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Does government spending efficiency improve fiscal sustainability?*

António Afonso[$] José Alves[#]

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Abstract

We evaluate the impact of government spending efficiency on fiscal sustainability for a panel of 35 OECD countries during the period of 2007-2020. To answer our research question we first compute the magnitude of the responses of government revenues to changes in government spending. Next, we make use of so-called government spending efficiency scores, which efficiently indicate how governments can maintain their level of performance whilst using fewer inputs. Our results show that for the input efficiency scores obtained, countries' fiscal balance and fiscal sustainability is directly improved by the use of less public resources, whilst maintaining the same level of output. In the cases of the output efficiency scores, the commitment of increased government outputs can lead to higher economic growth and the generation of additional government revenues, which also improves fiscal sustainability. Specifically, rationalising public expenditures without jeopardising the actual level of public goods and provision of services is a stronger determinant of fiscal sustainability, as well as for the improvement of the primary budget balance.

JEL: C23, E21, E62, H5, H62
Keywords: fiscal sustainability; spending efficiency; panel data

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1. Introduction

An ongoing macro and fiscal discussion pertains to the issue of whether public finances follow a sustainable intertemporal path. This question becomes even more relevant when economies are hit by diverse unforeseen shocks (e.g., financial, health, or energy crises, or war-related fallout developments), which usually prompt governments to take the necessary responses. Such policy measures generally imply incurring more government spending and lead to higher fiscal imbalances.

Specifically, the financial situation of public accounts at the start of 2021 in most advanced economies was much more difficult, both in terms of debt-to-GDP ratio and primary budget balances. Such difficulties may even have become structural, contrary to some views that the effect of COVID-19 on public accounts is purely cyclical, which illustrates how serious the effect of the unanticipated shocks can be on fiscal sustainability

Typically, fiscal sustainability is considered to be in place when government revenues move closely in pace with government spending and when the government is able to deliver a primary balance that is sufficient to stabilise the debt-to-GDP ratio. Furthermore, fiscal sustainability is linked (influenced) to (by) certain key factors, such as, for instance, sovereign debt behaviour, business cycle developments, the cost of long-term sovereign borrowing, and fiscal rules. In addition, the substantial outstanding stock of government debt, notably in many OECD economies, has especially fomented debate about the possibility of joint debt management at the Euro Area level (see, for instance, Amato and Saraceno, 2022).

Nevertheless, it can also be hypothesised that the efficient use of public resources by governments can be (should be) growth enhancing and, that this therefore effectively contributes to the increased sustainability of fiscal policies. Accordingly, in this paper we combine two topics and strands of literature, namely: fiscal sustainability and government spending efficiency. We proceed to postulate the research premise that the efficiency of government spending could have a positive effect on fiscal sustainability. In fact, a more efficient use of government spending, targeted to growth-enhancing activities, and with little wasted resources, would likely guarantee higher macroeconomic rates of return and avoid the undue crowding out of private investment (see, Afonso and St. Aubyn, 2019) and foster growth and deter fiscal imbalances.

Accordingly, in a context of unprecedented fiscal challenges for many economies, and in order to assess the research question, we first compute the magnitude of the responses of government revenues to changes in government spending for a panel of 35 OECD countries during the period of 2007-2020 in order to test the hypothesis that both sides of the budget

balance should co-move. Second, we make use of so-called government spending efficiency scores, which demonstrate notably how governments can increase their performance whilst maintaining the same level of inputs, and also how governments can reduce the level of inputs while maintaining the same level of performance. In this case, we use three different models to obtain the efficiency scores, both output-oriented and input-oriented. Third, we empirically evaluate the responsiveness of fiscal sustainability to changes in government spending efficiency.

With regards the answer to the title question, our results show notably that a more efficient government does indeed contribute to increased fiscal sustainability. In the case of the input efficiency scores, the underlying rational implies using less public resources to maintain the same level of output, which in turn directly improves both the fiscal balance and fiscal sustainability. In the case of the output efficiency scores, the explanation for the results obtained can be explained by the provision of more and better government outputs, which contribute to higher levels of economic growth and added government revenues, which in turn improve fiscal sustainability. More specifically, rationalising public expenditures without jeopardising the actual level of public goods and the provision of services is found to be a better determinant of fiscal sustainability than improving the primary budget balance.

The paper is organised as follows. Section 2 reviews the two-subject related literature. Section 3 discusses the methodology. Section 4 presents the data and the analysis of the results, and Section 5 is the conclusion.

2. Literature

2.1 Fiscal sustainability

In the context of fiscal sustainability, the studies of Hamilton and Flavin (1986) and Trehan and Walsh (1991) applied to the United States are pioneers. Hakkio and Rush (1991) sustain that when government revenues and expenditures series are non-stationary, then the existence of cointegration between both variables is a necessary condition for the government to comply with current value budget constraints.

For instance, Vanhorebeek and Rompuy (1995), Papadopoulos and Sidiropoulos (1999) and Afonso (2005) research the fiscal solvency of several European Union countries. Furthermore, the related literature has notably assessed the long-term relationship between public revenues and expenditures, notably for advanced economies, concluding that the sustainability of fiscal policy does indeed exist (Afonso and Rault, 2015; Afonso and Jalles, 2017; Brady and Magazzino, 2018, Magazzino et al, 2019). On the other hand, fiscal reaction

functions have also been used in research for estimating the response of primary balances to the development of government debt, in line with Bohn (2008).

Among the possible factors that contribute to sustainable fiscal developments, the cost of long-term sovereign borrowing vis-à-vis the economic growth rate also plays a role. For instance, Blanchard et al. (2020) debate the relevance of the interest rate-growth differential in the context of fiscal reaction functions. In the same vein, Afonso et al. (2022a) report that the interest rate (r)-growth rate (g) differential matters. Indeed, for 28 EU countries over the period of 1995 Q1 to 2021Q2, they discover a higher magnitude for the decrease in the debt-to-GDP ratio following improvements in the primary balance when a positive interest rate-growth rate differential exists. In addition, the business cycle can decisively influence fiscal policy, which is important for the need to stabilise more resilient fiscal policies to business cycles. As demonstrated in Aldama and Creel (2021), the response of fiscal policy to business cycle tends to be asymmetric, i.e., it is found to be pro-cyclical in downturns, while fiscal policy is not sensitive to economic upturns.

In addition, the potential lack of fiscal sustainability also raises the issue of the interactions between fiscal policy and monetary policy. Indeed, if the primary budget balance is set independently of observed debt levels, this could "force" monetary policy to adjust (a passive behaviour) in order to guarantee the fulfilment of intertemporal government budget constraints, with the price level also being influenced by fiscal developments (see Leeper, 1991; Sims, 1994; and Woodford, 1995 for the discussion of the Fiscal Theory of the Price Level hypothesis).

2.2. Public sector efficiency

The relevance of public sector efficiency has become a topic of growing interest in the literature (see, for example, the works by Gupta and Verhoeven, 2001; Afonso et al., 2005, 2010). Several studies assess the degree of efficiency of the public sector by looking at different country samples and time spans, using DEA and semi-parametric approaches, however most tend to focus on OECD and European countries (Adam at al., 2011; Dutu and Sicari, 2020; Afonso and Kazemi, 2017; Antonelli and de Bonis, 2019).

In the majority of these studies, the results point to the existence of possible public sector efficiency gains. For instance, Afonso et al. (2005) report that the average input efficiency in 2000 for 23 OECD countries is 0.79, which means that these countries should be able to attain the same level output while using only 79% of the inputs that they currently use. Similar results were reported for other country sets, both globally and for sectoral (social)

spending, with more recent analysis, respectively by Afonso and Kazemi (2017) and Antonelli and de Bonis (2019).

