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Does government spending efficiency improve fiscal sustainability?☆

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ABSTRACT

We evaluate the impact of government spending efficiency on fiscal sustainability and fiscal reaction function coefficients 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 as well as the coefficients of the cyclically adjusted primary balance as function of one-period lagged government debt. 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.

1. Introduction

An ongoing macro and fiscal discussion pertain 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 imposed a fiscal challenge, both in terms of debt-to-GDP ratio and primary budget balances. Such challenges may even create newer structural trends to the evolution of public finances, 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 (and eventually structural) shocks can influence fiscal sustainability trajectories.

Typically, fiscal sustainability is considered to be in place when government revenues move closely in pace with government

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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 inclusive 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 Aubyn, 2019) and foster growth and deter fiscal imbalances.

Therefore, and considering the fiscal challenges that economies are facing in the past recent years and, at the same time, the need to provide larger amount of public goods and services to population that experienced periods of income retrenchment during COVID-19 pandemic and after the final crisis of 2008, namely the one that is more fragile, the linkage between public sector efficiency and fiscal sustainability is of extreme importance to analyze. In order to analyze this, we first compute fiscal sustainability coefficients in considering two alternatives to assess fiscal sustainability, both well-established in the literature. The first one relies on government revenues as a function of government expenditures. In that sense, a coefficient obtained from this function closer to one signals a higher fiscal sustainability degree. On the other hand, we apply a modified Bohn's (2007) approach. In detail, we estimate cyclically adjusted primary balance (CAPB) as a function of one-period lagged debt. It is worth mentioning that Bohn's approach relies on the primary balance as a function of one-period lagged government debt. For reasons of business cycle and in order to provide a better robustness check of our results we rely on CAPB rather than primary balance. Taking into consideration both approaches, we compute the fiscal sustainability coefficients in an expanding-window approach for a panel of 35 OECD countries during the period of 2007–2020. 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 coefficients to changes in public sector efficiency, which is a novelty and our contribution to the fiscal policy literature. The linkage between these two topics are of extreme importance since it highlights that higher public sector efficiency levels can impact on intertemporal fiscal sustainability, that is, today's public sector efficiency will impose less burden to future generations, and, at the same time, it shows that it is possible for providing higher amount of public goods and services, namely to the poorest strata of population, without compromising the sustainability of fiscal stance.

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 fewer 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 Van 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 (2007,2008). As opposed to the viewpoint that public revenues and expenditures must be cointegrated, Bohn (2007) shows that cointegration may not exist and, at the same time, it can be consistent with the intertemporal budget constraint but not a true meaning of fiscal sustainability. In line with this, the Bohn claims that an alternative of fiscal sustainability based in a positive responsiveness of primary balance to changes in government debt is closer to reach a fiscal sustainability result.[1] In line with this approach. For instance, Bökemeier et al. (2022) found heterogeneous responses of primary balances to increases of government debt. In specific, the authors' results provide two different regimes marked by a 60% threshold value for the public debt ratio: the fiscal reaction function seems to be non-significant for low debt levels, whereas the other regime is characterized by a positive response by fiscal authorities. Additionally, Aldama and Creel (2019), by assessing the long-run fiscal sustainability of the United States, found that fiscal rules have no impact on the sustainable path of U.S. public debt. Given the government's behaviour instability of U.S. governments over the analysed timespan, the authors develop a Markov-switching regime, conditioned to fiscal rules, that enables to identify the periods of U.S. public debt (un)sustainability.

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 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 et 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., 2023), and Sub-Sahara Africa (Olanubi and Olanubi, 2023), 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 employing the actual level 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 employ two different approaches. First, 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

[1] For additional details on fiscal reaction function, see the seminal paper of Bohn (1998).

regressions for each country[2]:

$$R_t = \alpha + \beta G_t + u_t \quad (1)$$

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 what concerns to the second approach, we rely in slightly modified Bohn (1998) approach, estimating CAPB (instead of primary balance) as a function of one-period lagged debt (Equation (2)). We decided to employ this approach since it gives another interpretation of fiscal sustainability, namely the attitude of fiscal authorities facing increasing debt-to-GDP levels, but also because it serves a robustness check of the first approach.

$$CAPB_t = \alpha + \sigma Debt_{t-1} + u_t \quad (2)$$

In addition, we estimate Equations (1) and (2) by using an expanding window approach. That is to say, in order to obtain a time-series of β and σ for each country, we estimate both equations 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. With this expanding-window approach, the time-varying coefficients are more robust than other approaches as rolling-window or Schlicht (2021), whose time-varying coefficients display small variance through time and, therefore, not allowing to use the obtained estimated coefficient for second-step regressions.[3] 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).[4] 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.

Equation (3) 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[5]:

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

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

In Equation (3), 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' normalised total expenditure, and two outputs, the opportunity PSP and the "Musgravian" PSP scores.[6] Afonso et al. (2022b) 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

[2] 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.

[3] For a detailed discussion regarding the pros and cons of rolling and expanding window, see Pesaran and Timmermann (2004), Pesaran and Pick (2011), Phillips et al. (2015) and Jungmittag (2016), among others.

