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Tax structure and public sector efficiency: new evidence for developing countries*

Lucas Menescal† José Alves‡

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Abstract

This study examines the effects of the tax structure composition for public sector efficiency in a sample of 41 developing countries for the period between 1997-2019. We start by calculating Public Sector Performance (PSP) composite indicators and use them as outputs to compute data envelopment analysis (DEA) efficiency scores under different orientation setups. After using a general-to-specific approach to identify the most determinant variables, we analyze the relevance of different taxes for public efficiency in a panel regression specification. We find that tax effects are significantly different depending on the orientation of DEA scores. Notably, we observe that taxation presents stronger detrimental effects to input-oriented scores in comparison to output-oriented, and that *Opportunity* PSP indicators seem more affected by property taxes and working contributions, while *Musgravian* PSP indicators are more closely related to individual and corporate income taxes. Our results allow us to provide policy implications regarding better tax structures to improve efficiency on the provision of public goods and services.

JEL: C14, C23, H11, H21, H50

Keywords: Public sector performance; Government efficiency; Tax structure; Data envelopment analysis; Developing countries; Panel data

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1. Introduction

The effectiveness of governments in providing public goods and services demanded by societies represents a major issue on discussions about the structure of public systems which determine governments' capabilities related to its socioeconomic performances. This is given by the fact that governments face distinct challenges in each country to provide basic social rights and promote economic development, while being subject to different financing and productive constraints, as well as to macroeconomic and political conditions. In this sense, the efficiency of the public sector in attending to social demands may directly influence the living conditions of the population, their political perception and the government fiscal conditions, as well as the evolution of financial markets and, ultimately, the economic development of a country (see Angelopoulos et al., 2008, and Afonso et al., 2022, 2023).

More recently, due to largely spread economic and social crisis, broader attention seems to have been attracted to public sector efficiency, bringing renewed awareness on the need for improvements in the autonomous response capacities of national governments to worldwide phenomena, especially when unpredicted hikes in the demand for public goods and services are observed. On the brink of such events, governments are usually forced to incur in unexpected expenditures to provide the necessary responses, to smooth the adverse impacts of these shocks and assure further stabilization of the economy. These increased responses may lead, however, to worst fiscal imbalances and additional decreases in public efficiency, making the comprehension of the main determinants of social and economic performances an important issue to be analyzed.

Besides computing public efficiency scores for different countries and pointing essential improvements which could take place, part of the literature has attempted to determine the most important factors which affect these results and analyze how fiscal policy may influence them (see, for instance, Afonso and Kazemi, 2017). To this matter, as different government expenditures are often considered as input variables to compute public spending efficiency scores, some authors have focused on the role played by the tax policy, more specifically by the tax system composition, on determining these scores. In this context, the importance of tax structures for economic growth and income distribution in both developed and developing countries has been made clearer in the literature over the last years as their effects are disentangled in more details (see Afonso et al., 2020, 2021; Alves, 2019, 2021; Menescal and Alves, 2022).

Therefore, in this study we propose to assess how the tax structure affects not only overall public sector efficiency, but also efficiency specifically related to social and economic aspects, in a set of developing countries. To perform the empirical analysis, we follow a three-step approach. At first, we start by computing Public Sector Performance (PSP) indicators for a set of 41 developing countries from 1997 to 2019. Second, we use these indicators to compute input and output efficiency scores using Data Envelopment Analysis (DEA) for each year using different model specifications. Lastly, we empirically assess the effects of different taxes, along with a set of socio-economic variables selected by a general-to-specific approach, on public efficiency scores using a second-stage panel data regression setup.

Our first results show that input-oriented efficiency scores averaged around 0.62 for the whole period, implying that inputs could probably be lowered in about 40% while keeping the same output to improve efficiency. On the other hand, output-oriented scores averaged approximately 0.68, which suggests that outputs could possibly be around 30% higher with the same level of inputs to increase efficiency. Furthermore, on the second-stage regressions we find that there are significant differences in the results of the tax coefficients depending on the orientation setup of the DEA scores. Particularly, total taxation seems to have larger detrimental effects to efficiency when considering input-oriented scores in comparison to its effects on output-oriented. Moreover, we observe specifically that property taxes and working contributions seem to be more closely related to efficiency in the social aspects represented by *Opportunity* PSP indicators, while the economic aspects considered in *Musgravian* PSP indicators tend to be more affected by individual and corporate income taxes. Still, consumption taxes seem to have similar detrimental effects on both PSP indicators, as well as on overall efficiency scores. These results bring important contributions to the literature and implications for policy making authorities regarding the effects of tax structures under distinct efficiency improvement strategies.

The remainder of the paper is organized as follows. Section 2 provides an overview of the related literature as motivation for the empirical analysis. Section 3 presents and explains the methodology and datasets adopted. Section 4 reports and discusses the results for DEA scores and for second-stage regressions. Section 5 brings the conclusions and policy implications.

2. Literature Review

The computation of public sector efficiency indicators between different countries has been a growing subject in the literature over the last decades, as discussed by Afonso et al. (2010, 2013) and by Baciu and Botezat (2014). In this sense, several studies have used different methods and datasets to assess the capacity of the public sector in attending social needs and improving economic performance. Furthermore, an increased interest in the estimation of its main determinants and on the valuation of factor changes over time has also been noted. To this matter, empirical studies usually rely on composite efficiency indicators which relate different social and economic variables commonly considered by multilateral organizations and targeted by public policies. These variables tend to be normalized for comparison purposes and production function frontiers are computed by the adoption of non-parametric estimation approaches, while efficiency scores are derived based on the relative distances of less efficient observations to this frontier.[1]

These efficiency scores can evaluate not only the overall government efficiency in providing public goods and services but may also be computed to specific areas such as health, education and infrastructure, as done by Afonso and Aubyn (2004, 2006), Duti and Sicari (2016) and Herrera and Ouedraogo (2018). Therefore, this topic has been addressed for different sets of countries through several periods of time. Some of the first contributions were made by Gupta and Verhoeven (2001) and Herrera and Pang (2005) by applying non-parametric techniques to assess overall public efficiency indicators in large sets of developed and developing countries. Following on that, Afonso et al. (2005) developed a methodology to compute and compare socio-economic composite indicators known as the Public Sector Performance (PSP), which became frequently considered in the literature as the main output variable when calculating overall and specific efficiency scores. Subsequentially, the literature has identified significant differences in public efficiency between countries and pointed out substantial spending savings which could take place to improve these indicators (see Adam et al., 2011, Afonso and Kazemi, 2017, and Antonelli and de Bonis, 2019).[2]

Moreover, another branch of the literature focused on the main determinants of these cross-country differences by investigating the role played by different variables related to

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[1] The most common non-parametric techniques are the Free Disposal Hull (FDH) and Data Envelopment Analysis (DEA) based on Tulkens (1993) and on Charnes, Cooper and Rhodes (1978), respectively.

[2] The main implication of these results is that either more public services could be provided with same level of public resources, or that the same level of public services could be provided with fewer resources, both ways leading to an improvement of public efficiency.

demographic characteristics, educational and income levels, quality of institutions and political orientation, but also regarding the role of fiscal decentralization, fiscal sustainability and tax policies. Rayp and De Sijpe (2007) were one of the first to try explaining government inefficiencies by identifying structural, political and governance indicators which may have influenced scores. Their results suggest that inefficiencies are mainly determined by governance and political variables, such as rule of law and political stability measures, but also by structural indicators such as population demographics, adult illiteracy and private health spending. Even though the authors did not find significant impacts of economic policy variables or external aid, they highlight that foreign direct investments are associated with more inefficiency and that developing country governments should pursue more political stability and a stronger rule of law.

Chan and Karim (2010) also find that political stability and financial freedom have positive effects to public performance in eight East-Asian countries, while political freedom and civil liberties are negatively associated to efficiency. Hauner and Kyobe (2008) performed a similar analysis for the health and education sectors in a large panel of more than 100 countries by classifying the determinant variables into economic, institutional and demographic/geographic variables. The authors stress that efficiency tends to decline with the level of public spending and that improving institutions, by making governments more accountable and less corrupt, has a higher positive effect on public efficiency than economic growth and financial development. Moreover, besides accounting for demographic and political variables, Adam et al. (2014) analyzes the role of fiscal decentralization in explaining public sector efficiency for OECD countries. They find evidence that these variables are related in an inverted U-shaped way, meaning that fiscal decentralization has a positive effect to efficiency until a certain threshold level, and if raised past this point the effect may become negative.

