as follows: section 2 discusses literature review focusing on government expenditure efficiency. Data and empirical methodology which are used by this paper are presented in section 3. While section 4 presents, discusses and interprets the empirical results. Section 5 offers conclusion and policy implications.

2. Literature Review

We shall make a brief discussion about papers that have emphasized the importance of gauging the efficiency of public spending. It may be noted from the below review of existing literature that there is no such study in the case of developing countries.

Yi-Chang (2013) gauges the health expenditure efficiency for 46 European and Central Asia countries by applying DEA. He found that these countries could produce more quantity of outputs by about 2.1% while maintaining the same level of inputs.

Rouselle et al. (2015) assess the efficiency of health and education expenditure in Asian countries during the period1995–2012. Using DEA methodology, they reveal that countries could achieve higher health and education outcomes given their expenditures.

Dutu and Sicari (2016) evaluate the efficiency of health care, secondary education, and general public services in a sample of OECD countries for the year 2012. The study finds a wide dispersion in efficiency levels across OECD countries and suggested that improvements could be possible for both output and input efficiency.

Afonso and Kazemi (2017) measure the public sector efficiency of 20 OECD countries for the period 2009–2013. Public Sector Performance (PSP) and Public Sector Efficiency (PSE) indicators were constructed and Data Envelopment Analysis was conducted. The results reveal that the average input-oriented efficiency score is 0.732 denoting that on average countries could have reduced the level of public expenditure by 26.8% and still achieved the same level of public performance. The average output-oriented efficiency score is 0.769 signifying that on average the sample countries could have increased their performance by

23.1% by employing the same level of public expenditure.

Antonelli and Bonis (2019) assess the efficiency of government spending in the case of 22 European countries. First, they measure efficiencyby means of the Free Disposable Hull and Data Envelopment Analysis techniques. Second, the authors perform an econometric analysis to identify the factors that can be associated to cross-country differences. Their findings stress that, on average, 20 per cent cut in expenditure is feasible to maintain the existing output. Moreover, they show that countries scoring higher efficiency have highereducation and GDP levels, a smaller population size, a lower degree of selectivity of their welfare systems and a lower corruption level.

Moreno-Enguix and Bayano (2017) study the public spending efficiency of 35 economies in 2012 using single synthetic indicators, as well as a Free Disposal Hull and a Data Envelopment Analysis model. They exhibit that the differences in efficiency were very much pronounced across countries. Furthermore, they adopt a second-stage analysis in order to explain the inefficiency scores using a Tobit regression. Results show that a higher level of government expenditure efficiency was associated with significantly higher levels of GDP per capita, democracy, public trust in politicians, judicial independence, and a lower level of corruption. A significant finding was similarly reported between demographic factors and public spending efficiency. A higher level of population density was linked to a significantly lower level of efficiency.

Ouertani et al. (2018) examine the government spending efficiency in Saudi Arabia over the period 1988–2013 using DEA approach. The results show that, on average, the public spending is inefficient, implying that Saudi Arabia can improve their performance on health, education and infrastructure without increasing spending. They extended the analysis to identify the exogenous factors that could explain the efficiency of public expenditure. The empirical results using a DEA-Bootstrap analysis indicates that the unemployment and broad money negatively impact government expenditure mainly in the case of infrastructure and health.

Michael et al. (2020) analyse the public spending efficiency in a sample of 23 European countries over the period from 1995 to 2015 using several efficiency techniques, e.g., free disposal hull and investigate input-and output-oriented efficiency in the public sector. They investigate also the determinants of public-sector efficiency, in particular the role of fiscal decentralization and fiscal rules. The authors conclude that, whereas decentralization fosters efficiency, fiscal rules have no effect. In addition, fiscal rules, when combined with decentralization, may harm efficiency, which is consistent with the ratchet effect.

Sijuola et al. (2020) study the public sector efficiency in the design of a euro area-wide social benefit scheme. Their results reveal large-scale inefficiencies in the use of funds allocated to the scheme during the great recession and euro area sovereign debt crisis that followed, with member states wasting on average 34.6% of funds allocated to it.