Nevertheless, some studies have also addressed overall government spending efficiency for African countries (Gupta and Verhoeven, 2001), Emerging Markets (Afonso et al., 2010), Latin American countries (Afonso et al., 2013), Indian states (Mohanty et al, 2022), and Sub-Sahara Africa (Olanubi and Olanubi, 2022), with all using similar non-parametric frameworks.

All the above-mentioned studies identified substantial public spending efficiency differences between countries, as well as scope for savings in expenditure, which suggests that government spending efficiency could be improved. This typically implies that more public services could be provided, while using the same amount of public resources, or conversely, that the same level of public resources could be provided with fewer public resources. Hence, fiscal improvements in this respect can be positive for better assessments of financial markets.

In addition, to explain these cross-country efficiency differences, other studies have examined factors such as: population, education, income level, quality of institutions (property right security and level of corruption), quality of the country's governance, government size, governments' political orientation, voter participation rate, and civil service competence (Afonso et al., 2005; Hauner and Kyobe, 2010; Antonelli and de Bonis, 2019). More recently, Afonso et al. (2021) evaluated the role of tax structures and tax reforms in explaining cross-country efficiency differences. Furthermore, fiscal rules and government spending efficiency are found to be important for explaining fiscal sustainability, albeit, these institutional variables are considered to be substitutes, as fiscal rules tend to be the main explanation for higher fiscal sustainability when government efficiency is on the increase (Bergman et al., 2016).

3. Methodology

With regards fiscal sustainability, we follow Afonso (2005) and Afonso and Jalles (2017), mainly to assess whether a linear combination of government revenues and government expenditures is stationary. If that is the case, then government revenues and expenditures become cointegrated, which implies that the variables are attracted to a stable long-run (equilibrium) relation with only short-run (temporary) deviations from the equilibrium. Therefore, we estimate the following regression for each country[1]:

[1] Note that the issue of stationarity of variables has been assessed. In table A2 in the Appendix we checked country-by-country the stationarity properties of both government revenues and expenditures, for both levels and first differences. The majority of countries have non-stationary variables (one or the two). Additionally, we tested the cointegration between both revenues and expenditures series for each country, and discovered a long-term relation between these two fiscal variables for all the countries in our sample.

$$R_t = \alpha + \beta G_t + u_t \tag{1}$$

where R_t denotes the government revenue-to-GDP ratio, and G_t denotes the government expenditure-to-GDP ratio. u_t is a standard i.i.d. disturbance term that satisfies all the usual assumptions. The closer to unity the estimated β coefficient is, the more sustainable public finances will be, and a unitary increase in government spending will be matched by a β increase in government revenues. In addition, we estimate Equation (1) by using an expanding widow approach. That is to say, in order to obtain a time-series of β for each country, we estimate Equation (1) between 1980 and 2007; 1980 and 2008; 1980 and 2009;…; and lastly, for the period of 1980-2020 for each country considered in our study, respectively.

Second, the other main variable of interest arises from the measure of public sector efficiency. In this case, we use the so-called public sector efficiency scores as computed by Afonso et al. (2022b). These public sector efficiency scores are computed by using data envelopment analysis (DEA).[2] This is deemed to be a suitable approach for several reasons: first, it does not impose an underlying production function, and second, it accommodates deviations from the efficient frontier and also examines the efficiency of a country in relation to its peers.

(2) illustrates the case of the use of an input-oriented approach to measure the proportional reduction in inputs, while holding the output constant. One also assumes variable-returns to scale (VRS) to account for the fact that countries may not operate at the optimal scale. Conversely, from an output-oriented perspective, one can assess how much output could increase if the same level of inputs was maintained. The efficiency scores are computed by applying the following linear programming problem[3]:

$$\begin{gathered} \min_{\theta,\lambda} \theta \\ s.t. \ -y_i + Y\lambda \geq 0 \\ \theta x_i - X\lambda \geq 0 \\ I1'\lambda = 1 \\ \lambda \geq 0 \end{gathered} \tag{2}$$

[2] DEA is a non-parametric frontier methodology, drawing from Farrell's (1957) seminal work, which was further developed by Charnes et al. (1978). Coelli et al. (2002) offer an introduction to DEA.

[3] This is the equivalent envelopment form (see Charnes et al., 1978), which uses the duality property of the multiplier form of the original model.

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, $I1'$ is a vector of ones, X is the input matrix, and Y is the output matrix.

In Equation (2), θ is a scalar (which satisfies $0 \leq \theta \leq 1$) that measures the distance between a country and the efficiency frontier. The efficiency frontier is defined as being a linear combination of the best sampled countries (but not necessarily the best possible one). If $\theta < 1$, then the country is within the frontier and it is inefficient, whereas if $\theta = 1$, this implies that the country is on the frontier and that it is efficient.

We used three different DEA models, namely: the baseline model (Model 0), which includes just one input (government spending as percentage of GDP) and one output, and is in effect a composite public sector performance (PSP) indicator; Model 1 includes two inputs, governments' normalised spending on opportunity and on "Musgravian" indicators and one output, with total PSP scores; finally, Model 2 uses one input, governments' normalized total expenditure, and two outputs, the opportunity PSP and the "Musgravian" PSP scores[4]. Detailed results and definitions are reported in Afonso et al. (2021).[5]

We are thus interested in uncovering a positive contribution between government spending efficiency and fiscal sustainability. Our testing specification hypothesis is as follows:

$$\beta_{it} = \alpha_1 + \alpha_2\beta_{it-1} + \alpha_3\theta_{it} + \alpha_4\theta_{it}D_{it} + \pi X_{it} + u_{it} \quad (3)$$

where β is the time-varying sustainability coefficient, θ is the efficiency score obtained from (2), D is a dummy variable to test for the relevance of the magnitude of the efficiency score (for instance, efficiency level above 0.25 or if the country belongs to Eurozone), and X is a set of other relevant sustainability explanatory factors. Such factors can include notably: the primary balance (*pbalance*), the change in the level of sovereign indebtedness (*Δdebt*), the output gap

[4] We present the correlation matrices for both input-oriented and output-oriented models in Tables A6 and A7 in the Appendix, respectively.

[5] Afonso et al. (2005) used a set of metrics to construct a composite public sector performance (PSP) indicator. PSP is the simple average between so-called opportunity and Musgravian indicators. The opportunity indicators evaluate the performance of the government in terms of administration, education, health and infrastructure sectors, with equal weighting. The Musgravian indicators include three sub-indicators: distribution, stability, and economic performance, all of which also have equal weighting for the indicators. Accordingly, the opportunity and Musgravian indicators result from the average of the measures included in each sub-indicator. To ensure a convenient benchmark, each sub-indicator measure is first normalised by dividing the value of a specific country by the average of that measure for all the countries in the sample.

(*outputgap*), and, finally, the differential between the interest rate (*r*) and the output growth rate (*g*).

We estimate (3) in a panel setup due to: the fact that we can use the information contained in the cross-section dimension and increase the performance and accuracy of the tests; the existence of cross-country dependence which can mirror common changes in the behaviour of fiscal authorities (e.g., capital markets views, sovereign rating grouping, increased business cycle synchronisation, peer pressure, and Euro Area grouping); and common policy shocks, which can affect fiscal positions in several countries where policies and trade are more interconnected.

In addition, we estimate Equation (3) using OLS-Fixed Effects 2SLS estimator in order to compensate for endogeneity issues, as well as Weighted Least Squares with Fixed-Effects (WLS-FE). Indeed, since our dependent variable is based on estimates, the error u_t in (1) and (3) is distributed as $u_t \sim \mathrm{N}\left(0, \frac{\sigma^2}{s_i}\right)$, where s_i are the estimated standard deviations of the time-varying sustainability coefficients for country i, and σ^2 is an unknown parameter that is estimated in the second-stage regression.