On the other hand, Afonso and Alves (2023) assessed the impact of government efficiency on fiscal sustainability for OECD countries and found that countries' fiscal balances are directly improved by the use of less resources while keeping the same output, or by increasing outputs while keeping the same level of resources. This means that rationalizing public expenditures without hampering the provision of public goods and services is a strong determinant of primary budget balances, and consequently of fiscal sustainability. There are also studies which incorporate efficiency indicators into economic growth analysis, as done by Angelopoulos et al. (2008) and Rahmayanti and Horn (2010), which iterated efficiency scores and public spending (as a proxy to government size) to analyze the size-efficiency mix effects and assess if there are critical levels to economic growth.[3]

Apart from that, Wang and Alvi (2011) incorporates total government revenues as a proxy to the government size when analyzing the main determinants of public efficiency in a set of OECD and Asian countries. Even though the authors found significant positive effects for the share of private sector activities on the economy and that corruption seems more detrimental to efficiency in Asian than in OECD countries, results for government revenues, as a percentage of GDP, were unclear and not robust. Focusing specifically on changes in the tax policy, Afonso et al. (2020) analyzed the impacts of structural tax reforms on government spending efficiency in eighteen OECD countries. The authors found that reforms which increase tax rates, particularly for personal income taxes (PIT), tend to negatively affect public efficiency, but that increases in the tax bases may improve efficiency. Further, they find that increasing corporate income taxes (CIT) and reducing PIT during expansionary periods have positive effects on efficiency, while during recession periods efficiency improves when PIT and VAT tax bases increase, as well as CIT rates.

Finally, Afonso et al. (2021) evaluates the relevance of tax structures to overall public sector efficiency in a sample of OECD countries. Besides showing that inputs (government revenues) could theoretically be around 30% lower and that Malmquist indices display an overall decrease in both technology and total factor productivity during the period considered, the authors highlight that DEA scores of government efficiency are negatively associated with taxation, particularly indirect taxes which present the larger detrimental effects to efficiency, but also with direct taxes and social security contributions. The authors also call attention to the fact that there are clear differences in results regarding the determinants of government performance depending on the scores orientation, either input or output oriented, but focus their conclusions on the results for input-oriented scores.

3. Methodology and Data

3.1. Public Sector Performance (PSP)

At the first stage we follow Afonso et al. (2005) to construct an output composite indicator known as the *Public Sector Performance (PSP)* for 41 countries during the

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[3] Chan et al. (2017) also addressed this relationship but focused on the role played by value-added taxes to improve economic performance.

period between 1997 to 2019. The PSP is formed by two main components: *Opportunity* indicators and *Musgravian* indicators. Each of these components includes several sub-indicators on distinct areas where public policies may have direct and/or indirect impacts to overall performance.

The *Opportunity* indicators consider different measures in four sub-areas: administrative, educational, health and infrastructure. For the administrative sub-indicator, the variables included account for: corruption, burden of government regulation (red tape), judiciary independence, shadow (informal) economy and property rights. The education sub-indicator includes secondary school enrollment rates and the quality of the educational system. In the health sector sub-indicator, data on infant survival rates, life expectancy and survival rate from cardiovascular, cancer, diabetes and chronic respiratory diseases were considered, and for the infrastructure sub-indicator, we make use of data regarding the quality of overall infrastructure. Therefore, the opportunity PSP reflects government performance in providing basic social goods and services to the population of each country.

On the other hand, the *Musgravian* indicators focus on the performance related to the economic aspects of public policies. In this sense, it incorporates variables in three main sub-areas: income distribution, economic performance and economic stability. For the income distribution sub-indicator, we adopted the Gini coefficient. To evaluate economic performance, we considered the 5-year average of per capita GDP, annual GDP growth rate and unemployment rates. Lastly, for the economic stability sub-indicator, we used the standard deviation of 5-year inflation and the coefficient of variation for the 5-year averages of GDP growth rates. Table A1 in Appendix A summarizes all variables used to construct the PSP and their respective sources.

To establish a convenient framework for comparing results, data on each sub-area is normalized by dividing the value of each country by the average of that indicator for all countries in the sample. For each sub-component of the PSP, results are derived by simple averages of the normalized variables considered in each year. Accordingly, *Opportunity* and *Musgravian* indicators result from the average of the measures included in each sub-indicator, while Total PSP is a simple average of *Opportunity* PSP and *Musgravian* PSP, pondered with equal weights. Formally, we have:

$$\boldsymbol{PSP_i = \sum_{j=1}^{n} PSP_{ij}} \qquad (\mathbf{1})$$

where i denotes each developing country considered and j represents the socio-economic sub-indicators. Therefore, PSP_i represents the overall public sector performance of country i.

3.2. Data Envelopment Analysis (DEA)

As previously discussed, DEA represents a non-parametric approach to compute relative efficiencies of Decision-Making Units (DMUs) by using linear programming techniques. Hence, it identifies a production efficiency frontier where most efficient units are placed and from where the rest of DMUs scores are derived based on their relative distances to the frontier. This means that it compares the performance of a country with a frontier which contains the most efficient outputs obtained.[4] In our case, each DMU represents a country i, and their production functions can be represented as below:

$$Y_i = f(X_i), \qquad i = 1,2, \dots, n \qquad (2)$$

where Y_i is the composite or specific output measure and X_i is the composite or specific input measure. The former refers to the different PSP indicators previously explained, while the latter is usually represented by different government spending to GDP ratios. In this sense, country i is said to exhibit inefficiency if $Y < F(x)$, meaning that for the observed input levels, the actual output is smaller than the best achieved. Thus, inefficiencies are computed by calculating the distances of each DMU to the efficiency frontier. Furthermore, we may consider that the production function displays either constant returns to scales (CRS) or variable returns to scale (VRS). If CRS is assumed, it means that all countries are operating at their optimal scale and that output changes by the same proportion that inputs. On the other hand, assuming VRS would mean that countries might not be operating at their optimal scale and may exhibit different returns to scale.

Another important setup of this method is the fact that the model can be either input or output oriented, which means that we can study either how much input levels can be proportionally reduced while keeping the same level of output produced (input-oriented), or how much the output produced can be proportionally increased while keeping the same level of inputs (output-oriented). Yet, it is worth stressing that both setups provide the

[4] DEA has the advantage that the selection of best performing DMUs is made by solving the linear program problem and that it accommodates multiple inputs and outputs. Even so, results may be sensitive to the selection of the inputs and/or outputs.

same results under CRS, but different values under VRS. For illustration effects, suppose we have an input-oriented DEA model with variable returns to scale. The efficiency scores can be obtained through the following linear programming problem:

$$\begin{aligned} & Min_{\theta,\lambda}\, \theta \\ s.t. \;\; & -y_i + Y\lambda \geq 0 \\ & \theta x_i - x\lambda \geq 0 \\ & I1'\lambda = 1 \\ & \lambda \geq 0 \end{aligned} \qquad (3)$$

where y_i is a column vector of outputs, x_i is a column vector of inputs, θ is the efficiency scores, λ is a vector of constants, *I*1 is a vector of ones, Y is the output matrix and X is the input matrix.

Therefore, θ is a scalar number ($0 < \theta < 1$) which measures technical efficiency by computing the distance between a country and the efficiency frontier. If $\theta < 1$, it means that country *i* is inside (or below) the frontier and that it is inefficient. On the other hand, $\theta = 1$ implies that the country is efficient and is on the frontier. The vector λ represents the weights considered to compute the location of an inefficient country in case it was efficient, and the restriction $I1'\lambda = 1$ imposes convexity on the production frontier, which accounts for the assumption of VRS. If that restriction was not used, it would mean that constant returns to scale were admitted and that all countries operated at their optimal scales.

We use the PSP indicators as output variables to compute DEA efficiency scores for all 41 countries from 1997 to 2019, assuming variable returns to scale (VRS) and adopting both input and output-oriented setups.[5] We considered four different models to analyze the sensitiveness of results. In Model 1 we use one input variable, namely the total government expenditure, and one output, the total PSP. Model 2 also uses total government expenditure as input, but the output measures are both *Opportunity PSP* and *Musgravian PSP*. Model 3 still uses government expenditures as input but considers the *Opportunity PSP* as the only output, while Model 4 considers the *Musgravian PSP* as the

[5] In this case, VRS accounts for the fact that countries may not operate at their optimal scale, possibly displaying either increasing, decreasing or constant returns to scale. Moreover, as we intend to compare results according to DEA orientation setup, the computation of both input and output scores is essential to the analysis.

only output variable.[6] As we have seen in the PSP methodology section, the *Opportunity* PSP considered in Model 3 is composed by the administrative PSP, the health PSP, the education PSP and the infrastructure PSP, representing public performance focused mainly on "social aspects", whereas the *Musgravian* PSP considered in Model 4 is formed by the distribution PSP, the stabilization PSP and the economic performance PSP, exhibiting governments' performance focused on "economic aspects". Therefore, the main objective of considering them in two different models is to investigate if different taxes may affect public performance in distinct ways depending on the specific aspects considered, either "social" or "economic".