[4] 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.

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

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

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. Detailed results and data sources are reported in Afonso et al. (2022b).[7] We are thus interested in uncovering a positive contribution between government spending efficiency and fiscal sustainability. Our testing specification hypothesis is as follows:

$$\beta_{it} = \alpha_1 + \alpha_2 \beta_{it-1} + \alpha_3 \theta_{it} + \alpha_k X_{k,it} + u_{it} \quad (4)$$

$$\sigma_{it} = \alpha_1 + \alpha_2 \sigma_{it-1} + \alpha_3 \theta_{it} + \alpha_k X_{k,it} + u_{it} \quad (5)$$

where β is the time-varying sustainability coefficient, θ is the efficiency score obtained from (3), 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. In detail, we include the primary balance (*pbalance*), the change in the level of sovereign indebtedness (*Δdebt*), the output gap (*outputgap*), and the differential between the interest rate I and the output growth rate (g) in equation (4), while we only include these last two variables for equation (5). The reason relies on the fact that to compute the time-varying coefficients σ, they are estimated previously using the CAPB (which is very close to the primary balance) and government debt. Lastly, it is worth mentioning that we estimate the above-described equations with and without the auto-regressive term for robustness purposes.

We estimate (4) and (5) 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 equations (4) and (5) using 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 $u_t \sim N\left(0, \frac{\sigma^2}{s_i}\right)$, 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 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, as well as the descriptive statistics for efficiency scores are 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. Fig. 1 shows stylised evidence for some countries, using the DEA output-oriented Model 2 (one input, governments' normalised 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 2007–2020 can be observed, which highlights the possibility of theoretically obtaining 22 p. p. 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). In table A14, we provide the average values of fiscal sustainability coefficients[8] obtained from equations (1) and (2).

[7] The input opportunity indicators inputs include government consumption (administration), education expenditure (education), health expenditure (health), public investment (public infrastructure) – opportunity indicators – and social protection expenditure (distribution) and government total expenditure (stabilization/economic performance) – Musgravian indicators. The output opportunity indicators include the following variables corruption, red tape, judicial independence, property rights, shadow economy (administration), secondary school enrolment, quality of educational system, PISA scores (education), infant survival rate, life expectancy, CVD, cancer, diabetes or CRD survival rate (health), infrastructure quality (public infrastructure) – opportunity indicators -, and Gini index (distribution), coefficient of variation of growth and standard deviation of inflation (stabilization) and GDP per capita, GDP growth and unemployment (economic performance) – Musgravian indicators.

[8] It is important to highlight that there is conflicting results about fiscal reaction functions and fiscal sustainability coefficients in the recent literature that should be explored in the future, namely why Germany is presenting a lower fiscal sustainability and fiscal reaction function coefficients smaller than the other examples illustrated in Fig. 1, when Germany is the biggest economy in Europe.