4. Empirical assessment

4.1. Data

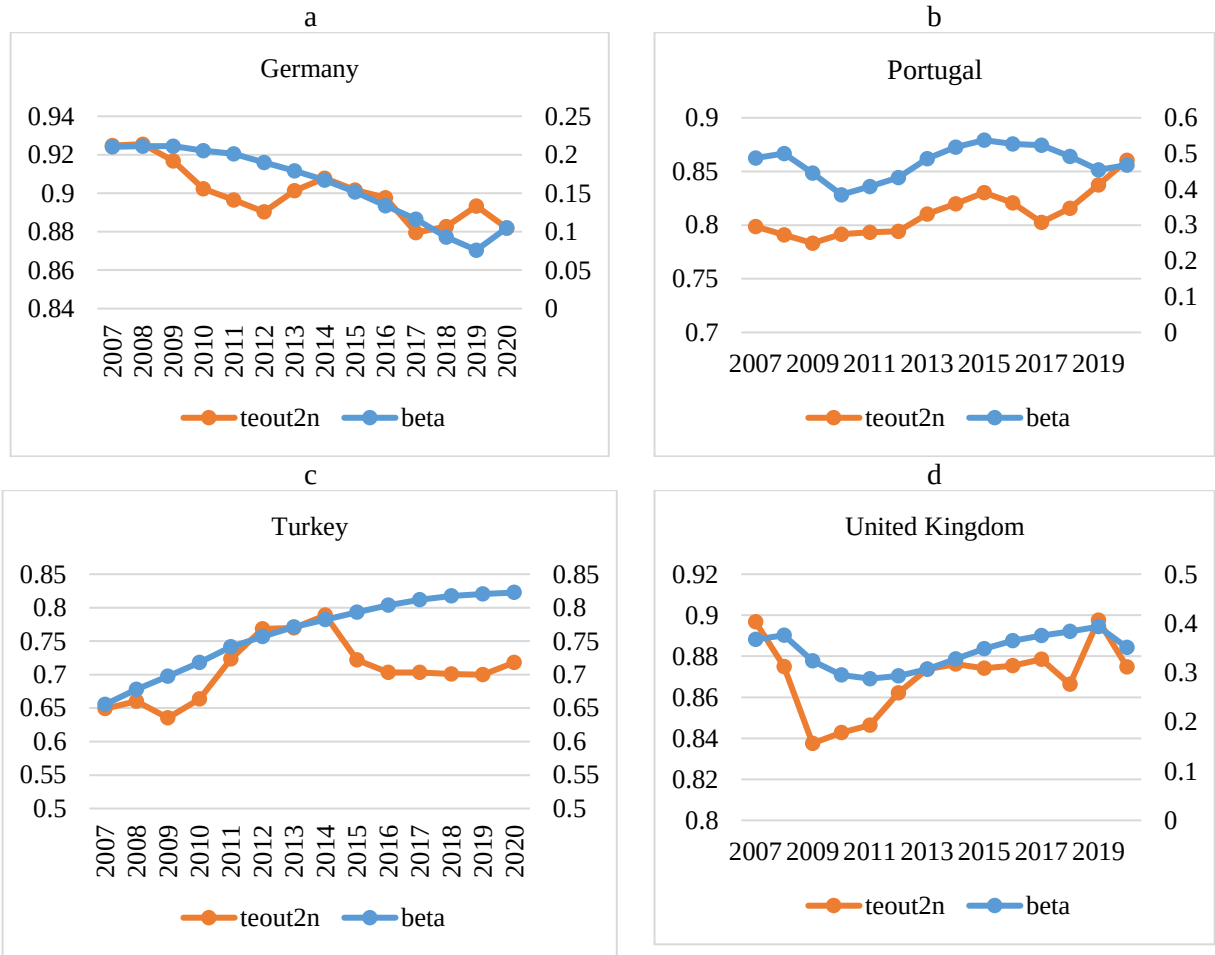
Our analysis covers a panel of 35 OECD economies during the period of 2007-2020. The country sample is as follows: Australia, Austria, Belgium, Canada, Chile, Colombia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

This time span is that for which data to calculate the efficiency scores is available (see Afonso et al., 2022b). Nevertheless, and in order to compute the sustainability magnitude, we used data starting in 1980 for the respective expanding window. The detailed information regarding the data used in the analysis is reported in the Appendix.

A first cursory look at the two main variables shows the magnitude of the sustainability coefficient, while the efficiency scores shows the expected pattern of co-movement. Figure 1 shows stylised evidence for some countries, using the DEA output-oriented Model 2 (one input, governments' normalized total expenditure, and two outputs, the opportunity PSP, and the "Musgravian" PSP scores).

For instance, in the case of the United Kingdom, an average output efficiency score of around 0.78 for the period of 2007-2022 can be observed, which highlights the possibility of theoretically obtaining 22% more in terms of outputs with the same level of input (government spending). On the other hand, during the same time period, the average value for the β coefficient in the UK is around 0.34, which is not close to unity, which implies that government revenue developments were lagging behind the stronger growth dynamics of government spending (a fiscal sustainability issue).

Figure 1 – sustainability magnitude (RHS) and efficiency scores (LHS)



Note: teout2n (θ): Model 2, output-oriented efficiency score (one input, governments' normalised total expenditure and two outputs).

4.2. Results

4.2.1. Input-Oriented Efficiency

We first estimate the impact of public spending efficiency on fiscal sustainability, employing the set of input-oriented efficiency scores. We present the results of Models 1 and 2

in Tables 1 and 2, respectively.[6] Both tables present three different estimation results: including one for the whole dataset; another one for the country-year pairwise whose correlation between the efficiency scores and the sustainability magnitudes is above 0.25 (to focus on the cases where a closer nexus can expected). The results obtained lead us to conclude that higher public spending efficiency positively contributes to improve fiscal sustainability. Indeed, we have obtained an expected and statistical positive coefficient for θ, not only when we estimate Equation (3) without control variables, but also when we include fiscal and macroeconomic variables that are considered in the literature to be important for explaining fiscal sustainability. When examined in more detail, our results show that a reduction in government expenditures for the two models – which is consistent with the improvement of public spending efficiency scores – tends to have a positive impact on fiscal solvency. However, the results obtained for Models 1 and 2 are not significant when applying the 2SLS estimator, whereby this estimator presents a significant positive coefficient for efficient scores for Model 0, but only for cases of correlation greater than 0.25 (see Appendix, Table A4).

Two major conclusions emerge from our results: the first is related to the fact that improvements in public spending efficiency are more associated with higher fiscal sustainability levels for the Euro-area countries, rather than for the remaining countries of our sample. The second, and probably the most interesting, is the fact that rationalising public expenditures, without jeopardising the actual level of public goods and the provision of services is found to be a better determinant for fiscal sustainability than the improvement of the primary budget balance. This result is obtained by comparing the magnitude of both coefficients when both variables are statistically significant, which is a result that presents important policy implications. In fact, this conclusion highlights other ways to lead public finances to a sustainable path, beyond the traditional tax increase or spending cuts measures employed by governments, usually without considering the efficiency of the public administration.