Moreover, to analyze the robustness of results we re-estimate Models 3 and 4 by considering different inputs and refer to them as Models 5 and 6, respectively. Model 5 is estimated using government consumption, government education expenditure and government health expenditure as inputs, while the output variable is still the *Opportunity* PSP. Model 6 uses total government expenditures and total investment (gross fixed capital formation) as input variables, while the output variable is still the *Musgravian* PSP. Variable selection was based on data availability and by the fact that increasing the number of inputs can lead to many countries being based as efficient on the frontier, which would decrease the ability to compare and evaluate the determinants of cross-country efficiency. As a last sensitivity analysis, we estimate the same regressions for models 3, 4, 5 and 6 for the period between 2007-2019, as it is the most considered time period in previous studies willing to offset the effects of the Global Financial Crisis (GFC) of 2007-2008, but also as it contains a more completely balanced panel in comparison to when the whole period is considered.

3.3. Second-Stage Regressions

Before proceeding to the second-stage analysis, we opt to follow a general-to-specific approach to select the main determinant variables of efficiency scores. We see this as a novelty procedure in this type of models and adopt it as there is no comprehensive or consented theory for the explanation of inefficiencies between different countries (see, for instance, Rayp and De Sijpe, 2007). Therefore, instead of choosing a specific set of variables or attempting several different combinations of candidate variables in a simple-to-general approach, we adopt a general-to-specific approach which performs a series of

[6] Table A2 and A3 in Appendix A displays the variables used as input components and the list of countries, respectively.

sequential test procedures using conventional critical values to select the most determinant variables in a large set of conventional socio-economic variables previously selected in the literature and which are not employed in the computation of PSP indicators. [7]

We collect these variables from different sources and perform the tests for all four models using both input and output-oriented setups to select the most significant variables. Thus, if the specification tests show that a variable is statistically significant for at least half of the regression specifications, it is then considered in second-stage regressions.[8] Table A4 in Appendix A summarizes all variables considered in the test procedure, while Table B1 in Appendix B shows the results of the tests for both input and output efficiency scores and the final set of selected variables.

Thereafter, we consider the determined variables together with the tax structure to assess how they influence DEA efficiency scores. To this matter, we estimate the following reduced-form panel model:

$$\theta_{it} = \delta_i + \mu_t + \sum \beta_{1,i,t} T_{n,i,t-1} + \beta_j X_{q,i,t-1} + \varepsilon_{i,t} \qquad (4)$$

where θ_{it} denotes the DEA efficiency score of country *i* in period *t*, $T_{n,i,t-1}$ is the set of *n* tax items representing the tax structure, $X_{q,i,t-1}$ represents the set of q socioeconomic variables selected by the general-to-specific approach, δ_i denotes region (continent) fixed effects to control for specific time invariant characteristics, μ_t are time (year) effects to account for global common shocks and $\varepsilon_{i,t}$ is the disturbance term satisfying the standard assumptions of zero mean and constant variance. To minimize reverse causality problems, we consider the variables in vector *T* and *X* in lagged values.

The set of tax structure variables included in vector $T_{n,i,t-1}$ are all represented in percentage of GDP. These variables are: i) Total tax revenues; ii) Taxes on income, profit and capital gains of individuals (PIT); iii) Taxes on income, profit and capital gains of corporations (CIT); iv) Payroll and workforce taxes; v) Social security contributions; vi) Property taxes; vii) Consumption taxes. However, as many developing countries do not have a completely solid social security system and/or do not collect payroll taxes

[7] For more details, see Clarke (2014).

[8] As we have four models under two different orientations, the specification test is performed on a total of eight regressions. This means that to be considered determinant, any variable needs to present significant coefficients in at least four of the eight estimated models in Table B1.

revenues, we classified social security contributions and payroll taxes together as working contributions. All these variables were collected from the OECD Statistics database from 1997 to 2019.

With respect to the set of demographic, macroeconomic and structural indicators considered in vector $X_{q,i,t}$, the final set of variables selected by the general-to-specific in Table B1 are: i) tourism, as a percentage of exports revenues; ii) primary balance, as a percentage of GDP; iii) population density (people per square kilometers of land area); iv) agricultural employment, as a percentage of total employment; v) Foreign Direct Investment (FDI), as a percentage of GDP; vi) Government debt-to-GDP ratio. Table A5 in Appendix A displays the summary statistics for all variables described and considered in regressions. Thus, we follow the second-stage analysis by estimating Equation (4) using Simar and Wilson (2007) estimation method. The authors argue that for efficiency scores this approach is superior to other methods such as OLS and Tobit. This is given by the fact that Simar and Wilson (2007) procedure constructs a data generating process which is consistent with second-stage estimation of truncated regression models.

4. Empirical analysis

4.1. Efficiency and tax structure

The aim of this section is to evaluate the main determinants of public efficiency scores and assess the effects of the tax structure composition. As we identified in Table B1 the main determinant variables selected by the general-to-specific approach, we consider these as control variables to estimate panel regressions on the scores obtained in Models 1, 2, 3 and 4 for both input and output orientation. We follow this approach to address two main issues. First, observe if there are significant differences in results according to the model orientation (either input or output-oriented). Second, compute and compare the effects of taxation on scores of Models 3 and 4, which consider respectively the performance in "social aspects" (*Opportunity* indicators) and the performance in "economic aspects" (*Musgravian* indicators).

Table 1 below brings the results for the estimation of Equation (4) using efficiency scores of Models 1 and 2 as dependent variables. We observe initially that total taxation seems to reduce efficiency levels in similar magnitudes for the input-oriented specification but presents weaker or non-significant coefficients for the output-oriented models. Moreover, when taxes are disaggregated, we find significant negative effects for both individual and corporate income taxes, particularly for input-oriented scores.

Significant positive effects for property taxes and working contributions are obtained in the output orientation, while consumption taxation has similar negative effects for both models, even though with higher coefficients in the input-oriented specification. With respect to the other regressors considered, results point out that countries with high public debt seem to have less efficient public sectors, whilst countries which are more densely populated and present positive primary balances tend to be more efficient.

Table 1 – Results for DEA efficiency scores of Models 1 and 2

	Model 1				**Model 2**			
VARIABLES	INPUT		OUTPUT		INPUT		OUTPUT	
Total tax revenue, t-1	-0.012***		-0.002**		-0.011***		-0.000	
	(0.001)		(0.001)		(0.000)		(0.001)	
PIT, t-1		-0.012**		-0.018***		-0.004		-0.011***
		(0.005)		(0.004)		(0.005)		(0.003)
CIT, t-1		-0.017***		0.000		-0.016***		0.001
		(0.002)		(0.002)		(0.002)		(0.002)
Property taxes, t-1		-0.007		0.003		0.007		0.020**
		(0.010)		(0.010)		(0.012)		(0.008)
Working contributions, t-1		-0.006**		0.011***		-0.005		0.009***
		(0.003)		(0.003)		(0.004)		(0.002)
Consumption taxes, t-1		-0.015***		-0.006***		-0.017***		-0.007***
		(0.002)		(0.002)		(0.002)		(0.002)
FDI, t-1	0.000	0.000	-0.001	-0.002	0.000	0.000	-0.001	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Government debt, t-1	-0.002***	-0.002***	-0.001***	-0.001***	-0.001***	-0.002***	-0.001*	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tourism, t-1	0.000	0.000	-0.000	0.001**	0.001**	0.001	0.001*	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Primary balance, t-1	0.007***	0.007***	0.000	0.002	0.008***	0.008***	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
Population density, t-1	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural Employment, t-1	0.000	0.000	-0.001***	-0.001**	0.000	0.000	-0.001***	-0.001**
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
sigma	0.125***	0.124***	0.120***	0.117***	0.131***	0.130***	0.090***	0.088***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)
Observations	656	646	561	558	592	582	532	527

Note: The table reports results from Equation (4) using Simar and Wilson two-stage efficiency regression model. The dependent variables are the DEA efficiency scores of Models 1 and 2 for both input and output orientation from 1997 to 2019. The definition and sources of the independent variables are presented in Table A4 of Appendix A. Five regions and year fixed effects are included but not reported for reasons of parsimony. Constant term also omitted. ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively.

At Table 2 we show the results of regressions using DEA scores of Models 3 and 4. At first, we see that the harmful effects of total tax revenues remain at similar levels for both input-oriented models, but weaker for the output-oriented. We also observe that individual income taxes present stronger negative effects in Model 4, while corporate income taxation seems harmful to both input models but can be beneficial to output-oriented scores of Model 4. Additionally, significant positive impacts of property taxes and working contributions are obtained for the output orientation of Model 3, while consumption taxes continue to present similar negative effects in both models. Lastly, besides finding similar results for government debt, primary balance and population density, tourism seems to improve scores in Model 3, while agricultural employment seems detrimental to output oriented scores, but favorable for input scores of Model 4.