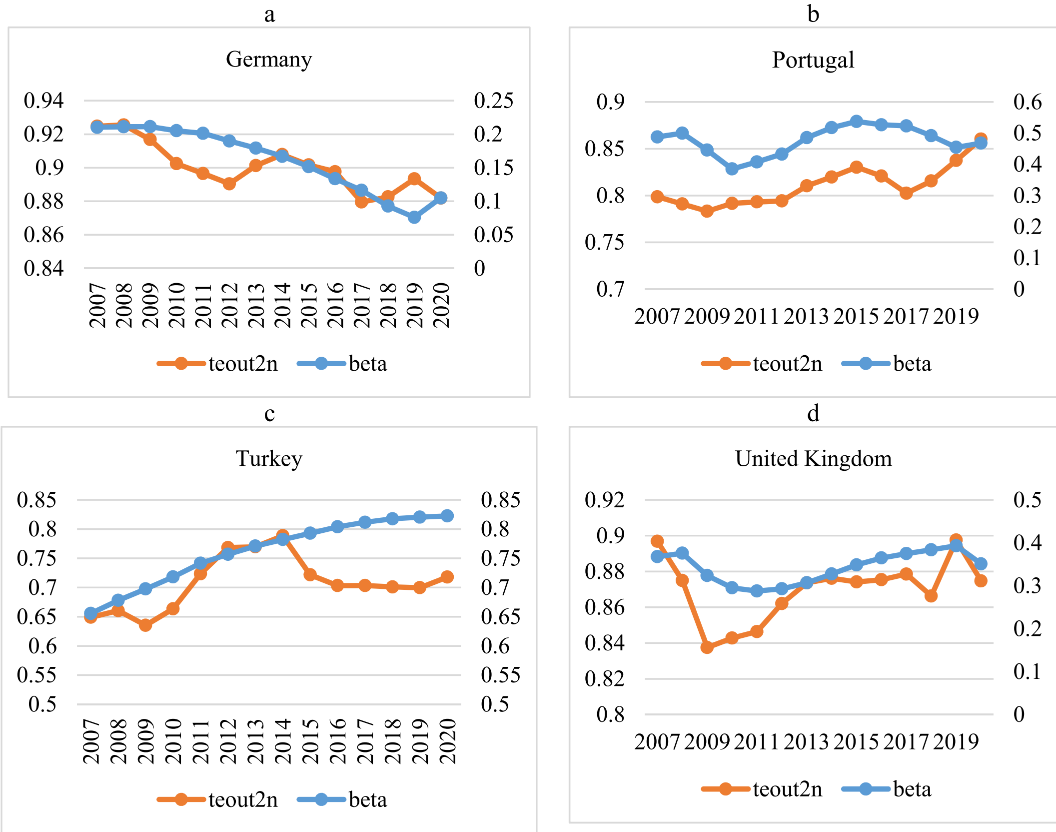

Fig. 1. Sustainability magnitude (RHS) and efficiency scores (LHS)
Note: teout2n (θ): Model 2, output-oriented efficiency score (one input, governments' normalised total expenditure and two outputs).

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.[9] Our results, for both input- and output-oriented models consist in three different estimation exercises: one including 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 be expected), and, lastly, for the euro-area countries. The results obtained lead us to conclude that higher public spending efficiency positively contributes to improve fiscal sustainability, as we obtained an expected and statistical positive coefficient for θ, not only when we estimate Equation (4) with the autoregressive term, but also when we exclude it. 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 for all samples, and also for both fiscal sustainability approaches. This conclusion is reached in the three models we used (see Model 0 results in table A4, in the appendix).

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

[9] We report the results of Model 0 for both input-oriented and output-oriented approaches in tables A4 and A5 in the Appendix, respectively.

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

	β					
	All Sample		Corr.>0.25		Euro	
β_{t-1}	0.948***		0.921***		0.927***	
	(0.034)		(0.044)		(0.043)	
θ	0.050***	0.066	0.022	0.100*	0.095***	0.201***
	(0.017)	(0.050)	(0.019)	(0.052)	(0.024)	(0.074)
pbalance	0.002*	0.002	0.004***	0.002	0.002**	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\Delta debt$	−0.000	0.001	−0.000	0.001	−0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
outputgap	−0.002*	0.006***	−0.002***	0.002	−0.002**	0.003
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
$r - g$	0.000	−0.000	0.000	−0.000	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	−0.028*	−0.300***	−0.006	−0.316***	−0.017	0.366***
Constant	(0.015)	(0.038)	(0.020)	(0.038)	(0.025)	(0.041)
Obs.	310	334	142	153	179	192
Adjusted R^2	0.997	0.983	0.997	0.986	0.996	0.979
	σ					
	All Sample		Corr.>0.25		Euro	
σ_{t-1}	0.694***		0.799***		0.683***	
	(0.120)		(0.066)		(0.150)	
θ	0.026	0.104***	0.049*	0.347***	0.040	0.098*
	(0.021)	(0.034)	(0.027)	(0.060)	(0.030)	(0.051)
outputgap	−0.001	−0.002	−0.002***	−0.003***	−0.002*	−0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$r - g$	−0.000	−0.000	−0.001***	−0.003***	−0.001	−0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
Constant	−0.035	−0.121***	−0.051**	−0.309***	−0.004	0.003
	(0.022)	(0.032)	(0.025)	(0.046)	(0.014)	(0.031)
Obs.	310	334	154	166	179	192
Adjusted R^2	0.939	0.778	0.961	0.870	0.897	0.639

Note: 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.

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 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.[10] Lastly, although the interest rate-GDP growth rate differentials are only significant for models 0 and 2 when analysing the fiscal sustainability through Bonh's approach and for the sample whose correlation between fiscal sustainability coefficients and efficiency scores are higher than 0.25, 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.

Moreover, it is worth discussing the fact of the high adjusted R^2 values, mainly when we estimate equation (4). There is indeed a persistence of the autoregressive term translating the higher persistence of lagged fiscal sustainability (the β approach) that explains the actual level of fiscal sustainability. However, when the autoregressive term is dropped our results also present a high explanatory power, although with a lower value for the adjusted R^2, leading us to conclude that the efficiency scores and the other control variables are a really important determinants of time-varying fiscal sustainability determinants. On the other hand, the study of fiscal sustainability through the revenues-expenditures relationship led to this high adjusted R^2 because government expenditures are quite sticky in the short term. In that sense, lagged β coefficients will necessarily play an important role in determining the present fiscal sustainability coefficient. This process also happens to Bohn's fiscal reaction function coefficients. In this case, we may also expect a less volatile fiscal behaviour from public authorities because during the period under analysis there was the financial crisis of 2008 and the sovereign debt crisis that compelled governments to pursue a more cautious public debt path. Following this rationale, we can also

[10] 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 2
Estimations results for the impact of public spending efficiency on fiscal sustainability, input-oriented scores, Model 2, 2007–2020.