3. Empirical Methodology and Data Description

3.1 Empirical Methodology

3.1.1. Public Sector Performance

Public sector performance as defined by Michael et al. (2020) is assessed by constructing composite indicators based on observable socio-economic variables that are assumed to be the output of pursued public policies. Specifically, the PSP for country i with j areas of government activity is determined by:

$$PSP_i = \Sigma\, PSP_{ij},\ i=1\ldots\ldots n;\ with\ PSP_{ij} = f\,(I_k), k=1,\ldots\ldots\ldots,n \quad (1)$$

Where is a function of *k* observable socio-economic indicators. Following Michael et al. (2020) seminar work we use two groups of indicators to define the PSP composite indicator.

The first group is composed of outcomes derived from government activities as public administrator as well as provider of public services such as education, health and infrastructure. Afonso et al. (2005) refer to this subset of indicators as “opportunity” indicators alluding to the role of the government as promoter of equal opportunities in the market place.

The second group comprises outcome indicators of government activities in terms of allocation, distribution, and stabilization functions as defined by Musgrave. Each group of indicators includes sub-indicators determined by the average value of the corresponding output variables. For instance, government performance as public administrator is defined by the average value of outcome indicators for corruption, burden of regulation (red tape), independence of the judiciary system, and the size of the informal economy. The rationale behind these indicators is the application of the rule of law, enforcement of contracts, defense of property rights and operability of well-functioning markets promoted by the state.

3.1.2 Estimating Technical Efficiency Using DEA Methodology

The non-parametric method DEA was originally developed and applied to firms that convert inputs into outputs. Coelli et al. (1998) and Sengupta (2000) introduce the reader to this literature and describe several applications. The term "firm", sometimes replaced by the more encompassing Decision Making Unit (DMUs), the term coined by Charnes et al. (1978), may include non-profit or public organisations, such as hospitals, universities, local authorities, or countries if a cross country analysis is envisaged (Afonso & Aubyn, 2005).

DEA is a widely used relative efficiency evaluation method (Afonso & Kazemi, 2017). This technique uses the tools of mathematical programming, namely linear programming (Fiala et al., 1997). The terminology"envelopment" stems out from the fact that the production frontier envelops the set of observations (Thanassoulis, 2001).

The DEA model is input or output oriented. An output oriented DEA model is channelled towards maximizing the outputs obtained by the DMUs while keeping the inputs constant, whilst the input oriented models focus on minimizing the inputs used for processing the givenamount of outputs. In present paper, the method applied for assessing the efficiency of public sector is DEA for an input oriented specification. The use of input orientation is based on the assumption that governments are concerned with minimizing budget size given a pre-determinedoutcome.DMUs are developing countries for which a number of inputs and outputs are selected.

3.1.3 Explaining Efficiency: DEA-Bootstrap Approach

The standard DEA models as the one described in (1) incorporate only discretionary inputs, those whose quantities can be changed at the DMU will, and do not take into account the presence of environmental variables or factors, also known as non-discretionary inputs. However, socio-economic differences may play a relevant role in determining heterogeneity across DMUs and influence outcomes. As non-discretionary and discretionary inputs jointly contribute to each DMU outputs, there are in the literature several proposals on how to deal with this issue, implying usually the use of two-stage and even three-stage models (Simar & Wilson, 2007).

After the estimation of efficiency scores, we attempt to explain the variations in efficiency scores of public sector, as well as to identify the most important factors that may explain the efficiency scores. Usually, we can apprehend the effects of some variables on efficiency scores by adopting the regressing equation below:

$$\delta_{it} = \beta z_{it} + \varepsilon_{it} \quad (2)$$

where :

δ_{it} is a vector of the efficiency scores;

$z_{it}$is a vector of explanatory variables that might affect the efficiency level;

β represents the unknown parameter vector to estimate;

ε_{it} is a residual term.

Fonchamnyo and Sama (2016) indicate that authors use the OLS technique, the Tobit estimation technique (Afonso et al., 2010), or the fractional logit estimation proposed by Papke and Wooldridge to estimate the linear equation (1996). Nevertheless, Simar and Wilson (2007) affirmed that the DEA efficiency scores are biased and serially correlated. We might also anticipate a correlation between inputs and outputs and non-discretionary variables that might explain efficiency. As a result, the assumption of independence between the noise terms ε_{it} and z_{it} is broken. Simar and Wilson (2007) provide the two-stage method to explain efficiency scores as a result of these shortcomings. In order to establish consistent inference on efficiency scores, i.e., standard errors, confidence intervals and to adequately estimate the model's parameters, the authors suggested a double-bootstrap approach.