Table 2 – Results for DEA efficiency scores of Models 3 and 4

	Model 3				**Model 4**			
VARIABLES	INPUT		OUTPUT		INPUT		OUTPUT	
Total tax revenue, t-1	-0.011***		-0.002***		-0.013***		-0.003**	
	(0.001)		(0.000)		(0.000)		(0.001)	
PIT, t-1		-0.008*		-0.009***		-0.013***		-0.028***
		(0.004)		(0.003)		(0.004)		(0.005)
CIT, t-1		-0.018***		-0.003		-0.017***		0.007**
		(0.002)		(0.003)		(0.002)		(0.003)
Property taxes, t-1		0.007		0.018**		-0.008		-0.002
		(0.011)		(0.007)		(0.010)		(0.011)
Working contributions, t-1		-0.004		0.005***		-0.010***		0.010***
		(0.003)		(0.002)		(0.003)		(0.003)
Consumption taxes, t-1		-0.016***		-0.008***		-0.013***		-0.006*
		(0.002)		(0.002)		(0.001)		(0.003)
FDI, t-1	-0.001	-0.001	-0.001	-0.002	-0.000	-0.000	0.002	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Government debt, t-1	-0.001***	-0.002***	-0.000	-0.001**	-0.001***	-0.002***	-0.001***	-0.001**
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tourism, t-1	0.001***	0.001**	0.001**	0.001***	0.000	0.000	-0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Primary balance, t-1	0.008***	0.008***	0.000	0.000	0.006***	0.006***	0.003*	0.005**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Population density, t-1	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural Employment, t-1	-0.000	-0.000	-0.001***	-0.001**	0.001***	0.001***	-0.001**	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
sigma	0.127***	0.127***	0.091***	0.090***	0.117***	0.116***	0.154***	0.151***
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Observations	654	643	588	582	664	653	573	570

Note: The table reports results from Equation (4) using Simar and Wilson two-stage efficiency regression model. The dependent variables are the DEA efficiency scores of Models 3 and 4 for both input and output orientation from 1997 to 2019. The definition and sources of the independent variables are presented in Table A4 of Appendix A. Five regions and year fixed effects are included but not reported for reasons of parsimony. Constant term also omitted. ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively.

4.2 Robustness analysis

As a robustness analysis, we start by changing the input variables considered in the computation of DEA scores for Models 3 and 4 and refer to them as Models 5 and 6, respectively. In Model 5, we considered as input variables government consumption, government health expenditures and government education expenditures, while the output variable is still the *Opportunity* PSP. Model 6 uses as input variables total government expenditures and the gross fixed capital formation, still considering *Musgravian* PSP as the output variable. Additionally, we re-estimate results for Models 3 and 4, as well as for Models 5 and 6, considering only the period between 2007 to 2019, as discussed in the methodology. Results are presented in Tables 3, 4 and 5, respectively.

Table 3 below displays the results for Models 5 and 6 considering the whole period. At first, we see that total taxation still presents significant detrimental impacts on input scores but weaker or non-significant effects on output-oriented scores. Moreover, individual income taxes continue to show significant and stronger negative effects in Model 6, as observed in Model 4. We also obtain significant positive impacts of corporate income taxes on output scores of both models, while property taxes and working contributions keep presenting strong positive effects for Model 5, similar to the observed for Model 3. Lastly, we see that consumption taxes have significant negative effects only in Model 5.

Table 3 – Results for DEA input efficiency scores of Models 5 and 6

	Model 5				**Model 6**			
VARIABLES	INPUT		OUTPUT		INPUT		OUTPUT	
Total tax revenue, t-1	-0.008***		0.002*		-0.002*		-0.001	
	(0.001)		(0.001)		(0.001)		(0.001)	
PIT, t-1		-0.015**		0.005		-0.018***		-0.012**
		(0.006)		(0.005)		(0.005)		(0.005)
CIT, t-1		0.009		0.018***		-0.013***		0.012***
		(0.008)		(0.004)		(0.004)		(0.004)
Property taxes, t-1		0.034**		0.029***		-0.009		-0.016
		(0.013)		(0.010)		(0.010)		(0.013)
Working contributions, t-1		-0.002		0.008***		0.006**		0.005
		(0.003)		(0.003)		(0.003)		(0.004)
Consumption taxes, t-1		-0.020***		-0.010***		0.001		-0.004
		(0.003)		(0.002)		(0.002)		(0.002)
FDI, t-1	0.005**	0.003	-0.000	-0.002	-0.008***	-0.007***	-0.000	-0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Government debt, t-1	-0.001*	-0.001***	-0.000	-0.001*	-0.001**	-0.000	-0.001**	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tourism, t-1	-0.000	0.001*	0.002***	0.003***	-0.004***	-0.003***	0.000	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Primary balance, t-1	0.001	0.002	-0.005***	-0.004***	-0.002	-0.001	-0.001	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Population density, t-1	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Agricultural Employment, t-1	0.001***	0.001***	0.000	0.000	-0.000	-0.000	-0.001**	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)

	Model 5				Model 6			
VARIABLES	INPUT		OUTPUT		INPUT		OUTPUT	
sigma	0.122***	0.115***	0.108***	0.101***	0.119***	0.116***	0.160***	0.158***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.003)	(0.005)	(0.004)
Observations	386	379	462	454	569	559	568	562

Note: The table reports results from Equation (4) using Simar and Wilson two-stage efficiency regression model. The dependent variables are the DEA efficiency scores of Models 5 and 6 for both input and output orientation from 1997 to 2019. The definition and sources of the independent variables are presented in Table A4 of Appendix A. Five regions and year fixed effects are included but not reported for reasons of parsimony. Constant term also omitted. ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively.

Results considering only the period from 2007 to 2019 are presented at Tables 4 and 5 below. In this case, we continue to obtain similar evidence regarding the differences in tax effects depending on the orientation of the models and according to the output variable considered. Particularly, we still observe stronger negative effects of taxation on input-oriented scores and find evidence that Models 3 and 5 seem more affected by property taxes and working contributions, while Models 4 and 6 seem to be directly influenced by individual and corporate income taxes. At last, we also find negative impacts of consumption taxes and government debt, whilst tourism, primary balance and population density continue to improve public efficiency.

Table 4 – Results for DEA input efficiency scores of Models 3 and 4 (2007-2019).

	Model 3				Model 4			
VARIABLES	INPUT		OUTPUT		INPUT		OUTPUT	
Total tax revenue, t-1	-0.010***		-0.002***		-0.013***		-0.005***	
	(0.001)		(0.000)		(0.001)		(0.001)	
PIT, t-1		-0.006		-0.009***		-0.020***		-0.037***
		(0.004)		(0.002)		(0.004)		(0.007)
CIT, t-1		-0.020***		-0.002		-0.021***		0.003
		(0.002)		(0.001)		(0.002)		(0.003)
Property taxes, t-1		0.003		0.018**		-0.004		0.009
		(0.010)		(0.008)		(0.011)		(0.016)
Working contributions, t-1		0.000		0.007***		-0.003		0.014***
		(0.003)		(0.002)		(0.003)		(0.004)
Consumption taxes, t-1		-0.017***		-0.008***		-0.014***		-0.009**
		(0.002)		(0.002)		(0.002)		(0.003)
FDI, t-1	0.001	0.000	-0.000	-0.001	-0.002	-0.003*	-0.001	-0.004
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)
Government debt, t-1	-0.002***	-0.002***	0.000	0.000	-0.002***	-0.002***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tourism, t-1	0.001***	0.002***	0.001***	0.002***	0.000	0.001***	-0.001**	0.002**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Primary balance, t-1	0.010***	0.011***	0.002	0.002*	0.011***	0.012***	0.014***	0.014***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
Population density, t-1	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001**	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural Employment, t-1	-0.000	-0.000	-0.001***	-0.001**	0.000	0.000	-0.000	0.000

	Model 3				Model 4			
VARIABLES	INPUT		OUTPUT		INPUT		OUTPUT	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
sigma	0.112***	0.109***	0.081***	0.078***	0.109***	0.105***	0.160***	0.155***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)
Observations	402	398	404	400	408	405	408	405

Note: The table reports results from Equation (4) using Simar and Wilson two-stage efficiency regression model. The dependent variables are the DEA efficiency scores of Models 3 and 4 for both input and output orientation from 2007 to 2019. The definition and sources of the independent variables are presented in Table A4 of Appendix A. Five regions and year fixed effects are included but not reported for reasons of parsimony. Constant term also omitted. ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively.

Table 5 – Results for DEA input efficiency scores of Models 5 and 6 (2007-2019).