Additionally, we found that changes in government debt-to-GDP ratios have a non-significant impact on fiscal solvency. However, the output gaps present a marginal and small detrimental impact on fiscal sustainability, which is indeed a surprising result. Indeed, a positive output gap would lead to inflationary pressures that would have the effect of increasing government revenues, leading to more sustainable public finances. Furthermore, in the cases of a positive gap, in theory, public authorities would need to increase taxes or reduce public expenditures to correct the excessive demand for the existing supply. This can also be another

[6] We report the results of Model 0 for both input-oriented and output-oriented approaches in the Appendix,.

way of improving fiscal sustainability. Therefore, and in order to explain such a result of the output gap effect on fiscal sustainability, it would be beneficial to study how the elasticity of government spending to GDP growth rate behaves during that same period, that is to say, to assess whether a Wagner's law event occurred.[7] Lastly, although the interest rate-GDP growth rate differentials are only significant for Model 0 (Table A4, in the Appendix), the negative impact obtained for such a differential is to be expected. Indeed, the greater the costs derived from debt interests when compared with the GDP growth effect, the greater the effect over revenues, as well as the reduction of the debt-to-GDP ratio. Conversely, the capability of public authorities in managing public debt in a sustainable path in the future becomes less.

[7] For instance, Afonso and Alves (2017) assess Wagner's law by function of the government. They found different responses when an economy has a positive output gap when compared to the cases when a given economy is below its potential GDP.

Table 1. Estimations results for the impact of public spending efficiency on fiscal sustainability, input-oriented scores, Model 1, 2007-2020.

			Baseline			
	OLS-FE		**2SLS**		**WLS-FE**	
	(1)		(2)		(3)	
β_{t-1}	0.913***	0.961***	1.344***	1.632***	0.866***	0.894***
	(0.037)	(0.038)	(0.090)	(0.424)	(0.042)	(0.052)
θ	0.058**	0.034	0.054	0.003	0.089***	0.055**
	(0.023)	(0.022)	(0.055)	(0.197)	(0.030)	(0.025)
$pbalance$		0.002**		0.002		0.003***
		(0.001)		(0.002)		(0.001)
$\Delta debt$		-0.000		-0.002		0.000
		(0.000)		(0.005)		(0.000)
$outputgap$		-0.002**		-0.010		-0.002*
		(0.001)		(0.025)		(0.001)
$r-g$		0.000		-0.000		-0.000
		(0.001)		(0.003)		(0.001)
Obs.	455	310	385	259	389	244
R^2	0.996	0.997	0.997	0.996	0.994	0.996
			Correlation>0.25			
	OLS-FE		**2SLS**		**WLS-FE**	
	(1)		(2)		(3)	
β_{t-1}	0.782***	0.874***	1.220***	1.543***	0.772***	0.845***
	(0.056)	(0.055)	(0.098)	(0.255)	(0.057)	(0.058)
θ	0.084***	0.014	0.003	0.008	0.106***	0.054*
	(0.029)	(0.027)	(0.040)	(0.060)	(0.030)	(0.030)
$pbalance$		0.004***		0.003*		0.003***
		(0.001)		(0.002)		(0.001)
$\Delta debt$		0.000		-0.001		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.002***		-0.008		-0.002**
		(0.001)		(0.008)		(0.001)
$r-g$		0.000		-0.000		-0.000
		(0.001)		(0.001)		(0.001)
Obs.	169	116	143	97	148	95
R^2	0.996	0.997	0.997	0.997	0.995	0.996
			Euro area			
	OLS-FE		**2SLS**		**WLS-FE**	
	(1)	(2)	(3)	(4)	(5)	(6)
β_{t-1}	0.884***	0.928***	1.236***	1.287***	0.827***	0.871***
	(0.042)	(0.041)	(0.112)	(0.196)	(0.064)	(0.061)
θ	0.152***	0.079***	0.044	-0.030	0.167***	0.103***
	(0.031)	(0.025)	(0.083)	(0.192)	(0.042)	(0.028)
$pbalance$		0.003***		0.003***		0.003***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		-0.000		0.000		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.002***		-0.004		-0.003***
		(0.001)		(0.005)		(0.001)
$r-g$		-0.000		-0.001		-0.000
		(0.000)		(0.001)		(0.001)
Obs.	194	179	167	149	181	166
R^2	0.995	0.996	0.996	0.997	0.993	0.995

Note: Constant term, country and time effects estimated and omitted for reasons of parsimony. Robust standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Model 1 includes two inputs, governments' normalised spending on opportunity and on "Musgravian" indicators, and one output.

Table 2. Estimations results for the impact of public spending efficiency on fiscal sustainability, input-oriented scores, Model 2, 2007-2020.

			Baseline			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.911***	0.957***	1.337***	1.618***	0.909***	0.908***
	(0.037)	(0.038)	(0.088)	(0.381)	(0.034)	(0.052)
θ	0.060**	0.037	0.056	-0.007	0.074***	0.011
	(0.023)	(0.024)	(0.049)	(0.126)	(0.023)	(0.040)
$pbalance$		0.002**		0.003		0.004***
		(0.001)		(0.002)		(0.001)
$\Delta debt$		-0.000		-0.001		0.000
		(0.000)		(0.004)		(0.000)
$outputgap$		-0.002**		-0.009		-0.002*
		(0.001)		(0.018)		(0.001)
$r-g$		0.000		-0.000		-0.000
		(0.001)		(0.002)		(0.001)
Obs.	455	310	385	259	455	244
R^2	0.996	0.997	0.997	0.996	0.997	0.996
			Correlation>0.25			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.791***	0.910***	1.154***	1.485***	0.776***	0.916***
	(0.051)	(0.038)	(0.088)	(0.160)	(0.063)	(0.047)
θ	0.102***	0.060***	0.042	0.084**	0.099***	0.041
	(0.025)	(0.020)	(0.032)	(0.039)	(0.029)	(0.028)
$pbalance$		0.002**		0.004***		0.004***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		-0.000		-0.001		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.002**		-0.001		-0.002***
		(0.001)		(0.004)		(0.001)
$r-g$		0.001		0.000		-0.000
		(0.001)		(0.001)		(0.001)
Obs.	260	181	220	152	226	147
R^2	0.996	0.997	0.998	0.998	0.994	0.996
			Euro Area			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.870***	0.920***	1.221***	1.410***	0.828***	0.872***
	(0.043)	(0.041)	(0.108)	(0.364)	(0.066)	(0.061)
θ	0.141***	0.080***	-0.026	0.133	0.143***	0.089***
	(0.032)	(0.027)	(0.090)	(0.526)	(0.041)	(0.034)
$pbalance$		0.003***		0.004***		0.003***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		0.000		-0.000		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.003***		0.001		-0.003***
		(0.001)		(0.009)		(0.001)
$r-g$		-0.000		-0.001		-0.001
		(0.001)		(0.001)		(0.001)
Obs.	194	179	167	149	181	166
R^2	0.995	0.996	0.997	0.997	0.993	0.995

Note: Constant term, country and time effects estimated and omitted for reasons of parsimony. Robust standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Model 2 uses one input, governments' normalised total expenditure and two outputs, the opportunity PSP and the "Musgravian" PSP scores.

4.2.2. Output-Oriented Efficiency

Moving to the results of the effects of output-oriented efficiency scores on fiscal sustainability, the linkage between higher efficiency generated by a higher provision of public goods with the same level of inputs and fiscal sustainability is not as clear as it was for the analysis of input-oriented related models. The rationale behind the results obtained for Models 1 and 2, as presented in Tables 3 and 4, respectively, is the following: for the same level of inputs, higher efficiency would provide a larger provision of public goods and services. In the same vein, the fiscal multiplier would be greater, causing more aggregate income and thus generating more public revenues. This mechanism would increase government revenues and also improve fiscal sustainability.

From our results for the output-oriented models, we found similar results to those found for the input-oriented models. However, it is important to notice some important differences: first, while we found higher effects of improving public administration efficiency on fiscal sustainability for the whole sample and for Euro Area economies for the input-oriented Model 1 when compared to the output-oriented approach for the same model, only the output-oriented Model 1 provides better results for the efficiency scores effects over fiscal sustainability. On the other hand, the results obtained for Model 2, in an output-oriented setup (Table 4), always provide higher coefficients for public efficiency scores on fiscal sustainability, whatever sample we chose to analyse.