The first bootstrap method ("algorithm 1") implies the estimation of the efficiency scores using DEA. However, the influence of non-discretionary inputs on efficiency is estimated by means of a truncated linear regression. Bootstrapping then assesses coefficient significance.

The scores derived from DEA are biased towards 1. Simar and Wilson (2007) second bootstrap procedure, "algorithm 2", includes a parametric bootstrap in the first stage problem, so that bias-corrected estimates for the efficiency scores are produced. These corrected scores replace the DEA original ones, and estimation of environment effects proceeds like in algorithm 1.

3.2 Data Description

This paper employs panel data of 75 developing countries covering the period from 2000 to 2018. Developing countries here refer to those classified by the World Bank as low-income, lower-middle-income, and upper-middle-income countries. We focused on developing countries for several reasons. First, the income similarities among sample countries make the comparison more reasonable. Second, not enough attention has been paid to developing countries in the literature on public expenditure efficiency. (See the Appendix A).

3.2.1 Public Sector Performance Indicators

The performance of the government as supplier of public goods and services is limited to the provision of education, health, and public infrastructure. As for education we focus on literacy rate and secondary school enrolment rate. For health we consider the traditional output indicators of infant mortality and life expectancy. As for the provision of infrastructure we center our attention on electricity usage and telephone per 100 habits.

Musgravian sub-indicators are defined in a similar fashion. We use Gini coefficient as the output indicator for income distribution; price stability (inflation rate) for the stability sub-indicator; and GDP growth rate for economic performance.

To obtain PSP indicators we initially assign equal weights to each sub-indicator, computed as the average of the corresponding outcome indicators, each one of them normalized by its sample mean. The PSP indicator for each country is then obtained by averaging the values of all sub-indicators. Resulting PSP scores are then related to the average value of one of the normalized output indicators. Hence, countries with PSP scores in excess of one are seen as good performers, as opposed to countries with PSP values below the mean.

3.2.2 Inputs and Outputs Definition

It is prominent in the frontier approach literature that the specification and definition of inputs and outputs represent the keystone of this kind of research. According to some recent studies (Afonso et al., 2010; Afonso & Kazemi, 2017), we adopt the final consumption of government to GDP as input, whereas the PSP indicator as output to calculate the aggregate technical efficiency of government spending.

3.2.3 Input and Output Statistics

As described above, the main input used isfinal consumption of government to GDP. In the production process, the input is mobilized to produce a given amount of outputs, such as literacy rate, secondary school enrolment, infant mortality, life expectancy, electricity usage, telephone per 100 habits, Gini coefficient, inflation rate and GDP growth rate.

Table 1 displays the main statistics of the structure of the different inputs used and outputs produced over the period 2000–2018. It offers a simple, but useful look at the main inputs and the main outputs that we will use here in the construction of the frontier efficiency and then in the analysis of technical efficiency level of government spending.

Table 1. Descriptive statistics

Variables		Mean	Standard deviation	Min	Max
Input	final consumption of government to GDP	13.39	5.42	9.80	32.40
Outputs	literacy rate	88	45.8	26.0	95
	secondary school enrolment	23.56	11.21	5.34	38.45
	infant mortality	79	44.2	2.7	89.6
	life expectancy	68	35.1	38.8	82
	electricity usage	8,98	823.09	3,63	9,25
	telephone per 100 habits	16.32	17.51	8.36	39.89
	Gini coefficient	56.6	37.8	53.3	60.9
	inflation rate	8.89	14.83	-100	100
	GDP growth rate	2.48	8.16	-11.22	15.53

Source: Own elaboration.

4. Results Discussion

4.1 Analysis by Stylized Facts

Fig 1 shows that on average the share of public expenditure in GDP has increased over the period 2000-2018. It represents around 22% of GDP in 2000 and reached nearly 33% in 2018. At the same time, the performance of the public sector (PSP) improved from 0.89 in 2000 to 0.91 in 2018. Consequently, it can be stressed that government expenditure was nobe used in the right way leading to improve significantly the public sector performance in developing countries.