	β					
	All Sample		Corr.>0.25		Euro	
β_{t-1}	0.943***		0.884***		0.918***	
	(0.034)		(0.037)		(0.043)	
θ	0.047**	0.124*	0.051**	0.211***	0.080***	0.260***
	(0.019)	(0.064)	(0.023)	(0.071)	(0.027)	(0.073)
pbalance	0.002*	0.001	0.002**	0.000	0.003**	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$\Delta debt$	−0.000	0.001	−0.000	0.000	−0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
outputgap	−0.002**	0.005***	−0.002*	0.001	−0.002**	0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
$r - g$	0.000	−0.000	0.001	0.001	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−0.029	−0.348***	−0.042*	−0.383***	−0.004	0.332***
	(0.018)	(0.047)	(0.023)	(0.055)	(0.024)	(0.043)
Obs.	310	334	155	167	179	192
Adjusted R^2	0.997	0.983	0.998	0.986	0.996	0.980
	σ					
	All Sample		Corr.>0.25		Euro	
σ_{t-1}	0.696***		0.602***		0.685***	
	(0.117)		(0.146)		(0.148)	
θ	0.030*	0.063*	0.204**	0.530***	0.046	0.052
	(0.018)	(0.038)	(0.083)	(0.075)	(0.031)	(0.061)
outputgap	−0.001	−0.002	−0.003***	−0.006***	−0.002*	−0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$r - g$	−0.001	−0.000	−0.002***	−0.004***	−0.001	−0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−0.038**	−0.092***	−0.182**	−0.461***	−0.006	0.032
	(0.019)	(0.034)	(0.071)	(0.061)	(0.015)	(0.034)
Obs.	310	334	167	180	179	192
Adjusted R^2	0.940	0.773	0.928	0.788	0.898	0.632

Note: 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.

expect a sticky behaviour of fiscal authorities in pursuing a better management of public finances. Finally, these patterns regarding the adjusted R^2 are also observed for the output-oriented analysis.

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 was also present the same conclusion that the one 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. However, and regarding the estimated fiscal sustainability coefficients resorting to Bohn's approach highlight a negative impact of public sector efficiency on fiscal sustainability for the euro-area countries during the period under analysis.

From our results for the output-oriented models, we found similar results to those found for the input-oriented models, but, however, an important difference is important to highlight: we found higher effects of improving public administration efficiency on fiscal sustainability for the whole sample and for Euro Area economies for the output-oriented models when compared to input-oriented models for both fiscal sustainability approaches. This is an important result since it leads us to conclude that it is preferable to increase public sector efficiency through the increase of public goods and services to the society, that will stimulate the aggregate economic activity, then generating more public revenues and, therefore, improving fiscal sustainability, rather than keep the actual level of public goods and services provision, while reducing the level of inputs. This result is somehow important because provide new insights that must be explored, namely, the stickiness of public revenues and expenditures – which may be surely different among countries - when analysing public sector performance.

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 does not matter when analysing output-oriented models, probably because the higher efficiency in an output-oriented approach will lead to boost economic performance (diminishing the interest rate-growth differential), reducing the explanatory of such component of government debt dynamics.

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

	β					
	All Sample		Corr.>0.25		Euro	
β_{t-1}	0.947***		0.908***		0.923***	
	(0.034)		(0.044)		(0.043)	
θ	0.024	0.055	0.009	0.175***	0.061**	0.188**
	(0.015)	(0.047)	(0.017)	(0.064)	(0.029)	(0.080)
pbalance	0.002**	0.002*	0.002*	0.000	0.003***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Δ*debt*	−0.000	0.001	−0.000	0.001	−0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
outputgap	−0.002**	0.005**	0.002	0.008**	−0.003***	−0.001
	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)	(0.002)
$r-g$	0.000	−0.000	0.001	0.000	−0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−0.014	−0.301***	0.026	0.192***	−0.013	0.323***
	(0.018)	(0.044)	(0.019)	(0.048)	(0.030)	(0.066)
Obs.	310	334	117	126	179	192
Adjusted R^2	0.997	0.983	0.998	0.990	0.996	0.979
	σ					
	All Sample		Corr.>0.25		Euro	
σ_{t-1}	0.658***		0.523***		0.651***	
	(0.127)		(0.192)		(0.164)	
θ	0.009	0.020	0.105*	0.085**	0.014	0.022
	(0.015)	(0.017)	(0.062)	(0.036)	(0.031)	(0.024)
outputgap	−0.002**	−0.002	−0.002	0.004	−0.003**	−0.004**
	(0.001)	(0.002)	(0.003)	(0.003)	(0.001)	(0.002)
$r-g$	−0.000	−0.001	−0.002	0.000	0.000	−0.001
	(0.000)	(0.001)	(0.002)	(0.003)	(0.001)	(0.001)
Constant	−0.008	−0.060***	−0.024	−0.094***	0.024***	0.045**
	(0.012)	(0.020)	(0.024)	(0.034)	(0.008)	(0.019)
Obs.	310	334	90	97	179	192
Adjusted R^2	0.939	0.770	0.779	0.438	0.896	0.631

Note: 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.