	Model 5				Model 6			
VARIABLES	INPUT		OUTPUT		INPUT		OUTPUT	
Total tax revenue, t-1	-0.012***		0.000		-0.011***		-0.002	
	(0.001)		(0.001)		(0.000)		(0.002)	
PIT, t-1		-0.012*		0.002		-0.015**		-0.017**
		(0.007)		(0.007)		(0.006)		(0.008)
CIT, t-1		0.000		0.010**		-0.017***		0.010*
		(0.006)		(0.004)		(0.004)		(0.005)
Property taxes, t-1		0.019		0.017*		0.013		-0.000
		(0.014)		(0.011)		(0.013)		(0.019)
Working contributions, t-1		0.007*		0.011***		0.003		0.006
		(0.004)		(0.004)		(0.004)		(0.005)
Consumption taxes, t-1		-0.026***		-0.013***		0.001		-0.007
		(0.004)		(0.003)		(0.002)		(0.004)
FDI, t-1	0.000	0.002	-0.001	-0.003*	0.000	-0.007***	-0.004	-0.005*
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)
Government debt, t-1	-0.002***	-0.002***	-0.000*	-0.000**	-0.001***	0.000	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tourism, t-1	0.000	0.003***	0.002***	0.003***	0.001**	-0.004***	0.000	0.002**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Primary balance, t-1	0.007***	0.004	-0.006**	-0.004	0.008***	-0.000	0.009**	0.009**
	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.004)
Population density, t-1	0.001***	0.000***	0.000***	0.000***	0.001***	0.000***	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural Employment, t-1	0.000	0.001***	0.000	0.000	0.000	-0.000	-0.000	-0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
sigma	0.117***	0.109***	0.101***	0.094***	0.117***	0.114***	0.160***	0.157***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)
Observations	267	264	298	295	350	347	360	357

Note: The table reports results from Equation (4) using Simar and Wilson two-stage efficiency regression model. The dependent variables are the DEA efficiency scores of Models 5 and 6 for both input and output orientation from 2007 to 2019. The definition and sources of the independent variables are presented in Table A4 of Appendix A. Five regions and year fixed effects are included but not reported for reasons of parsimony. Constant term also omitted. ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively.

4.3 Discussion

These results imply a few inferences which deserve to be highlighted and discussed: i) There are significant differences in results regarding the effects of taxation depending on the orientation of DEA scores; ii) Even though individual income taxes present significant detrimental effects in all models under both orientation setups, the strongest negative effects are on Models 4 and 6; iii) Corporate income taxes tend to be harmful to input oriented scores but can be improve output efficiency scores; iv) Property taxes and working contributions have strong positive effects, especially in output oriented models; v) Consumption taxes seem to negatively affect efficiency in all models.

Regarding the first point, differences in the results of taxation according to the orientation setup of the model may be derived from the fact that on input-oriented models the government intends to increase efficiency by decreasing the inputs utilized, in this case total expenditures, while maintaining the output constant, in this case public goods and services. Therefore, the process of increasing revenues may be counterproductive in the sense that, even though it increases the funding capacity of the public sector, which is already being considered by the effects of the primary balance, these increments would not be used in the provision of public goods and services as the output is supposed to remain constant, probably producing stronger harmful effects for taxation. Oppositely, for output-oriented models, as inputs are supposed to remain constant while the output increases, additional increments in tax revenues could be used to improve the provision of public goods and services which may help to raise efficiency.

On top of that, with respect the other points, we observed that the *Opportunity* PSP considered in Models 3 and 5 seems to be directly affected by property taxes and working contributions, while the *Musgravian* PSP considered in Models 4 and 6 seems more closely related to income taxes. In this context, as local governments tend to be more directly responsible by the provision of basic social goods and services for the population and these are mainly considered in the indicators of the *Opportunity* PSP, while federal or central governments tend to be in charge of organizing and implementing macroeconomic strategies which affect overall economic conditions of a country and are mostly considered in the indicators of the *Musgravian* PSP, it is important to understand the funding characteristics of each government level.[9]

Accordingly, Figure 3 below shows that local governments in all regions are mainly funded by property taxes, consumption taxes and working contributions, but also

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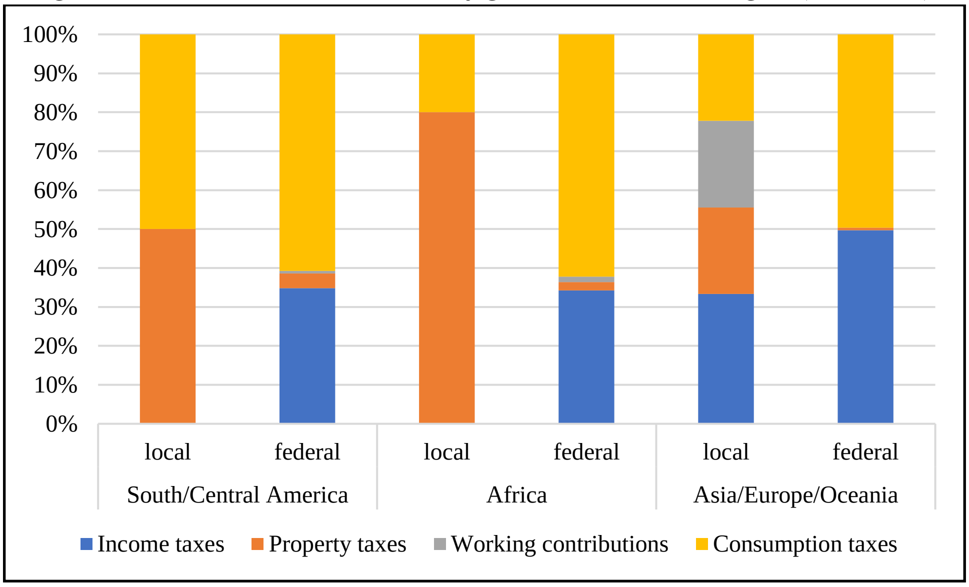
[9] Adam et al. (2014) had shown that fiscal decentralization is beneficial to public efficiency in OECD countries until a certain point. Even though there is no sufficient available data on fiscal decentralization for our sample of developing countries, we believe that results regarding the different tax effects on *Opportunity* and *Musgravian* PSPs are supported by the distribution of tax revenues according to government levels, as shown in Figure 3.

naturally by federal transfers. This may shed light on the fact that these are the tax items which seem to be more important to public efficiency on the social aspects considered in the *Opportunity* PSP, such as health and education. On the other hand, we see that federal governments are mainly funded by income taxes and consumption taxes, validating the evidence pointed in our results regarding the stronger effects of income taxation on *Musgravian* PSP. Therefore, we may affirm that increasing financial capacities of local governments through better conditions for revenue collection of property taxes and working contributions can improve public sector efficiency, especially on the health and education sector, but also on administrative issues and on public infrastructure. Oppositely, the federal government should address its macroeconomic objectives and pursue less income inequality by using mainly both individual and corporate income taxes.

Figure 3 – Distribution of tax revenues by government level and region (1997-2019).



Note: authors' calculations based on data considered in second-stage regressions.

5. Conclusions

In this research we investigate the relationship between tax structures and public sector efficiency scores for 41 developing economies between 1997 and 2019. At the first stage, we start by calculating Public Sector Performance (PSP) indicators which are used to compute, via Data Envelopment Analysis (DEA), public spending efficiency scores for each country and year in the sample. At the second stage analysis, we initially follow a general-to-specific approach to select the main determinant variables of scores, which are considered in regression estimations together with different tax variables. Thus, by using a reduced-form panel data analysis, we empirically assess the effects of taxation on input and output efficiency scores, also addressing differences in results regarding the effects on sub-components of Total PSP, namely on *Opportunity* PSP and on *Musgravian* PSP.

The first results of our study can be summarized as follows: i) inputs could probably be lowered, on average, in around 40%, while keeping the same level of outputs; ii) output could possibly be increased, on average, in around 30%, while keeping the same level of inputs, to increase overall public sector efficiency. These values are similar to the ones found by Afonso et al. (2021) for OECD countries, even though there is evidence of more volatility in our DEA scores for developing countries. With respect to the results of second-stage regressions, the first evidence observed were significant differences in results according to the orientation setup of the models. For instance, regressions using input-oriented DEA scores showed stronger negative effects of total tax revenues in similar magnitudes for almost all models.

On the contrary, in regressions using output-oriented DEA scores we found that total taxation presents significantly weaker or non-significant effects. Additionally, while individual income taxes and consumption taxes presented significant detrimental effects to public sector efficiency on both input and output-oriented scores, corporate income taxes presented mainly negative effects on input scores but positive on output-oriented. We also observe that property taxes and working contributions can improve efficiency scores, particularly for the *Opportunity* PSP indicators (Models 3 and 5), while the *Musgravian* PSP (Models 4 and 6) seems to be more affected by both individual and corporate income taxes.