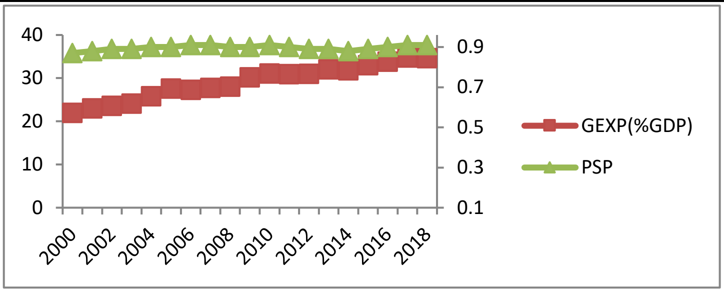

Figure 1. Government expenditure and public sector performance

4.2 DEA Efficiency Results

The Table 2 shows that on average, input efficiency score is 58 percent while output efficiency score is 67 percent. This means that countries can achieve the same level of outcome using 42 percent less spending or can increase their performance by 33 percent with the same level of inputs.

In addition, we redid the analysis using instead of the overall PSP indicator (Model 1), two outputs, which are the so-called opportunity PSP and Musgravian PSP sub-indicators (Model 2). The results in Table 2 show that in this case, Sri-Lanka and Soloman-Island shows up in the efficiency frontier. In fact, Sri-Lanka and Soloman-Island were rather close the frontier in the one input and one output set of results.

Table 2. Descriptive statistics of DEA efficiency scores and model specification

		Model 1	Model 2
Mean	Input-oriented	0.58	0.577
	Output-oriented	0.666	0.67
Maximum		1	1
Minimum	Input-oriented	0.25	0.246
	Output-oriented	0.274	0.27

Std.dev.	Input-oriented	0.182	0.184
	Output-oriented	0.091	0.092
Total countries		75	75
Total efficient countries		10	12
Countries on the frontier		Bahamas, Belize, El-Salvador, Guayana, Korea, Mexique, Mongolia, Myanmar,Peru,Panama,	Bahamas, Belize, El-Salvador, Guayana, Korea, Mexique, Mongolia, Myanmar, Peru, Panama, Sri-Lanka, Soloman-Island
Inputs		public spending	public spending
Outputs		PSPindicator	Opportunity PSP Musgravian PSP

Source: Own elaboration.

The Table 3 shows that the different income groups have on average the same levels of efficiency. The efficiency scores by region affirm that on average African countries are the least efficient in the production of public services, with an efficiency score varying between 49% (input orientation) and 58% (output orientation).These results can be justified by the fact that African economies suffer from several institutional distortions which are characterized by instability, corruption and the absence of the rule of law, which lead to unproductive public spending (Jacob, 2015).

In addition, we can rise a very close mean efficiency scores implying the robustness of our efficiency assessment and then the robustness of the efficiency level obtained by the two models.

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Table 3. Distribution of efficiency by income group and region

	Model 1		Model 2	
	Input	Output	Input	Output
		Income group		
Low income	0.57	0.66	0.58	0.65
Low middle income	0.55	0.67	0.54	0.68
High middle income	0.58	0.69	0.58	0.68
		Régions		
Africa	0.49	0.59	0.50	0.58
Asia	0.65	0.75	0.64	0.76
Latin America	0.59	0.68	0.58	0.67

Source: Own elaboration.