When it comes to the control variables, we also reach similar conclusions to those found for input-oriented models. Once again, while government debt-to-GDP increments are not crucial to explain fiscal solvency, interest rate-GDP growth rate differential only matters when analysing Model 0, and for the euro-area economies (see Table A5, in the Appendix).

Lastly, when comparing our overall set of results, there is a need to highlight the role of public administration and how it is organised to improve and increases the provision of public goods and services with the same level of public expenditure, both in an output-oriented approach, or by providing the same amount of existing goods and services with less government spending. In this context, we can come to the conclusion that programme budgeting could be an important tool for improving such public spending efficiency. Furthermore, and in order to provide a better understanding of these relationships, there is a need to analyse how inputs and outputs impact fiscal sustainability to better design public administration rules and strategies.

Table 3. Estimations results for the impact of public spending efficiency on fiscal sustainability, output-oriented, Model 1, 2007-2020.

			Baseline			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.908***	0.961***	1.345***	1.502***	0.873***	0.910***
	(0.040)	(0.039)	(0.086)	(0.155)	(0.042)	(0.052)
θ	0.025	0.017	0.016	-0.118	0.050**	0.018
	(0.017)	(0.017)	(0.018)	(0.463)	(0.022)	(0.026)
$pbalance$		0.003***		0.002		0.004***
		(0.001)		(0.005)		(0.001)
$\Delta debt$		-0.000		-0.001		0.000
		(0.000)		(0.004)		(0.000)
$outputgap$		-0.003***		-0.004		-0.002*
		(0.001)		(0.011)		(0.001)
$r-g$		0.000		0.000		-0.000
		(0.001)		(0.003)		(0.001)
Obs.	455	310	385	259	389	244
R^2	0.996	0.997	0.997	0.997	0.994	0.996
			Correlation>0.25			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.692***	0.890***	1.030***	0.374	0.634***	0.843***
	(0.087)	(0.048)	(0.110)	(7.629)	(0.092)	(0.056)
θ	0.104***	0.030	0.085***	0.098	0.124***	0.042
	(0.033)	(0.028)	(0.033)	(0.215)	(0.036)	(0.034)
$pbalance$		0.002**		0.004		0.003***
		(0.001)		(0.004)		(0.001)
$\Delta debt$		-0.000		0.001		0.000
		(0.000)		(0.013)		(0.001)
$outputgap$		0.002		-0.002		0.001
		(0.001)		(0.044)		(0.001)
$r-g$		0.001		-0.002		-0.000
		(0.001)		(0.013)		(0.001)
Obs.	156	91	132	77	135	70
R^2	0.997	0.999	0.998	0.992	0.996	0.998
			Euro Area			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.885***	0.927***	1.345***	1.273***	0.875***	0.910***
	(0.047)	(0.041)	(0.094)	(0.203)	(0.068)	(0.061)
θ	0.050*	0.064**	0.066	-0.226	0.053	0.027
	(0.030)	(0.030)	(0.061)	(0.758)	(0.036)	(0.038)
$pbalance$		0.004***		-0.000		0.004***
		(0.001)		(0.010)		(0.001)
$\Delta debt$		-0.000		-0.001		0.000
		(0.000)		(0.005)		(0.000)
$outputgap$		-0.004***		0.004		-0.003**
		(0.001)		(0.027)		(0.001)
$r-g$		-0.000		0.000		-0.000
		(0.000)		(0.005)		(0.001)
Obs.	194	179	167	149	181	166
R^2	0.995	0.996	0.996	0.993	0.992	0.994

Note: Constant term, country and time effects estimated and omitted for reasons of parsimony. Robust standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Model 1 includes two inputs, governments' normalised spending on opportunity and on "Musgravian" indicators, and one output.

Table 4. Estimations results for the impact of public spending efficiency on fiscal sustainability, output-oriented, Model 2, 2007-2020.

			Baseline			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.905***	0.954***	1.302***	1.638***	0.876***	0.905***
	(0.038)	(0.038)	(0.090)	(0.288)	(0.042)	(0.052)
θ	0.102***	0.109***	0.006	0.060	0.118**	0.073
	(0.034)	(0.033)	(0.051)	(0.363)	(0.050)	(0.051)
$pbalance$		0.002***		0.003		0.004***
		(0.001)		(0.002)		(0.001)
$\Delta debt$		-0.000		-0.001		0.000
		(0.000)		(0.003)		(0.000)
$outputgap$		-0.002***		-0.009		-0.002*
		(0.001)		(0.016)		(0.001)
$r-g$		0.000		-0.000		-0.000
		(0.001)		(0.002)		(0.001)
Obs.	455	310	385	259	389	244
R^2	0.996	0.997	0.997	0.996	0.994	0.996
			Correlation>0.25			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.750***	0.954***	1.060***	1.638***	0.769***	0.905***
	(0.070)	(0.038)	(0.134)	(0.288)	(0.087)	(0.052)
θ	0.201***	0.109***	-0.024	0.060	0.251***	0.073
	(0.061)	(0.033)	(0.086)	(0.363)	(0.082)	(0.051)
$pbalance$		0.002***		0.003		0.004***
		(0.001)		(0.002)		(0.001)
$\Delta debt$		-0.000		-0.001		0.000
		(0.000)		(0.003)		(0.000)
$outputgap$		-0.002***		-0.009		-0.002*
		(0.001)		(0.016)		(0.001)
$r-g$		0.000		-0.000		-0.000
		(0.001)		(0.002)		(0.001)
Obs.	195	310	165	259	169	244
R^2	0.997	0.997	0.998	0.996	0.992	0.996
			Euro Area			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.886***	0.931***	1.192***	1.325***	0.873***	0.907***
	(0.043)	(0.039)	(0.211)	(0.201)	(0.065)	(0.061)
θ	0.182***	0.119***	-0.158	-0.011	0.164**	0.069
	(0.056)	(0.039)	(0.679)	(0.791)	(0.079)	(0.061)
$pbalance$		0.004***		0.003***		0.004***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		0.000		-0.000		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.002***		-0.003		-0.003***
		(0.001)		(0.004)		(0.001)
$r-g$		-0.000		-0.001		-0.000
		(0.000)		(0.002)		(0.001)
Obs.	194	179	167	149	181	166
R^2	0.995	0.997	0.996	0.997	0.992	0.994

Note: Constant term, country and time effects estimated and omitted for reasons of parsimony. Robust standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Model 2 uses one input, governments' normalised total expenditure and two outputs, the opportunity PSP and the "Musgravian" PSP scores.

5. Conclusion

In this paper we assessed to what extent better government spending efficiency contributes to higher levels of fiscal sustainability, for a panel of 35 OECD countries during the period of 2007-2020.

We first compute the magnitude of the response of government revenues to changes in government spending, to test the hypothesis that both sides of the budget balance should move together. Next, we make use of so-called government spending efficiency scores, which show notably how governments could increase their performance whilst maintaining the same level of inputs, or how governments can reduce the level of inputs, while maintaining the same level of performance. Finally, we empirically evaluate the responsiveness of fiscal sustainability to changes in government spending efficiency.

Regarding the answer to our research question, our results show notably that more efficient governments contribute more to increased fiscal sustainability. For the case of the input-oriented efficiency scores, the underlying rational implies that less public resources can provide the same level of output and can directly improve the fiscal balance and fiscal sustainability. In the case of the output-oriented efficiency scores, the explanation can be explained by the provision of more and better government outputs, which affect higher economic growth and greater government revenues, which in turn also improves fiscal sustainability. More specifically, rationalising public expenditures without jeopardising the actual level of public goods and the provision of services is found to be a better determinant for fiscal sustainability than improving the primary budget balance.