	β					
	All Sample		Corr.>0.25		Euro	
β_{t-1}	0.942***		0.845***		0.927***	
	(0.034)		(0.054)		(0.042)	
θ	0.118***	0.260**	0.214***	0.652***	0.124***	0.307**
	(0.029)	(0.112)	(0.044)	(0.099)	(0.040)	(0.134)
pbalance	0.002**	0.002*	0.002**	0.000	0.003***	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Δ*debt*	−0.000	0.001*	0.000	0.001	−0.000	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
outputgap	−0.002**	0.005***	−0.001	0.007***	−0.002**	0.002
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
$r - g$	0.000	−0.000	0.001	0.002	−0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−0.102***	−0.491***	−0.210***	−0.819***	−0.081*	0.189
	(0.028)	(0.102)	(0.049)	(0.093)	(0.042)	(0.123)
Obs.	310	334	156	168	179	192
Adjusted R^2	0.997	0.984	0.998	0.990	0.996	0.979
	σ					
	All Sample		Corr.>0.25		Euro	
σ_{t-1}	0.705***		0.538***		0.694***	
	(0.116)		(0.183)		(0.147)	
θ	−0.001	−0.105	0.278*	0.578**	−0.016	−0.188*
	(0.038)	(0.077)	(0.142)	(0.283)	(0.062)	(0.104)
outputgap	−0.001	−0.001	0.000	0.002	−0.001	−0.002
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)
$r - g$	−0.000	−0.000	−0.001	−0.001	−0.001	−0.001
	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Constant	−0.013	0.055	−0.271**	−0.555**	0.034	0.231**
	(0.036)	(0.074)	(0.133)	(0.261)	(0.058)	(0.094)
Obs.	310	334	65	70	179	192
Adjusted R^2	0.939	0.771	0.818	0.475	0.896	0.639

Note: 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.

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 conclude 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 analyze how inputs and outputs impact fiscal sustainability to better design public administration rules and strategies. Moreover, an important policy recommendation that result from this study is that fiscal consolidation programs must have into consideration public sector performance when design such programs. For instance, Afonso and Alves (2022) find positive impacts of (well-implemented) fiscal consolidation programs to improve public sector efficiency.

5. Conclusions

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 fiscal sustainability coefficients using two different approaches: one that computes 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, while the second one is by using a modified Bohn (1998)'s approach. 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 described 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 organization 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.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix

Table A1
Data series and sources.

Variable	Series	Source
Input, output efficiency scores	ltein0, ltein1, ltein2, teout0n, teout1n, teout2n Efficiency scores, input oriented and output oriented, 3 models, see notes.	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

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

Notes: WEO – Woodford, 1995. Model 0, one input (government spending as percentage of GDP) and one output, composite public sector performance (PSP) indicator; Model 1, two inputs, governments' normalised spending on opportunity and on "Musgravian" indicators and one output, PSP scores; Model 2, one input, governments' normalised total expenditure, and two outputs, the opportunity PSP and the "Musgravian" PSP scores.

Table A3
Engle-Granger cointegration test results for the relationship between government revenues and expenditures and average values for β coefficients.

	Z(t)	Average β
Australia	−3.652**	−0.223
Austria	−5.425***	0.462
Belgium	−3.994***	−0.109
Canada	−3.649**	0.207
Chile	−4.772***	0.309
Colombia	−5.006***	0.999
Czech Republic	−4.355**	0.208
Denmark	−4.608***	0.015
Finland	−4.255***	0.426
France	−3.686**	0.547
Germany	−4.906***	0.161
Greece	−4.406***	0.934
Hungary	−3.983**	0.310
Iceland	−5.106***	0.647
Ireland	−4.669***	0.327
Israel	−3.375*	0.586
Italy	−4.919***	0.539
Japan	−4.107**	−0.030
Latvia	−3.925**	0.483
Lithuania	−4.742***	0.255
Luxembourg	−4.527***	0.280
Netherlands	−4.540***	0.564
New Zealand	−3.708**	0.435
Norway	−4.262**	−0.232
Poland	−5.063***	0.645
Portugal	−8.086***	0.476
Slovakia	−6.779***	0.518
Slovenia	−3.414*	0.112
South Korea	−4.643***	0.887
Spain	−4.963***	0.936
Sweden	−3.524**	1.005
Switzerland	−3.170*	0.719
Turkey	−3.228*	0.762
UK	−3.873**	0.342
US	−4.903***	−0.256

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

β						
	All Sample		Corr.>0.25		Euro	
β_{t-1}	0.947***		0.942***		0.924***	
	(0.034)		(0.032)		(0.043)	
θ	0.048***	0.081	0.031	0.180**	0.091***	0.218***
	(0.018)	(0.058)	(0.019)	(0.076)	(0.023)	(0.080)
pbalance	0.002**	0.002	0.004***	0.001	0.003**	0.000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
$\Delta debt$	−0.000	0.001	0.000	0.001	−0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
outputgap	−0.002**	0.006***	−0.001*	0.004	−0.002**	0.002
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
$r-g$	0.000	−0.000	0.000	0.000	−0.000	0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Constant	−0.024	−0.307***	−0.006	−0.356***	−0.006	0.372***
	(0.016)	(0.041)	(0.017)	(0.054)	(0.023)	(0.040)
Obs.	310	334	142	153	179	192

(continued on next page)

Table A4 (*continued*)