4.3 Analysis of the Results on the Malmquist Productivity Index

A DEA study in general considers performance analysis at a given point of time. However, extensions of the DEA procedures, such as the Malmquist productivity index approach, have been reported to provide performance analysis over a period of time. A summary of results listing the efficiency change (EFFCH), technological change (TECHCH) and Malmquist productivity index (MPI) for each country is presented in Table 2 (the Appendix A). If the value of the Malmquist productivity index or any of its components is less (greater) than one, it denotes a deterioration (an improvement) in performance. EFFCH provides a measure of how far each country has moved from the efficient frontier over the time period of interest. The mean value of 1.039 for samples suggests that, overall, member countries have moved closer to the frontier, representing an increase in efficiency change. On the contrary, the mean technological change (TECHCH) value of 0.928 would suggest that the technology with respect to which individual countries are producing outputs has declined slightly, that is, the efficiency of the whole sample has remained steady (or declined slightly), and that over this time period absolute output values have decreased. The MPI value of 0.956 may be interpreted as reflecting the sum of movements. It is worth noting that over the period under examination, higher efficiency from one period to another does not necessarily suggest that the operating unit achieves higher productivity since the technology may have changed. As can be seen in Table 2 (the Appendix A), only 15% developing countries show MPI progress, but most of them are regressing. The top four countries are Bahamas, Benin, Brazil and Malaysia in the rank order of MPI. In the case of Bahamas, the gains in productivity are due to gains in efficiency progress, and thus productivity is found to have grown above thesample average in the period. Guatemala, Rwanda and Swaziland on the contrary, experienced losses in all the periods considered. The important finding for these three countries is the lower efficiency change.

4.4 Determinants of Public Sector Efficiency: DEA-Bootstrap Analysis

The DEA approach considers essentially discretionary inputs, the ones for which quantities can be changed rather autonomously by the policy makers in each country. However, exogenous constraints or so-called non-discretionary inputs play a role in the possibility of attaining outputs more efficiently.Among them include the GDP per capita, money growth, openness, development assistance per capita, foreign direct investment, external debt service, secondary school enrolment, composite indicator of governance,transparency index, democracy index, Ethnic fractionalization and religion fractionalization (Sijpe & Rayp, 2007;

Afonso, Romero, & Monsalve, 2013; Moreno & Bayano, 2017). In the empirical literature, numerous techniques can beconsidered to include these variables and consistently to explain the different efficiency levels obtained. Jacob (2015) and Moreno-Enguix and Bayano (2017) among others used the Tobit model to explain public expenditure efficiency.

In this paper, we use the sampling technique and we adopt the so-called DEA-bootstrap technique in order to appreciate the main environmental variables that might explain efficiency of public sector and to control the dependency problem between explanatory variables and the noise term. Formally, the linear model relating efficiency to a set of some explanatory variables is as follows:

$$\delta_{it} = \alpha_0 + \sum \beta_{it} z_{it} + \varepsilon_{it} \quad (3)$$

where δ_{it} represent DEA technical efficiency scores of public sector; ε_{it} is a random variable with mean 0 and standard deviation σ; $z_1, \ldots, z_{18}$ are summarized in Table 4 bellow. We note that the non-discretionary variables had been chosen in line with the current literature.

Table 5 displays the main statistics of the structure of the different variablesproduced over the period 2000-2018.

Table 4. Description of explanatory variables used

Variables	Variables	Descriptions	Expected signs
GDP/capita	Z_1	GDP per capita	+
MG	Z_2	money growth	+/-
OPEN	Z_3	openness	+
DA/capita	Z_4	development assistance per capita	+/-
FDI	Z_5	foreign direct investment	+/-
EDS	Z_6	external debt service	+/-
SSE	Z_7	secondary school enrolment	+

GOV	Z_8	composite indicator of governance	+
DMC	Z_9	democracy index	+
TRP	Z_{10}	transparency index	+
ENC	Z_{11}	Ethnic fractionalization	-
REG	Z_{12}	religion fractionalization	-

Source: Own elaboration.

Table 5. Descriptive statistics

Variables	Mean	Standard deviation	Min	Max
PSE	0.582	0.311	0.253	1.000
GDP/capita	4084.867	3953.663	113.818	4537.24
MG	15.199	10.763	-45.473	72.39
OPEN	21.306	14.361	2.235	89.68
DA/capita	9.856	13.510	0.000	97.38
FDI	3.718	4.093	2.495	31.42
EDS		9.531	6.754	39.481
SSE	15.942	34.2	41.5	83.7
	67.01			
GOV	0.025	0.994	-2.186	2.487
DMC	4.896	3.595	0.000	7
TRP	3.268	1.924	1	5.7
ENC	0.522	0.275	0.061	0.874
REG	0.588	0.306	0.127	0.674

Source: Own elaboration.

Applying the algorithm proposed by Simar and Wilson (2007), we obtained the possible effect of the contextual variables technical efficiency of government spending. Table 6reports estimated parameters from bootstrapping procedure.