We bring two potential explanations for the differences in results. First, the distinct impacts of taxation depending on the orientation setup of the model may be conditioned by the optimization problem considered in each case. In this sense, given that for input-oriented models the output must remain constant, meaning that no additional revenues can be used for improvements in public services, this may produce stronger harmful effects of taxation, while for output-oriented models the output must increase to improve efficiency, which may be directly associated with additional tax revenues. Moreover, with respect the diverse impacts of the different tax items on models which consider either the *Opportunity* or the *Musgravian* PSP as the output variable, we show that this is potentially connected to the funding characteristics of the different levels of the public sector, as well as with the scope of action and responsibilities of each public authority.

These findings bring novelty contributions to the literature and suggest two main final conclusions. First, higher care should be taken when selecting the orientation setup for computation of efficiency scores by taking into consideration differences in the effects of the main determinant variables under these two scenarios. Second, even though consumption taxes seem to negatively affect efficiency scores in all models on similar magnitudes, individual income taxes and corporate income taxes seem to be greatly associated with public efficiency on the economic aspects considered by the *Musgravian* PSP represented in Models 4 and 6, while property taxes and working contributions seem to be more closely related to efficiency in the social aspects considered in *Opportunity PSP* scores of Models 3 and 5.

Therefore, given that the margin for efficiency improvements is, on average, around 30-40%, our findings carry a relevant message for policy making. Besides carefully considering the strategy to improve efficiency, either by increasing outputs or decreasing inputs, authorities in charge of budgetary issues should bear in mind the distinct effects that each type of tax can have on specific sub-areas of public policies, namely on public efficiency related to social or economic aspects. For instance, to improve public sector performance in sectors such as health and education, increasing fiscal conditions and revenue collection capacities of local governments through property taxes and working contributions seems more appropriate, while macroeconomic performance and stability, as well as income distribution, may be better addressed through revenues from income taxes which lead to sustainable fiscal conditions.

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Appendix A

Table A1 – Summary of variables used for Public Sector Performance (PSP)

Sub Index	Variable	Source/Period	Series
Opportunity Indicators			
Administration	Corruption	Transparency International Corruption Perception Index (CPI), (1998-2019)	Corruption on a scale from 10 (Perceived to have low levels of corruption) to 0 (highly corrupt), 1998–2011; Corruption on a scale from 100 (Perceived to have low levels of corruption) to 0 (highly corrupt), 2012–2019.
	Red Tape	World Economic Forum: The Global Competitiveness Report, (2007–2017)	Burden of government regulation on a scale from 7 (not burdensome at all) to 1 (extremely burdensome).
	Judicial Independence	World Economic Forum: The Global Competitiveness Report, (2007–2017)	Judicial independence on a scale from 7 (entirely independent) to 1 (heavily influenced).
	Property Rights	World Economic Forum: The Global Competitiveness Report, (2007–2017)	Property rights on a scale from 7 (very strong) to 1 (very weak).
	Shadow Economy	Medina and Schneider (2017), (1997-2017)	Shadow economy measured as percentage of official GDP. Reciprocal value 1/x.
Education	Secondary School Enrollment	World Bank, World Development Indicators, (1997–2019)	Ratio of total enrolment, regardless of age, in secondary education.
	Quality of Educational System	World Economic Forum: The Global Competitiveness, Report (2007–2017)	Quality of educational system on a scale from 7 (very well) to 1 (not well at all).
Health	Infant Survival Rate	World Bank, World Development Indicators, (1997–2019)	Infant survival rate = (1000-IMR)/1000. IMR is the infant mortality rate measured per 1000 lives birth in a given year.
	Life Expectancy	World Bank, World Development Indicators, (1997–2019)	Life expectancy at birth, measured in years.
	CVD, cancer, diabetes or CRD Survival Rate	World Health Organization, Global Health Observatory Data Repository, (2000-2019).	CVD, cancer and diabetes survival rate = 100-M. M is the mortality rate between the ages 30 and 70.
Public Infrastructure	Infrastructure Quality	World Economic Forum: The Global Competitiveness Report, (2007–2017)	Infrastructure quality on a scale from 7 (extensive and efficient) to 1 (extremely underdeveloped)
Musgravian Indicators			
Distribution	Gini Index	World Bank, World Development Indicators, (1997–2019)	Gini index on a scale from 1 (perfect inequality) to 0 (perfect equality). Transformed to 1-Gini.
Stabilization	Coefficient of Variation of Growth	IMF World Economic Outlook (WEO database), (1997–2019)	Coefficient of variation = standard deviation/mean of GDP growth based on 5-year data. GDP constant prices

Sub Index	Variable	Source/Period	Series
			(percent change). Reciprocal value 1/x.
	Standard Deviation of Inflation	IMF World Economic Outlook (WEO database), (1997–2019)	Standard deviation of inflation based on 5-year consumer prices (percent change) data. Reciprocal value 1/x.
Economic Performance	GDP per Capita	IMF World Economic Outlook (WEO database), (1997–2019)	GDP per capita based on PPP, current international dollar.
	GDP Growth	IMF World Economic Outlook (WEO database), (1997–2019)	GDP constant prices (percent change).
	Unemployment	IMF World Economic Outlook (WEO database), (1997–2019)	Unemployment rate, as a percentage of total labor force. Reciprocal value 1/x.

Table A2 – Input components (1997-2019)

Variables	**Series**	**Source**
Government expenditures	General government total expenditure (% of GDP)	World Economic Outlook (WEO) - IMF
Government consumption	Government final consumption expenditure (% of GDP)	World Development Indicators (WDI) – World Bank
Education expenditure	Government expenditure on education (% GDP)	World Development Indicators (WDI) – World Bank
Health expenditure	Government expenditure on health (% GDP)	World Development Indicators (WDI) – World Bank
Gross fixed capital formation	Total gross fixed capital formation (% GDP)	World Development Indicators (WDI) – World Bank

Table A3 – List of countries

Country	**Code**	**Country**	**Code**
Argentina	ARG	Madagascar	MDG
Barbados	BRB	Malaysia	MYS
Belize	BLZ	Mali	MLI
Bhutan	BTN	Mauritius	MUS
Bolivia	BOL	Morocco	MAR
Brazil	BRA	Nicaragua	NIC
Bulgaria	BGR	Niger	NER
Burkina Faso	BFA	Panama	PAN
Cabo Verde	CPV	Papua New Guinea	PNG
Cameroon	CMR	Paraguay	PRY
Colombia	COL	Peru	PER
Côte d'Ivoire	CIV	Philippines	PHL
Dominican Republic	DOM	Rwanda	RWA
Egypt	EGY	St. Lucia	LCA
El Salvador	SLV	Senegal	SEN
Guatemala	GTM	South Africa	ZAF
Guyana	GUY	Thailand	THA
Honduras	HND	Trinidad and Tobago	TTO
Jamaica	JAM	Tunisia	TUN
Kazakhstan	KAZ	Uruguay	URY
Kenya	KEN		

Table A4 – Second-stage variables (1997-2019)

Variables	**Series**	**Source**
Total tax revenue (% GDP)	Total taxes revenues, as a percentage of GDP.	OECD database
Income taxes (% GDP)	Total taxes on income, profits and capital gains, as a percentage of GDP.	OECD database
PIT (% GDP)	Total taxes on income, profits and capital gains of individuals, as a percentage of GDP.	OECD database
CIT (% GDP)	Total taxes on income, profits and capital gains of corporates, as a percentage of GDP.	OECD database
Property taxes (% GDP)	Total taxes on property, as a percentage of GDP.	OECD database
Working contributions (% GDP)	Sum of total taxes on payroll and workforce and social security contributions, as a percentage of GDP.	OECD database
Consumption taxes (% GDP)	Total taxes on goods and services, as a percentage of GDP.	OECD database
Government debt (% GDP)	General government gross debt, as a percentage of GDP.	World Economic Outlook (WEO) - IMF
Trade Openness (% GDP)	Sum of exports and imports of goods and services, as a percentage of GDP.	World Development Indicators (WDI) – World Bank
Total Savings (% GDP)	Gross national savings, as a percentage of GDP.	World Economic Outlook (WEO) - IMF
Tourism (% exports)	International tourism revenues, as a percentage of total exports.	World Development Indicators (WDI) – World Bank
Population (log)	Logarithm of domestic residents.	World Development Indicators (WDI) – World Bank
Internet users (% population)	Number of individuals using the internet, as a percentage of total population.	World Development Indicators (WDI) – World Bank
Agricultural Employment (% employment)	Employment in agriculture, as a percentage of total employment.	World Development Indicators (WDI) – World Bank
Foreign Direct Investment - FDI (% GDP)	Foreign direct investment, net inflows, as a percentage of GDP.	World Development Indicators (WDI) – World Bank
Military Expenditures (% GDP)	Total military expenditures, as a percentage of general government expenditures.	World Development Indicators (WDI) – World Bank
Young population	Population aged 0-14, as a percentage of total population.	World Development Indicators (WDI) – World Bank
Urban population	Urban population, as a percentage of total population.	World Development