β						
	All Sample		Corr.>0.25		Euro	
Adjusted R^2	0.997	0.983	0.998	0.980	0.996	0.979
σ						
	All Sample		Corr.>0.25		Euro	
σ_{t-1}	0.693***		0.599***		0.682***	
	(0.119)		(0.145)		(0.149)	
θ	0.032	0.106***	0.182**	0.461***	0.044	0.101*
	(0.021)	(0.035)	(0.072)	(0.057)	(0.029)	(0.052)
outputgap	−0.001	−0.002	−0.003***	−0.006***	−0.002*	−0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$r-g$	−0.001	−0.001	−0.002***	−0.004***	−0.001	−0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−0.038*	−0.117***	−0.152***	−0.371***	−0.002	0.011
	(0.020)	(0.030)	(0.058)	(0.043)	(0.012)	(0.027)
Obs.	310	334	193	208	179	192
Adjusted R^2	0.940	0.779	0.942	0.829	0.898	0.641

Note: 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.

β						
	All Sample		Corr.>0.25		Euro	
β_{t-1}	0.947***		0.897***		0.924***	
	(0.034)		(0.044)		(0.043)	
θ	0.023	0.063	0.042	0.273***	0.062**	0.197**
	(0.016)	(0.049)	(0.030)	(0.097)	(0.031)	(0.086)
pbalance	0.002**	0.002*	0.002*	0.000	0.003***	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Δ*debt*	−0.000	0.001	−0.000	0.001	−0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
outputgap	−0.002**	0.005**	0.001	0.006	−0.003***	−0.001
	(0.001)	(0.002)	(0.001)	(0.004)	(0.001)	(0.002)
$r-g$	0.000	−0.000	0.000	0.000	−0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−0.012	−0.307***	−0.001	0.110	−0.016	0.314***
	(0.018)	(0.045)	(0.027)	(0.075)	(0.031)	(0.072)
Obs.	310	334	104	112	179	192
Adjusted R^2	0.997	0.983	0.998	0.986	0.996	0.979
σ						
	All Sample		Corr.>0.25		Euro	
σ_{t-1}	0.707***		0.554***		0.697***	
	(0.118)		(0.176)		(0.149)	
θ	−0.007	0.022	0.016	0.082**	−0.007	0.025
	(0.009)	(0.017)	(0.025)	(0.037)	(0.012)	(0.024)
outputgap	−0.000	−0.002	0.003	0.004	−0.001	−0.004**
	(0.001)	(0.002)	(0.002)	(0.003)	(0.001)	(0.002)
$r-g$	−0.000	−0.001	−0.000	0.000	−0.001	−0.001
	(0.000)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)
Constant	−0.008	−0.061***	−0.023	−0.089**	0.024***	0.042**
	(0.012)	(0.019)	(0.024)	(0.035)	(0.008)	(0.018)
Obs.	310	334	90	97	179	192
Adjusted R^2	0.939	0.771	0.779	0.436	0.896	0.631

Note: 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

Notes: Model 0 is built based in one input, governments' normalised spending, and one output, total PSP scores (*ltein0*). Model 1 uses two inputs and one output (*ltein1*). Model 2 includes one input and two outputs (*ltein2*).

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

Notes: Model 0 is built based in one input, governments' normalised spending, and one output, total PSP scores (*teout0n*). Model 1 uses two inputs and one output (*teout1n*). Model 2 includes one input and two outputs (*teout2n*).