In sum, on the one hand the policy implications of our overall set of results point to the crucial role of the organisation of public administration for improving the provision of public goods and services whilst maintaining the same level of public expenditure. On the other hand, the same level of existing public goods and services could be guaranteed with less government spending.

References

1. Adam, A., Delis, M., Kammas, P. (2011). Public sector efficiency: levelling the playing field between OECD countries. *Public Choice*, 146(1-2), 163–183. https://doi.org/10.1007/s11127-009-9588-7

2. Afonso, A. (2005). Fiscal Sustainability: The Unpleasant European Case. *FinanzArchiv/Public Finance Analysis*, 61(1), 19-44. https://doi.org/10.1007/s11127-009-9588-7

3. Afonso, A., Alves, J. (2017). Reconsidering Wagner's law: evidence from the functions of the government. *Applied Economics Letters*, 24(5), 346-350. https://doi.org/10.1080/13504851.2016.1192267

4. Afonso, A., Alves, J., Jalles, J. (2022a). Fiscal Reaction Functions in the EU: a tale of (r-g) and whether it matters. *Révue française d´économie*, XXXVI, 65-101. https://doi.org/10.3917/rfe.213.0065

5. Afonso, A., Jalles, J., Venâncio, A. (2022b). Do Financial Markets Reward Government Spending Efficiency? *Journal of International Financial Markets, Institutions & Money*, 77(101505), 1-21. https://doi.org/10.1016/j.intfin.2022.101505

6. Afonso, A., Jalles, J. (2017). Euro area time-varying fiscal sustainability. *International Journal of Finance and Economics*, 22(3), 244-254. https://doi.org/10.1002/ijfe.1582

7. Afonso, A., Jalles, J., Venâncio, A. (2021). Taxation and Public Spending Efficiency: An International Comparison. *Comparative Economic Studies*, 63(3), 356-383. https://doi.org/10.1057/s41294-021-00147-2

8. Afonso, A., Kazemi, M. (2017). "Assessing Public Spending Efficiency in 20 OECD Countries", in *Inequality and Finance in Macrodynamics (Dynamic Modeling and Econometrics in Economics and Finance)*, Bökemeier, B., Greiner, A. (Eds), 23, Springer. https://doi.org/10.1007/978-3-319-54690-2_2

9. Afonso, A., Rault, C. (2015). Multi-step analysis of public finances sustainability. *Economic Modelling*, 48, 199-209. https://doi.org/10.1016/j.econmod.2014.10.011

10. Afonso, A., Romero, A., Monsalve, E. (2013). "Public Sector Efficiency: Evidence for Latin America Public". Inter-American Development Bank, 80478, Inter-American Development Bank. http://dx.doi.org/10.2139/ssrn.2365007

11. Afonso, A., Schuknecht, L., Tanzi, V. (2005). Public Sector Efficiency: An International Comparison. *Public Choice*, 123(3-4), 321-347. https://doi.org/10.1007/s11127-005-7165-2

12. Afonso, A., Schuknecht, L., Tanzi, V. (2010). Public Sector Efficiency: Evidence for New EU Member States and Emerging Markets. *Applied Economics*, 42(17), 2147-2164. https://doi.org/10.1080/00036840701765460

13. Afonso, A., St. Aubyn, M. (2019). Economic Growth, Public, and Private Investment Returns in 17 OECD Economies. *Portuguese Economic Journal*, 18(1), 47-65. https://doi.org/10.1007/s10258-018-0143-7

14. Aldama, P. Creel, J. (2021). "Real-time fiscal policy responses in the OECD from 1997 to 2018: Procyclical but sustainable?" *European Journal of Political Economy*, 1-21. https://doi.org/10.1016/j.ejpoleco.2021.102135

15. Amato, M., Saraceno, F. (2022). *Squaring the Circle: How to Guarantee Fiscal Space and Debt Sustainability with a European Debt Agency*. BAFFI CAREFIN Centre Research Paper No. 2022-172, 1-25. http://dx.doi.org/10.2139/ssrn.4011081

16. Antonelli, M., de Bonis, V. (2019). The efficiency of social public expenditure in European countries: a two-stage analysis. *Applied Economics*, 51(1), 47-60. https://doi.org/10.1080/00036846.2018.1489522

17. Bergman, U. M., Hutchison, M. M., Jensen, S. E. H. (2016). "Promoting sustainable public finances in the European Union: The role of fiscal rules and government efficiency". *European Journal of Political Economy*, 44(1), 1-19. https://doi.org/10.1016/j.ejpoleco.2016.04.005

18. Blanchard, O., Leandro, A., Zettelmeyer. J. (2020). *Redesigning the EU Fiscal Rules: From Rules to Standards*. Mimeo, August 30, 2020. 72nd Economic Policy Panel Meeting 22-23 October 2020, Supported by the Federal Ministry of Finance, Germany.

19. Bohn, H. (2008). "The Sustainability of Fiscal Policy in the United States", in Neck, R., Sturm, J.-E. (eds.), *Sustainability of Public Debt*. The MIT Press, Cambridge, Massachusetts.

20. Brady, G., Magazzino, C. (2018), "Fiscal Sustainability in the EU", *Atlantic Economic Journal*, 46, 297-311.

21. Charnes, A.; Cooper, W., Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

22. Coelli T., Rao, D., Battese, G. (2002). *An Introduction to Efficiency and Productivity Analysis*, 6th edition, Massachusetts, Kluwer Academic Publishers.

23. Dutu, R., Sicari, P. (2020). Public Spending Efficiency in the OECD: Benchmarking Health Care, Education, and General Administration. *Review of Economic Perspectives*, 20(3), 253-280. https://doi.org/10.2478/revecp-2020-0013

24. Farrell, M. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society: Series A* (General), 120, 253-281. https://doi.org/10.2307/2343100

25. Gupta, S., Verhoeven, M. (2001). The efficiency of government expenditure – experiences from Africa. *Journal of Policy Modelling*, 23(4), 433-467. https://doi.org/10.1016/S0161-8938(00)00036-3

26. Hakkio, C., Rush, M. (1991). Is the Budget Deficit "Too Large?". *Economic Inquiry*, 29(3), 429-445. https://doi.org/10.1111/j.1465-7295.1991.tb00837.x

27. Hamilton, J., Flavin, M. (1986). On the Limitations of Government Borrowing: A Framework for Empirical Testing. *The American Economic Review*, 76(4), 808-819.

28. Hauner, D. Kyobe, A. (2010). Determinants of Government Efficiency. *World Development*, 38(11), 1527-1542. https://doi.org/10.1016/j.worlddev.2010.04.004

29. Leeper, E. (1991). Equilibria under 'Active' and 'Passive' Monetary and Fiscal Policies. *Journal of Monetary Economics*, 27(1), 129-147. https://doi.org/10.1016/0304-3932(91)90007-B

30. Magazzino, C., Brady, G., Forte, F. (2019). A panel data analysis of the fiscal sustainability of G-7 countries. *The Journal of Economic Asymmetries*, 20, 1-9. https://doi.org/10.1016/j.jeca.2019.e00127

31. Mauro, P., Romeu, R., Binder, A., Zaman, A. (2013). "A Modern History of Fiscal Prudence and Profligacy". IMF Working Paper No. 13/5, International Monetary Fund, Washington, DC.

32. Mohanty, R., Bhanumurthy, N., Sahoo, B. (2022). "Analysing Public Sector Efficiency of the Indian States", in Afonso, A., Jalles, J., Venâncio, A. (eds.) *Handbook on Public Sector Efficiency*, Edward Elgar Publishing, forthcoming.