Variables	**Series**	**Source**
		Indicators (WDI) – World Bank
Primary balance (% GDP)	General government primary net lending/borrowing, as a percentage of GDP.	World Economic Outlook (WEO) - IMF
Current Account (% GDP)	Current account balance, as a percentage of GDP.	World Economic Outlook (WEO) - IMF
Population density	Population density, as people per square km of land area.	World Development Indicators (WDI) – World Bank

Table A5 – Summary statistics

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Government expenditures	916	24.592	7.086	9.118	54.044
Government consumption	836	14.375	3.337	4.997	28.009
Education expenditure	701	4.239	1.406	1.538	8.94
Health expenditure	820	2.588	1.27	0.121	6.824
Gross fixed capital formation	844	21.651	7.499	8.253	69.673
Tax revenue	900	18.771	6.266	6.46	33.57
Income taxes	915	5.831	3.327	0.988	24.388
PIT	887	2.182	1.729	0	10.05
CIT	882	3.371	2.405	0.34	21.17
Property taxes	896	0.603	0.658	0	2.89
Consumption taxes	900	9.575	3.093	2.88	20.37
Working contributions	900	2.50	2.355	-0.05	10.8
Government debt	891	51.543	27.175	4.092	158.264
Trade Openness	868	76.094	36.536	16.439	220.407
Total Savings	815	19.181	7.535	-1.418	51.826
Tourism	819	17.053	16.037	0.019	88.775
Population	943	22.750	34.401	0.150	211.049
Internet users	926	21.508	22.105	0.002	84.187
Agricultural Employment	943	31.574	22.039	0.06	88.8
Foreign Direct Investment - FDI	940	3.691	3.561	-7.021	32.765
Military Expenditures	790	5.431	2.847	0.535	23.131
Young population	943	33.106	8.654	13.509	49.502
Urban population	943	50.639	20.343	12.466	95.426
Primary balance	911	-0.026	3.511	-15.895	31.243
Current Account	910	-3.483	7.351	-53.296	38.304
Population density	943	116.182	150.735	3.779	651.581

Note: Population in millions of people.

Appendix B

Table B1 – Specification Test: General-to-specific

Input-oriented DEA scores				
VARIABLES	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Tourism (% exports), t-1	0.005***	0.008***	0.005***	0.005***
	(0.001)	(0.001)	(0.000)	(0.001)
Population (log), t-1	-0.195***			-0.264***
	(0.056)			(0.052)
Internet users (% population), t-1	-0.001***	-0.001***	-0.001***	
	(0.000)	(0.000)	(0.000)	
FDI (% GDP), t-1	0.004***			0.005***
	(0.001)			(0.001)
Primary balance (% GDP), t-1	0.005***	0.004***	0.004***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)
Population density, t-1	0.001***	0.001***		0.002***
	(0.000)	(0.000)		(0.000)
Government debt (% GDP), t-1		0.001***	0.001**	
		(0.000)	(0.000)	
Trade Openness (% GDP), t-1			-0.001***	
			(0.000)	
Agricultural Employment, t-1			-0.003***	
			(0.001)	
Urban population, t-1			0.003**	
			(0.001)	
Young population, t-1				0.007***
				(0.002)
Observations	754	729	676	757
R-squared	0.184	0.173	0.138	0.167
Output-oriented DEA scores				
VARIABLES	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Government debt (% GDP), t-1	-0.001***		0.001***	-0.002***
	(0.000)		(0.000)	(0.000)
Tourism (% exports), t-1	0.003**		0.002**	
	(0.001)		(0.000)	
Agricultural Employment, t-1	0.005***		-0.003***	0.004***
	(0.001)		(0.001)	(0.001)
FDI (% GDP), t-1	0.004**			0.009***
	(0.002)			(0.002)
Primary balance (% GDP), t-1	0.004***			0.006***
	(0.001)			(0.001)
Current Account (% GDP), t-1	0.002**			
	(0.001)			
Population density, t-1	0.001***	0.001***		0.002***
	(0.000)	(0.000)		(0.000)
Young population, t-1		0.007***	0.011***	
		(0.001)	(0.001)	
Trade Openness (% GDP), t-1			-0.001***	
			(0.000)	
Urban population, t-1			0.004***	
			(0.001)	
Observations	593	738	596	690
R-squared	0.109	0.046	0.143	0.146

Note: The table reports the estimated results from Equation (4) using the general-to-specific approach. The dependent variables are the DEA input and output-oriented scores from 1997 to 2019 of Models 1, 2, 3 and 4. The definition and sources of the independent variables tested are presented in Table A4 of Appendix A. Five regions fixed effects are included but not reported for reasons of parsimony. Constant term also omitted. ***, **, * denote statistical significance at 1%, 5% and 10% levels, respectively. **Selected variables:** Tourism (% exports), Primary balance (% GDP), Population density, Government debt (% GDP), Agricultural Employment (% employment), FDI (% of GDP).

Appendix C

Table C1 – Summary of DEA scores for Model 1 (input-oriented)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Efficient	4	3	3	3	3	4	3	3	3	2	4	3
Code	DOM; GTM; KEN; TUN	DOM; KEN; TUN	DOM; KEN; TUN	DOM; TTO; TUN	KEN; MDG; TUN	GTM; KAZ; MYS; KEN	KAZ; KEN; THA	KEN; KAZ; MYS	KEN; KAZ; MYS	KEN; KAZ;	CMR; KEN; THA; URY	MDG; URY; PRY
Average	0.63	0.62	0.58	0.65	0.64	0.62	0.66	0.66	0.65	0.64	0.68	0.66
Min	0.28	0.27	0.25	0.32	0.32	0.35	0.34	0.38	0.35	0.33	0.37	0.33
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.21	0.20	0.21	0.19	0.20	0.19	0.17	0.17	0.18	0.17	0.20	0.17

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Efficient	4	3	3	5	3	4	3	3	2	3	4
Code	CMR; MDG; BTN; RWA	MDG; THA; URY	MDG; THA; URY	CIV; MDG; MUS; MYS; PHL	MDG; MUS; PHL	MDG; MUS; MYS; PHL	MUS; GTM; PHL	MUS; GTM; PHL	GTM; PHL	BTN; GTM; THA	CIV; BTN; GTM; PHL
Average	0.63	0.61	0.59	0.58	0.57	0.57	0.56	0.56	0.54	0.59	0.58
Min	0.32	0.31	0.34	0.30	0.33	0.31	0.28	0.30	0.31	0.33	0.35
Max	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.20	0.19	0.19	0.21	0.19	0.20	0.20	0.19	0.17	0.19	0.18

Note: Summary of DEA results from 1997 to 2019 for Model 1 using input-oriented setup. Model 1 uses one input variable, total government expenditures and one output, the total PSP.

Table C2 – Summary of DEA scores for Model 1 (output-oriented)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Efficient	3	3	3	1	3	3	3	3	3	5	3	4
Code	KEN; KAZ; THA	KEN; KAZ; MYS	KEN; KAZ; MYS	KAZ	CMR; THA; URU	MDG; PRY; URY	CMR; BTN; RWA	MDG; THA; URY	MDG; THA; URY	CIV; MDG; MUS; MYS; PHL	MDG; MUS; PHL	MDG; MUS; MYS; PHL
Average	0.70	0.68	0.69	0.62	0.77	0.76	0.62	0.74	0.73	0.69	0.65	0.64
Min	0.41	0.35	0.44	0.34	0.52	0.45	0.19	0.43	0.46	0.43	0.39	0.43
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.15	0.17	0.15	0.14	0.13	0.14	0.22	0.13	0.14	0.16	0.15	0.16

	2015	2016	2017	2018	2019
Efficient	3	3	2	3	4
Code	MUS; GTM; PHL	MUS; GTM; PHL	GTM; PHL	BTN; GTM; THA	BTN; CIV; GTM; PHL
Average	0.65	0.64	0.64	0.68	0.62
Min	0.44	0.41	0.46	0.34	0.29
Max	1	1	1	1	1
Std. Dev.	0.15	0.15	0.14	0.15	0.16

Note: Summary of DEA results from 2003 to 2019 for Model 1 using output-oriented setup. Model 1 uses one input variable, total government expenditures and one output, the total PSP. For reasons of data availability, scores were only possible to compute for this period.