Table A8
Descriptive Statistics for the input-oriented efficiency scores, model 0.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Australia	0.735	0.664	0.661	1.000	1.000	1.000	1.000	1.000	0.791	0.694	0.687	0.680	0.708	1.000
Austria	0.560	0.496	0.473	0.489	0.466	0.464	0.463	0.460	0.501	0.499	0.519	0.515	0.536	0.531
Belgium	0.469	0.488	0.479	0.493	0.477	0.470	0.456	0.448	0.484	0.494	0.520	0.520	0.538	0.527
Canada	0.707	0.601	0.707	0.607	0.576	0.562	0.561	0.572	0.753	0.641	0.645	0.633	0.651	0.637
Chile	0.979	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.979	0.992	1.000
Colombia	0.773	0.761	0.769	0.818	0.814	0.791	0.797	0.832	0.828	0.811	0.848	0.862	0.876	0.746
Czech Republic	0.520	0.528	0.552	0.566	0.536	0.542	0.537	0.542	0.574	0.607	0.597	0.641	0.689	0.650
Denmark	0.476	0.426	0.412	0.444	0.408	0.396	0.391	0.394	0.438	0.442	0.465	0.463	0.489	0.644
Finland	0.486	0.482	0.460	0.488	0.444	0.436	0.425	0.403	0.418	0.425	0.456	0.450	0.477	0.469
France	0.530	0.426	0.412	0.440	0.423	0.418	0.414	0.408	0.440	0.447	0.469	0.462	0.482	0.475
Germany	0.496	0.499	0.518	0.546	0.515	0.518	0.526	0.524	0.604	0.587	0.597	0.581	0.598	0.579
Greece	0.496	0.485	0.482	0.471	0.471	0.480	0.472	0.456	0.506	0.517	0.548	0.550	0.556	0.569
Hungary	0.523	0.441	0.474	0.514	0.527	0.527	0.528	0.521	0.527	0.538	0.557	0.629	0.629	0.601
Iceland	0.573	0.577	0.483	0.509	0.524	0.537	0.519	0.549	0.593	0.622	0.646	0.591	0.633	0.601
Ireland	0.666	0.597	0.535	0.500	0.452	0.474	0.529	0.552	0.677	1.000	0.913	0.909	0.995	1.000
Israel	0.540	0.551	0.576	0.616	0.640	0.651	0.665	0.715	0.701	0.685	0.710	0.697	0.693	0.678
Italy	0.477	0.477	0.488	0.495	0.491	0.496	0.495	0.490	0.502	0.525	0.549	0.561	0.581	0.567
Japan	0.607	0.762	0.604	0.630	0.595	0.575	0.557	0.550	0.592	0.614	0.642	0.638	0.662	0.650
Latvia	0.640	0.634	0.618	0.600	0.557	0.573	0.596	0.582	0.608	0.659	0.690	0.719	0.722	0.676
Lithuania	0.630	0.614	0.576	0.561	0.531	0.534	0.572	0.617	0.672	0.702	0.743	0.764	0.790	0.751
Luxembourg	0.636	0.682	0.566	0.599	0.555	0.547	0.544	0.526	0.655	0.613	0.625	0.614	0.625	0.621
Netherlands	0.513	0.558	0.645	0.736	0.524	0.509	0.491	0.490	0.538	0.554	0.579	0.579	0.611	0.608
New Zealand	0.593	0.547	0.549	0.619	0.580	0.527	0.501	0.548	0.687	0.662	0.684	0.683	1.000	0.697
Norway	0.515	0.523	0.500	0.551	0.491	0.498	0.496	0.484	0.576	0.509	0.485	0.455	0.482	0.474
Poland	0.500	0.497	0.516	0.549	0.553	0.633	0.588	0.535	0.560	0.580	0.621	0.634	0.644	0.615
Portugal	0.474	0.493	0.506	0.511	0.485	0.466	0.492	0.505	0.511	0.548	0.592	0.618	0.641	0.635
Slovakia	0.547	0.566	0.620	0.607	0.565	0.561	0.567	0.568	0.571	0.569	0.556	0.621	0.650	0.625
Slovenia	0.461	0.472	0.502	0.511	0.478	0.461	0.465	0.442	0.464	0.496	0.540	0.583	0.614	0.597
South Korea	1.000	1.000	1.000	1.000	1.000	1.000	0.991	1.000	1.000	1.000	1.000	1.000	1.000	0.958
Spain	0.760	0.646	0.546	0.541	0.515	0.509	0.507	0.529	0.559	0.591	0.626	0.648	0.674	0.648
Sweden	0.443	0.431	0.433	0.471	0.466	0.468	0.455	0.432	0.485	0.500	0.509	0.488	0.505	0.496
Switzerland	1.000	1.000	1.000	1.000	0.795	0.818	0.746	0.784	1.000	1.000	1.000	0.782	0.810	0.808
Turkey	0.662	0.681	0.696	0.705	0.681	0.713	0.738	0.690	0.721	0.755	0.763	0.738	0.760	0.721
UK	0.647	0.587	0.542	0.568	0.529	0.518	0.521	0.524	0.629	0.600	0.620	0.617	0.641	0.631
US	0.675	0.630	0.603	0.613	0.591	0.584	0.592	0.609	0.811	0.719	0.723	0.699	0.727	0.719
Average	0.609	0.595	0.586	0.611	0.579	0.579	0.577	0.579	0.628	0.634	0.649	0.646	0.677	0.663
Std. Dev.	0.147	0.151	0.151	0.161	0.155	0.157	0.156	0.161	0.155	0.158	0.148	0.135	0.148	0.141
Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min.	0.443	0.426	0.412	0.440	0.408	0.396	0.391	0.394	0.418	0.425	0.456	0.450	0.477	0.469
Obs.	35	35	35	35	35	35	35	35	35	35	35	35	35	35

Source: Afonso et al. (2022b).