Table 6 shows that governance has a positive effect on public sector efficiency. Furthermore, we find a positive relationship between democracy (DMC) and government spendingefficiency. Transparency (TRP) is found to have a positive impact on public sector efficiency. According to Grigoli and Mills (2014), more governancepromotes public spending efficiency.Our findings reported also a significant positive effect of the GDP per-capita (GDP/capita) on public spending efficiency. In addition, secondary school enrolment (SSE) is found to be positively related to government spending efficiency. Afonso, Sckuknecht, and Tanzi (2006) and Afonso and Fernandes (2008) found that per-capita income and education levels contribute significantly to public spending efficiency. Furthermore, the results show that development assistance per capita (DA/capita) is positively associated with public sector efficiency. Sijpe and Rayp (2007) reported a positive impact. The authors reveal that IMF programs and development assistance often imposes fiscal austerity. Insisting governments cut their budget deficits and prompt them to raise efficiency. On contrary,foreign direct investment (FDI) is negatively associated with public spending efficiency. Todaro and Smith (2003) conclude that foreign direct investment has a negative effect on public sector efficiency. They indicate that foreign direct investment in developing countries may be linked to rent extraction and rent sharing between the political elite and the foreign corporations, leading to favoritism, corruption… and, ultimately, more inefficiency. Moreover, we find a negative relationship between ethnic fractionalization (ENC) and government spending efficiency. As stated by Alesina and La Ferrara (2005), more ethnic diversity reduces public spending efficiency. They claim: conflicts of preferences, racism, prejudices often lead to policies which are suboptimal from the point of view of a society as a whole.

Table 6. DEA-Bootstrap results

Variables	Parameters	Model 1	Model 2
Constant	β_0	0.442^{*}	0.283^{*}
GDP/capita	β_1	0.075^{**}	0.068^{**}
MG	β_2	-0.031	-0.026
OPEN	β_3	0.007^{**}	0.005^{**}
DA/capita	β_4	0.012^{***}	0.014^{***}
FDI	β_5	-0.007^{**}	-0.006^{**}
EDS	β_6	-0.093	-0.096
SSE	β_7	0.083^{**}	0.078^{**}
GOV	β_8	0.381^{*}	0.372^{*}
DMC	β_9	0.275^{*}	0.264^{*}
TRP	β_{10}	0.175^{*}	0.163^{*}
ENC	β_{11}	-0.043^{**}	-0.058^{**}
REG	β_{12}	0.205	0.262

Note. *, ** and *** represent significance at 1%, 5% and 10%, respectively.

5. Conclusions

Providing more public services with less public spending is an ongoing challenge for any countries. In this paper, we assess public sector efficiency over the period 2000–2018. We developed indicators of public sector performance for 75 developing countries. For that purpose we used a number of socio-economic indicators as proxies for performance, and total spending as proxies for resource use. We find moderate differences in the public sector performance (PSP) indicators across developing countries. Unsurprisingly, countries with small public sectors report the "best" economic performance.

The results that we get from the production-frontier-related DEA analysis, which uses the PSP indicators, are also in line with the aforementioned conclusions. First, there are important differences across countries in the resulting public sector efficiency (PSE) indicators. Second, countries with small public sectors report significantly higher PSE indicators than countries with medium-sized or big public sectors. All these findings suggest diminishing marginal products of higher public spending.However, the use of the nonparametric method DEA can mislead results in the presence of outliers, misspecification of inputs and/or outputs.

By applying DEA-bootstrap analysis in the second stage, empirical results show that there are some environmental variables that affect public sector efficiency. So, the governance indicators positively affect public spending efficiency. The results further revealed that GDP per-capita and secondary school enrolment positively impact public sector efficiency. The results also show that development assistance per capita has apositive effect on government spending efficiency. On contrary,foreign direct investment and ethnic fractionalization are negatively related to public spending efficiency.

Our findings could help policymakers to answer to the question: Can developing countries obtain the same performance results in public sectors using the less resources? Furthermore, at the empirical side, we suggest using another non-parametric approach (e.g., FDH) and/or the parametric one (namely, the SFA approach) for checking the robustness of our results.