Table C3 – Summary of DEA scores for Model 2 (input-oriented)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Efficient	7	5	6	8	10	7	9	6	6	4	9	6
Average	0.69	0.69	0.68	0.72	0.75	0.76	0.78	0.78	0.73	0.72	0.72	0.69
Min	0.29	0.30	0.34	0.34	0.39	0.42	0.47	0.47	0.44	0.38	0.40	0.39
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.23	0.20	0.21	0.19	0.19	0.18	0.17	0.17	0.18	0.18	0.19	0.19

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Efficient	10	6	4	8	5	6	5	5	5	8	5
Average	0.70	0.70	0.67	0.68	0.64	0.64	0.64	0.65	0.67	0.73	0.73
Min	0.39	0.41	0.39	0.40	0.38	0.32	0.28	0.32	0.36	0.44	0.47
Max	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.20	0.19	0.18	0.20	0.19	0.20	0.19	0.19	0.19	0.18	0.16

Note: Summary of DEA results from 1997 to 2019 for Model 2 using input-oriented setup. Model 2 uses one input variable, total government expenditures and two outputs, the Opportunity PSP and the Musgravian PSP. Country codes not reported for reasons of parsimony.

Table C4 – Summary of DEA scores for Model 2 (output-oriented)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Efficient	7	9	6	6	4	9	6	10	6	4	8	5
Average	0.87	0.87	0.84	0.81	0.80	0.81	0.81	0.83	0.84	0.80	0.81	0.80
Min	0.58	0.60	0.58	0.58	0.54	0.56	0.55	0.55	0.67	0.57	0.59	0.56
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.10	0.11	0.13	0.13	0.13	0.13	0.12	0.12	0.10	0.12	0.11	0.11

	2014	2015	2016	2017	2018	2019
Efficient	6	5	5	5	8	5
Average	0.79	0.81	0.81	0.82	0.82	0.79
Min	0.54	0.53	0.60	0.60	0.62	0.57
Max	1	1	1	1	1	1
Std. Dev.	0.11	0.10	0.11	0.10	0.11	0.12

Note: Summary of DEA results from 2002 to 2019 for Model 2 using output-oriented setup. Model 2 uses one input variable, total government expenditures and two outputs, the Opportunity PSP and the Musgravian PSP. For reasons of data availability, scores were only possible to compute for this period. Country codes not reported for reasons of parsimony.

Table C5– Summary of DEA scores for Model 3 (input-oriented)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Efficient	3	3	3	4	4	4	5	2	3	3	2	3
Code	DOM; KEN; ARG	DOM; KEN; LCA	DOM; KEN; BRB	DOM; KEN; BRB; SEN	DOM; KEN; CIV; BRB	DOM; KEN; MUS; BRB	KEN; SEN; BRB; MUS; URY	KEN; BRB	KEN; DOM; BRB	KEN; MUS; BRB	KEN; SEN	PRY; GTM; SEN
Average	0.60	0.61	0.62	0.63	0.66	0.69	0.74	0.72	0.69	0.69	0.67	0.63
Min	0.25	0.30	0.26	0.25	0.23	0.40	0.46	0.45	0.37	0.38	0.36	0.35
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.21	0.19	0.20	0.18	0.18	0.18	0.16	0.16	0.17	0.18	0.17	0.17

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Efficient	3	4	2	4	3	3	2	3	3	4	3
Code	MDG; GTM; SEN	MDG; BRB; GTM; TUN	MDG; SEN	MDG; BRB; GTM; SEN	MDG; GTM; SEN	MDG; GTM; SEN	MYS; GTM	MYS; GTM; SEN	MYS; GTM; BRB	GTM; SEN; KAZ; URY	BTN; GTM; URY
Average	0.61	0.67	0.65	0.64	0.62	0.62	0.62	0.64	0.65	0.72	0.72
Min	0.35	0.36	0.39	0.39	0.37	0.32	0.28	0.31	0.36	0.44	0.47
Max	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.17	0.18	0.16	0.17	0.17	0.17	0.18	0.18	0.17	0.16	0.16

Note: Summary of DEA results from 1997 to 2019 for Model 3 using input-oriented setup. Model 3 uses one input variable, total government expenditures and one output, the Opportunity PSP.

Table C6 – Summary of DEA scores for Model 3 (output-oriented)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Efficient	4	5	2	3	3	2	2	3	4	2	4	3
Code	KEN; BRB; DOM; MUS	KEN; SEN; MUS; URY; BRB	KEN; BRB	KEN; DOM; BRB	KEN; BRB; MUS	KEN; SEN	GTM; SEN	MDG; GTM; SEN	MDG; BRB; GTM; TUN	MDG; SEN	MDG; BRB; GTM; SEN	MDG; GTM; SEN
Average	0.83	0.84	0.78	0.76	0.76	0.72	0.71	0.71	0.81	0.73	0.76	0.74
Min	0.55	0.60	0.55	0.53	0.51	0.46	0.48	0.51	0.64	0.54	0.54	0.51
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.11	0.11	0.13	0.13	0.13	0.13	0.12	0.13	0.10	0.11	0.11	0.11

	2014	2015	2016	2017	2018	2019
Efficient	2	2	3	3	4	3
Code	GTM; SEN	MYS; GTM	GTM; MYS; SEN	MYS; GTM; BRB	GUA; SEN; KAZ; URY	BTN; GTM; URY
Average	0.75	0.80	0.81	0.79	0.80	0.78
Min	0.48	0.53	0.60	0.60	0.62	0.57
Max	1	1	1	1	1	1
Std. Dev.	0.11	0.10	0.10	0.10	0.11	0.12

Note: Summary of DEA results from 2002 to 2019 for Model 3 using output-oriented setup. Model 3 uses one input variable, total government expenditures and one output, the Opportunity PSP. For reasons of data availability, scores were only possible to compute for this period.

Table C7 – Summary of DEA scores for Model 4 (input-oriented)

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Efficient	3	4	3	4	5	3	2	3	2	2	4	3
Code	GTM; KEN; TUN	DOM; KEN; TUN; TTO	DOM; KEN; TTO	TTO; KEN; BTN; CMR	KEN; TUN; GTM; CMR; BTN	GTM; KAZ; KEN	KAZ; KEN	KAZ; KEN; GTM	KAZ; KEN	KAZ; KEN	CMR; KEN; URY; MDG	MDG; PRY; URY
Average	0.60	0.63	0.57	0.64	0.63	0.59	0.63	0.61	0.61	0.62	0.63	0.61
Min	0.27	0.27	0.25	0.26	0.29	0.30	0.29	0.32	0.30	0.32	0.35	0.36
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.20	0.22	0.21	0.20	0.22	0.19	0.18	0.17	0.18	0.17	0.18	0.18

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Efficient	3	3	3	4	2	2	3	2	2	3	3
Code	CMR; MDG; RWA	MDG; THA; URY	MDG; THA; URY	CIV; MDG; MYS; PHL	MDG; PHL	MDG; PHL	MUS; GTM; PHL	GTM; PHL	GTM; PHL	GTM; PHL; THA	CIV; GTM; PHL
Average	0.59	0.59	0.56	0.55	0.55	0.54	0.55	0.55	0.54	0.57	0.56
Min	0.32	0.31	0.32	0.30	0.33	0.30	0.28	0.30	0.31	0.33	0.35
Max	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.19	0.19	0.19	0.22	0.18	0.18	0.19	0.18	0.17	0.18	0.17

Note: Summary of DEA results from 1997 to 2019 for Model 4 using input-oriented setup. Model 4 uses one input variable, total government expenditures and one output, the Musgravian PSP.

Table C8 – Summary of DEA scores for Model 4 (output-oriented)

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Efficient	1	1	1	1	3	2	5	3	3	4	1	2
Code	KAZ	KAZ	KAZ	KAZ	CMR; URY; MDG	MDG; URY	CMR; RWA; BRB; JAM; TTO	MDG; THA; URY	MDG; THA; URY	CIV; MDG; MYS; PHL	PHL	MUS; PHL
Average	0.46	0.46	0.49	0.44	0.64	0.60	0.51	0.63	0.60	0.56	0.50	0.51
Min	0.21	0.12	0.21	0.14	0.22	0.16	0.03	0.13	0.09	0.10	0.14	0.18
Max	1	1	1	1	1	1	1	1	1	1	1	1
Std. Dev.	0.18	0.18	0.18	0.16	0.18	0.19	0.29	0.20	0.21	0.23	0.20	0.19

	2015	**2016**	**2017**	**2018**	**2019**
Efficient	3	1	2	4	3
Code	MUS; GTM; PHL	PHL	GTM; PHL	BTN; GTM; THA; PHL	CIV; GTM; PHL
Average	0.53	0.48	0.46	0.55	0.47
Min	0.19	0.10	0.24	0.14	0.08
Max	1	1	1	1	1
Std. Dev.	0.21	0.19	0.19	0.22	0.21

Note: Summary of DEA results from 2003 to 2019 for Model 4 using output-oriented setup. Model 4 uses one input variable, total government expenditures and one output, the Musgravian PSP. For reasons of data availability, scores were only possible to compute for this period.