33. Olanubi, S., Olanubi, O. (2022). "Political Short-termism and Government Spending Efficiency in Sub-Sahara Africa", in Afonso, A., Jalles, J., Venâncio, A. (eds.) *Handbook on Public Sector Efficiency*, Edward Elgar Publishing, forthcoming.

34. Papadopoulos, A., Sidiropoulos, M. (1999). The sustainability of fiscal policies in the European Union. *International Advances in Economic Research*, 5(3), 289-307. https://doi.org/10.1007/BF02296413

35. Sims, C. (1994). A Simple Model for the Study on the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy. *Economic Theory*, 4(3), 381-399. https://doi.org/10.1007/BF01215378

36. Trehan, B., Walsh, C. (1991). Testing Intertemporal Budget Constraints: Theory and Applications to U. S. Federal Budget and Current Account Deficits. *Journal of Money, Credit and Banking*, 23(2), 206-223. https://doi.org/10.2307/1992777

37. Vanhorebeek, F., Van Rompuy, P. (1995). Solvency and sustainability of fiscal policies in the EU. *De Economist*, 143(4), 457-473. https://doi.org/10.1007/BF01384910

38. Woodford, M. (1995). Price Level Determinacy without Control of Monetary Aggregate. *Carnegie-Rochester Conference Series on Public Policy*, 43, 1-46. https://doi.org/10.1016/0167-2231(95)90033-0

Appendix

Table A1. Data series and sources.

Variable	Series	Source
Input, output efficiency scores	ltein0, ltein1, ltein2, teout0n, teout1n, teout2n	Afonso et al. (2022b)
Government spending	General government total expenditure	WEO and Mauro et al. (2013)
Government revenue	General government revenue	WEO and Mauro et al. (2013)
Government debt	General government gross debt	WEO
Output gap	Output gap in percent of potential GDP	WEO
Interest rate	The series was computed by the ratio between government spending on government debt's interests and the government debt, both in GDP terms; The expenditures on interest were obtained by calculating the difference between the primary and global budget balances, both with series from the WEO	Own calculations
GDP growth rate	Annual GDP growth rate	WEO

Notes: WEO – World Economic Outlook, October 2021.

Table A2. Augmented Dickey-Fuller and Phillips-Perron Unit Root tests for revenues and expenditures (% of GDP), 1980-2020.

	Revenues								Expenditures							
	ADF				PP				ADF				PP			
	Levels	Obs.	F.D.	Obs.	Levels	Obs.	F.D.	Obs.	Levels	Obs.	F.D.	Obs.	Levels	Obs.	F.D.	Obs.
Australia	-2.610	39	-3.573**	38	-2.274	40	-5.934***	39	-1.617	39	-2.498***	38	-1.172	40	-2.557	39
Austria	-2.222	39	-5.263***	38	-2.387	40	-6.097***	39	-2.851*	39	-3.528**	38	-2.766*	40	-3.989***	39
Belgium	-1.803	39	-4.105***	38	-1.866	40	-5.715***	39	-1.961	39	-2.938*	38	-1.663	40	-6.841***	39
Canada	-1.654	39	-3.552**	38	-2.016	40	-4.454***	39	-1.791	39	-2.443	38	-1.595	40	-2.605*	39
Chile	-2.767*	39	-5.088***	38	-2.626*	40	-6.038***	39	-2.11	39	-3.803***	38	-1.524	40	-4.088***	39
Colombia	-1.062	39	-4.721***	38	-0.974	40	-5.743***	39	-0.397	39	-4.506***	38	-0.384	40	-6.391***	39
Czech Republic	-1.723	24	-4.109***	23	-2.256	25	-6.091***	24	-2.727*	24	-3.551**	23	-5.391***	25	-6.613***	24
Denmark	-2.939*	39	-4.583***	38	-2.596*	40	-5.344***	39	-3.046**	39	-4.357***	38	-2.629*	40	-4.979***	39
Finland	-2.559	39	-3.506**	38	-3.264**	40	-7.108***	39	-2.777*	39	-3.844***	38	-2.138	40	-3.461***	39
France	-1.527	39	-3.786***	38	-1.571	40	-5.338***	39	-0.716	39	-3.683***	38	-1.388	40	-4.004***	39
Germany	-1.689	39	-4.851***	38	-1.973	40	-7.05***	39	-2.795*	39	-4.708***	38	-3.109**	40	-6.887***	39
Greece	-1.144	39	-4.556***	38	-0.784	40	-5.655***	39	-1.464	39	-3.954***	38	-1.613	40	-5.352***	39
Hungary	-2.23	24	-3.731**	23	-2.057	25	-4.4***	24	-3.418**	24	-4.088***	23	-4.34***	25	-4.473***	24
Iceland	-2.192	39	-5.455***	38	-3.079**	40	-10.191***	39	-2.116	39	-4.827***	38	-2.224	40	-6.314***	39
Ireland	0.776	39	-4.608***	38	0.741	40	-6.238***	39	-1.644	39	-4.273***	38	-1.623	40	-6.286***	39
Israel	-1.550	39	-4.559***	38	-1.681	40	-6.507***	39	-1.986	35	-4.294***	33	-2.191	37	-6.949***	35
Italy	-2.911	39	-4.759***	38	-2.525	40	-5.361***	39	-1.954	39	-2.605	38	-2.777*	40	-3.424**	39
Japan	-0.797	39	-4.036***	38	-0.623	40	-5.752***	39	-0.401	39	-2.817*	38	-0.315	40	-3.363**	39
Latvia	-0.859	21	-2.906*	20	-0.845	22	-3.518***	21	-2.282	21	-3.811***	20	-1.783	22	-3.277**	21
Lithuania	-3.058**	24	-4.256***	23	-1.727	25	-5.146***	24	-2.513	24	-2.191	23	-2.129	25	-3.353**	24
Luxembourg	-2.794*	24	-4.998***	23	-2.613*	25	-4.693***	24	-3.826***	24	-4.324***	23	-2.604*	25	-3.281**	24
Netherlands	-1.203	39	-4.534***	38	-1.108	40	-5.847***	39	-1.546	39	-3.953***	38	-1.414	40	-5.859***	39
New Zealand	-1.565	34	-2.663*	33	-1.019	35	-3.703***	34	-2.479	34	-3.500**	33	-1.603	35	-2.799*	34
Norway	-2.429	39	-5.077***	38	-2.35	40	-5.607***	39	-1.845	39	-4.610***	38	-1.517	40	-4.133***	39
Poland	-5.318***	24	-4.614***	23	-2.613*	25	-5.758***	24	-3.860***	24	-1.761	23	-2.346	25	-3.918***	24
Portugal	-1.964	33	-7.387***	32	-2.301	34	-6.923***	33	-3.109**	33	-4.93***	32	-3.183**	34	-4.039***	33
Slovakia	-1.637	24	-2.460	23	-2.004	25	-5.757***	24	-2.552	24	-4.049***	23	-2.060	25	-5.481***	24
Slovenia	-2.246	24	-3.333**	23	-1.957	25	-5.224***	24	-2.371	24	-3.508**	23	-3.294**	25	-6.222***	24
South Korea	-0.924	39	-3.824***	38	-0.949	40	-6.334***	39	-0.452	39	-3.477**	38	-0.488	40	-7.087***	39
Spain	-2.265	39	-7.303***	38	-1.304	40	-9.891***	39	-1.863	39	-5.595***	38	-1.104	40	-9.122***	39
Sweden	-1.914	39	-4.806***	38	-2.14	40	-6.282***	39	-2.344	39	-4.024***	38	-2.301	40	-5.301***	39
Switzerland	-1.915	39	-3.263**	38	-1.958	40	-6.211***	39	-2.024	39	-3.245**	38	-1.734	40	-3.643***	39
Turkey	-0.855	39	-3.078**	38	-0.606	40	-4.041***	39	-1.178	39	-3.55**	38	-1.071	40	-5.307***	39
UK	-1.812	39	-3.897***	38	-1.309	40	-6.299***	39	-3.156**	39	-2.522	38	-2.137	40	-3.085**	39
US	-2.047	39	-4.82***	38	-1.937	40	-5.577***	39	-2.480	39	-2.257***	38	-2.048	40	-2.250	39

Table A3. Engle-Granger cointegration test results.