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Appendix

Appendix A. List of countries

Pays	Code	Domonica	DMC	Mali	MLI
Afghanistan	AFG	Ecuador	EDR	Mongolia	MNG
Afrique du sud	AFS	El Salvador	SLV	Myanmar	MYR
Argentine	ARG	Equatorial Guinea	EGN	Mozambique	MZM
Bahamas	BHM	Ethiopie	ETH	Népal	NPL

Belize	BLZ	Fiji	FJI	Niger	NGR
Benin	BNN	Gambie	GBE	Nicaragua	NIG
Bangladesh	BAG	Guatemala	GTM	Nigeria	NGA
Barbados	BAD	Guinea	GNA	Peru	PER
Botswana	BTS	Guyana	GYN	Panama	PNM
Bolivia	BLV	Honduras	HDR	Paraguay	PRG
Bhutan	BHT	Inde	IND	Pakistan	PKT
Brazil	BZL	Jamaique	JMQ	Philippines	PHL
Burkina Faso	BFS	Indonesie	IND	Rwanda	RWD
Cambodia	CMD	Korea	KRA	Singapore	SIN
Cameroun	CRN	Kenya	KNY	Sénégal	SNG
Chile	CHL	Lesotho	LSO	Soloman Island	SLD
Chine	CHN	Liberia	LBR	Sri-Lanka	SLK
Congo	CGO	Madagascar	MDG	Swaziland	SZD
Comoros	CMR	Malawi	MWI	Tunisie	TUN
Colombie	CLB	Malaysia	MYS	Thailand	TLD
Cote d'ivoire	CIV	Maldives	MDV	Tonga	TNG
Costa Rica	CRC	Mexique	MXQ	Trinid and Tobaggo	TTG
DominicanRep	DRP	Mauritus	MTS	Togo	TGO

Appendix B

Pays	Efficiency Score (VRS)	Malmquist Index		Efficiency Change (EFFCH)		Technological Change (TECHCH)	
	2000-20	2000-200	2009-201	2000-200	2009-201	2000-200	2009-201

	18	8	8	8	8	8	8
Afghanista n	0.438	0.99	1.041	0.979	1.009	1.002	1.000
Afriq du sud	0.540	0.956	1.088	0.952	0.99	1.005	1.013
Argentine	0.563	0.939	0.991	0.978	1.031	1.000	1.000
Bahamas	1.000	0.874	1.141	0.966	1.051	0.994	1.010
Bangladesh	0.581	0.786	0.695	1.000	1.000	0.972	0.838
Barbados	0.827	0.761	0.834	0.918	1.000	1.047	0.918
Belize	1.000	0.968	1.2	1.000	1.015	0.959	1.051
Benin	0.287	0.916	1.017	0.952	0.99	1.005	1.013
Bhutan	0.553	1.23	0.911	1.015	1.000	1.051	0.959
Bolivia	0.394	1.189	0.973	1.040	1.035	1.000	0.986
Botswana	0.516	0.924	0.801	0.995	1.018	1.000	1.000
Brazil	0.756	0.975	1.133	0.971	0.986	1.005	1.015
Burkin Faso	0.391	0.961	0.893	0.937	1.067	1.016	0.996
Cambodia	0.374	0.852	0.93	0.796	1.098	1.008	0.984
Cameroun	0.363	1.035	1.181	1.026	1.002	1.000	1.000
Chile	0.524	1.077	1.001	1.361	1.040	1.007	1.001
Chine	0.460	0.802	0.745	1.003	1.025	1.000	1.000
Colombie	0.501	1.022	0.991	1.003	0.997	1.000	1.000
Comoros	0.420	1.122	0.933	1.105	1.026	1.016	0.996
Congo	0.341	0.968	1.092	0.692	0.897	1.101	1.020
Costa Rica	0.477	0.971	1.005	0.968	0.980	0.994	1.007
Cote	0.349	0.93	1.12	0.968	0.987	1.014	1.014

d'Ivore							
Domini-Rep	0.513	0.953	0.866	1.031	0.839	1.134	1.098
Domonica	0.602	1.019	0.979	1.012	1.006	0.998	0.994
Ecuador	0.455	1.066	1.013	1.062	0.978	0.995	1.011
El Salvador	1.000	1.018	0.991	1.009	1.008	1.000	1.000
EqutGuinea	0.459	1.048	0.921	1.039	1.020	1.000	0.995
Ethiopie	0.734	0.986	1.001	0.782	1.112	0.995	1.005
Fiji	0.644	0.803	0.949	1.020	1.008	0.993	0.994
Gambie	0.504	1.078	1.009	1.158	0.979	1.020	1.009
Guatemala	0.345	0.744	0.657	0.739	0.617	0.994	0.983
Guinea	0.386	0.879	1.019	0.865	0.858	1.006	1.014
Guyana	1.000	0.78	1.003	1.000	1.000	0.993	1.006
Honduras	0.465	0.851	0.921	1.031	0.839	1.134	1.098
Inde	0.565	0.795	0.517	1.106	1.537	0.751	0.630
Indonesie	0.526	1.128	0.783	0.952	0.983	1.119	1.001
Jamaique	0.551	1.15	1.052	1.134	0.980	1.006	1.015
Kenya	0.673	0.712	0.97	1.003	1.001	1.000	1.000
Korea	1.000	0.999	0.991	0.990	1.046	1.000	1.000
Lesotho	0.536	1.02	0.989	1.012	1.014	0.999	0.999
Liberia	0.497	1.065	0.967	1.048	0.784	1.008	0.988
Madagascar	0.494	0.951	0.728	1.005	1.184	0.938	0.858
Malawi	0.455	0.678	0.854	0.644	0.886	1.039	0.980
Malaysia	0.799	1.199	1.139	1.966	0.839	1.000	1.058

Maldives	0.691	1.166	1.103	1.144	1.078	0.999	1.004
Mali	0.522	1.014	0.981	1.005	1.002	1.000	0.995
Mauritius	0.486	0.66	0.77	1.362	1.204	0.984	0.988
Mexique	1.000	1.041	1.001	1.040	1.070	0.992	1.005
Mongolia	1.000	0.972	0.995	0.949	1.021	1.015	1.002
Mozambique	0.571	1.036	0.991	1.027	1.022	1.000	1.000
Myanmar	1.000	0.991	0.991	0.982	1.049	1.000	1.000
Népal	0.844	1.116	1.095	1.005	1.001	1.002	1.002
Nicaragua	0.548	0.812	1.023	1.003	1.005	1.000	1.001
Niger	0.497	0.976	0.934	0.963	0.868	1.004	0.971
Nigeria	0.386	1.061	1.102	1.859	1.126	0.993	1.015
Pakistan	0.589	1.027	0.977	1.020	1.002	0.998	0.993
Panama	1.000	1.118	0.993	1.110	1.023	0.999	1.001
Paraguay	0.340	1.018	0.989	1.010	1.000	0.999	0.999
Peru	1.000	1.065	0.967	1.048	0.784	1.008	0.988
Philippines	0.489	1.047	1.125	1.352	1.068	1.010	1.016
Rwanda	0.399	0.833	0.777	0.896	0.745	1.089	0.992
Sénégal	0.500	0.85	0.797	1.000	0.947	0.942	0.897
Singapore	0.756	0.844	0.717	1.014	1.005	1.003	1.015
Solo Island	1.000	0.97	1.161	0.961	1.001	1.000	1.000
Sri-Lanka	1.000	1.004	0.999	0.999	1.004	0.996	1.004
Swaziland	0.410	0.878	0.807	0.822	0.269	1.057	0.903
Thailand	0.400	1.009	0.995	1.003	1.000	0.997	1.002
Togo	0.444	1.586	0.504	0.965	0.768	1.628	0.621
Tonga	0.543	1.016	0.993	1.005	1.001	1.002	1.001

Trinid-Tobg	0.579	0.856	0.847	0.963	1.000	0.982	1.000
Tunisie	0.936	1.004	0.935	1.005	0.938	1.000	0.997
Uruguay	0.572	0.781	0.9	1.000	1.000	0.989	0.989
Venezuela	0.398	1.018	0.991	1.009	1.001	1.000	1.000
Vietnam	0.716	1.022	0.979	1.020	1.008	0.993	0.994
Zimbabwe	0.420	0.811	0.92	0.796	1.098	1.008	0.984
Mean	0.58	0.956	0.945	1.039	1.028	0.923	0.931