	Z(t)
Australia	-3.652**
Austria	-5.425***
Belgium	-3.994***
Canada	-3.649**
Chile	-4.772***
Colombia	-5.006***
Czech Republic	-4.355**
Denmark	-4.608***
Finland	-4.255***
France	-3.686**
Germany	-4.906***
Greece	-4.406***
Hungary	-3.983**
Iceland	-5.106***
Ireland	-4.669***
Israel	-3.375*
Italy	-4.919***
Japan	-4.107**
Latvia	-3.925**
Lithuania	-4.742***
Luxembourg	-4.527***
Netherlands	-4.540***
New Zealand	-3.708**
Norway	-4.262**
Poland	-5.063***
Portugal	-8.086***
Slovakia	-6.779***
Slovenia	-3.414*
South Korea	-4.643***
Spain	-4.963***
Sweden	-3.524**
Switzerland	-3.170*
Turkey	-3.228*
UK	-3.873**
US	-4.903***

Table A4. Estimations results for the impact of public spending efficiency on fiscal sustainability, input-oriented, Model 0, 2007-2020.

			Baseline			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.914***	0.961***	1.349***	1.592***	0.870***	0.896***
	(0.037)	(0.038)	(0.089)	(0.348)	(0.042)	(0.053)
θ	0.054**	0.035	0.057	-0.020	0.088***	0.059**
	(0.024)	(0.025)	(0.055)	(0.235)	(0.028)	(0.025)
$pbalance$		0.002**		0.003*		0.003***
		(0.001)		(0.002)		(0.001)
$\Delta debt$		-0.000		-0.001		0.000
		(0.000)		(0.004)		(0.000)
$outputgap$		-0.002**		-0.008		-0.002**
		(0.001)		(0.018)		(0.001)
$r-g$		0.000		-0.000		-0.000
		(0.001)		(0.002)		(0.001)
Obs.	455	310	385	259	389	244
R^2	0.996	0.997	0.997	0.997	0.994	0.996
			Correlation>0.25			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.765***	0.907***	1.062***	1.486***	0.727***	1.486***
	(0.055)	(0.036)	(0.094)	(0.159)	(0.067)	(0.159)
θ	0.096***	0.034	0.025	0.132*	0.112***	0.132*
	(0.032)	(0.021)	(0.043)	(0.074)	(0.032)	(0.074)
$pbalance$		0.003***		0.004***		0.004***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		-0.000		-0.001		-0.001
		(0.000)		(0.001)		(0.001)
$outputgap$		-0.001		0.004		0.004
		(0.001)		(0.004)		(0.004)
$r-g$		0.000		-0.001		-0.001
		(0.000)		(0.001)		(0.001)
Obs.	195	142	165	119	161	119
R^2	0.996	0.998	0.998	0.999	0.995	0.999
			Euro Area			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.880***	0.926***	1.242***	1.351***	0.846***	0.884***
	(0.042)	(0.041)	(0.107)	(0.143)	(0.064)	(0.061)
θ	0.141***	0.082***	0.015	0.051	0.142***	0.094***
	(0.033)	(0.024)	(0.072)	(0.142)	(0.040)	(0.028)
$pbalance$		0.003***		0.004***		0.003***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		-0.000		0.000		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.003***		-0.001		-0.003***
		(0.001)		(0.004)		(0.001)
$r-g$		-0.000		-0.001**		-0.000
		(0.000)		(0.000)		(0.001)
Obs.	194	179	167	149	181	166
R^2	0.995	0.997	0.996	0.998	0.993	0.995

Note: Constant term, country and time effects estimated and omitted for reasons of parsimony. Robust standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Model 0 includes only one input (government spending as percentage of GDP) and one output, a composite public sector performance (PSP) indicator.

Table A5. Estimations results for the impact of public spending efficiency on fiscal sustainability, output-oriented, Model 0, 2007-2020.

			Baseline			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.908***	0.961***	1.347***	1.494***	0.874***	0.911***
	(0.040)	(0.039)	(0.088)	(0.139)	(0.043)	(0.052)
θ	0.023	0.015	0.005	0.027	0.040*	0.013
	(0.017)	(0.018)	(0.017)	(0.087)	(0.020)	(0.027)
$pbalance$		0.003***		0.004***		0.004***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		-0.000		0.000		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.002***		-0.001		-0.002*
		(0.001)		(0.003)		(0.001)
$r-g$		0.000		-0.001		-0.000
		(0.001)		(0.001)		(0.001)
Obs.	455	310	385	259	389	244
R^2	0.996	0.997	0.997	0.998	0.994	0.996
			Correlation>0.25			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.725***	0.888***	1.044***	1.280***	0.701***	0.844***
	(0.087)	(0.048)	(0.113)	(0.397)	(0.100)	(0.054)
θ	0.091***	0.035	0.055*	0.140**	0.101***	0.044
	(0.030)	(0.031)	(0.028)	(0.062)	(0.031)	(0.036)
$pbalance$		0.002**		0.003***		0.003***
		(0.001)		(0.001)		(0.001)
$\Delta debt$		-0.000		-0.000		0.000
		(0.000)		(0.000)		(0.001)
$outputgap$		0.002		0.003		0.001
		(0.001)		(0.002)		(0.002)
$r-g$		0.001		-0.000		-0.000
		(0.001)		(0.001)		(0.001)
Obs.	156	91	132	77	135	70
R^2	0.996	0.999	0.998	0.999	0.994	0.998
			Euro Area			
	OLS-FE		**2SLS**		**WLS-FE**	
β_{t-1}	0.888***	0.928***	1.361***	1.191***	0.879***	0.912***
	(0.047)	(0.040)	(0.091)	(0.217)	(0.067)	(0.061)
θ	0.046	0.065**	0.067	0.111	0.046	0.021
	(0.031)	(0.032)	(0.064)	(0.277)	(0.038)	(0.040)
$pbalance$		0.004***		0.004**		0.004***
		(0.001)		(0.002)		(0.001)
$\Delta debt$		-0.000		0.001		0.000
		(0.000)		(0.001)		(0.000)
$outputgap$		-0.004***		-0.004		-0.003**
		(0.001)		(0.005)		(0.001)
$r-g$		-0.000		-0.001*		-0.000
		(0.000)		(0.001)		(0.001)
Obs.	194	179	167	149	181	166
R^2	0.995	0.996	0.996	0.997	0.991	0.994

Note: Constant term, country and time effects estimated and omitted for reasons of parsimony. Robust standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Model 0 includes only one input (government spending as percentage of GDP) and one output, a composite public sector performance (PSP) indicator.

Table A6. Correlation Matrix of Efficiency Scores for Input-Oriented Models.

	ltein0	*ltein1*	*ltein2*
ltein0	1.000		
ltein1	0.955	1.000	
ltein2	0.951	0.921	1.000

Table A7. Correlation Matrix of Efficiency Scores for Output-Oriented Models.

	teout0n	*teout1n*	*teout2n*
teout0n	1.000		
teout1n	0.982	1.000	
teout2n	0.688	0.691	1.000

Model 0, one input, governments' normalised spending, and one output, total PSP scores (*ltein0; teout0n*). Model 1, two inputs and one output (*ltein1, teout1n*). Model 2, one input and two outputs (*ltein2, teout2n*).