Table A9
Descriptive Statistics for the input-oriented efficiency scores, model 1.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Australia	0.833	0.702	0.693	1.000	1.000	1.000	1.000	1.000	0.892	0.701	0.693	0.709	0.739	1.000
Austria	0.603	0.572	0.564	0.591	0.582	0.575	0.577	0.575	0.606	0.619	0.617	0.584	0.592	0.603
Belgium	0.541	0.582	0.564	0.597	0.598	0.586	0.561	0.546	0.582	0.592	0.608	0.586	0.595	0.596
Canada	0.736	0.624	0.766	0.671	0.661	0.619	0.619	0.627	0.789	0.709	0.690	0.654	0.654	0.650
Chile	0.983	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Colombia	0.791	0.766	0.770	0.862	0.847	0.799	0.820	0.846	0.831	0.853	0.876	0.866	0.877	0.766
Czech Republic	0.529	0.539	0.561	0.600	0.570	0.582	0.583	0.583	0.640	0.658	0.603	0.643	0.692	0.655
Denmark	0.517	0.498	0.472	0.531	0.505	0.487	0.477	0.476	0.499	0.521	0.532	0.500	0.520	0.718
Finland	0.533	0.553	0.536	0.586	0.557	0.548	0.528	0.491	0.507	0.527	0.556	0.517	0.541	0.546
France	0.554	0.507	0.490	0.547	0.543	0.528	0.525	0.515	0.544	0.570	0.584	0.549	0.561	0.571
Germany	0.633	0.642	0.658	0.710	0.682	0.664	0.671	0.665	0.716	0.731	0.733	0.685	0.690	0.688
Greece	0.540	0.525	0.548	0.556	0.568	0.617	0.640	0.648	0.656	0.703	0.698	0.664	0.628	0.704
Hungary	0.558	0.476	0.546	0.656	0.681	0.667	0.663	0.647	0.639	0.624	0.589	0.695	0.641	0.607
Iceland	0.691	0.703	0.493	0.568	0.534	0.562	0.521	0.557	0.607	0.653	0.654	0.593	0.663	0.673
Ireland	0.682	0.632	0.559	0.546	0.579	0.531	0.605	0.643	0.730	1.000	1.000	0.924	1.000	1.000
Israel	0.545	0.559	0.584	0.640	0.688	0.684	0.692	0.733	0.702	0.716	0.729	0.699	0.693	0.678
Italy	0.557	0.544	0.580	0.620	0.623	0.634	0.642	0.644	0.673	0.717	0.718	0.702	0.710	0.729
Japan	0.636	0.776	0.668	0.737	0.714	0.686	0.657	0.642	0.669	0.695	0.712	0.686	0.700	0.709
Latvia	0.647	0.671	0.671	0.617	0.639	0.646	0.633	0.586	0.632	0.711	0.722	0.754	0.725	0.683
Lithuania	0.637	0.632	0.588	0.602	0.610	0.576	0.579	0.649	0.711	0.767	0.773	0.766	0.792	0.787
Luxembourg	0.643	0.734	0.666	0.734	0.695	0.665	0.679	0.645	0.733	0.742	0.748	0.704	0.706	0.733
Netherlands	0.569	0.582	0.673	0.737	0.592	0.568	0.552	0.551	0.590	0.623	0.628	0.601	0.624	0.635
New Zealand	0.647	0.548	0.568	0.621	0.598	0.535	0.529	0.561	0.767	0.680	0.716	0.724	1.000	0.773
Norway	0.516	0.551	0.518	0.596	0.545	0.555	0.554	0.532	0.587	0.539	0.519	0.455	0.482	0.478
Poland	0.590	0.558	0.584	0.619	0.642	0.699	0.629	0.608	0.658	0.673	0.696	0.720	0.702	0.669
Portugal	0.497	0.525	0.554	0.595	0.571	0.524	0.589	0.640	0.673	0.717	0.731	0.758	0.730	0.745
Slovakia	0.598	0.583	0.682	0.698	0.656	0.646	0.645	0.664	0.669	0.655	0.573	0.652	0.672	0.667
Slovenia	0.513	0.512	0.554	0.584	0.565	0.546	0.553	0.553	0.542	0.577	0.604	0.645	0.666	0.653
South Korea	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.958
Spain	0.818	0.649	0.573	0.608	0.589	0.590	0.606	0.661	0.727	0.774	0.764	0.766	0.783	0.780
Sweden	0.497	0.509	0.500	0.549	0.553	0.549	0.536	0.497	0.534	0.554	0.567	0.515	0.519	0.517
Switzerland	1.000	1.000	1.000	1.000	0.953	0.976	0.900	0.904	1.000	1.000	1.000	0.876	0.882	0.907
Turkey	0.695	0.690	0.727	0.798	0.822	0.831	0.864	0.733	0.745	0.806	0.811	0.744	0.762	0.724
UK	0.661	0.652	0.619	0.658	0.639	0.607	0.610	0.613	0.683	0.681	0.687	0.656	0.660	0.672
US	0.824	0.717	0.698	0.658	0.600	0.600	0.627	0.653	1.000	0.796	0.782	0.769	0.783	0.814
Average	0.652	0.638	0.635	0.677	0.663	0.654	0.653	0.654	0.701	0.711	0.712	0.696	0.714	0.717
Std. Dev.	0.140	0.136	0.135	0.137	0.137	0.142	0.139	0.137	0.137	0.130	0.131	0.127	0.136	0.129
Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min.	0.497	0.476	0.472	0.531	0.505	0.487	0.477	0.476	0.499	0.521	0.519	0.455	0.482	0.478
Obs.	35	35	35	35	35	35	35	35	35	35	35	35	35	35

Source: Afonso et al. (2022b).

Table A10
Descriptive Statistics for the input-oriented efficiency scores, model 2.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Australia	0.787	0.736	0.722	1.000	1.000	1.000	1.000	1.000	0.809	0.755	0.742	0.738	0.710	1.000
Austria	0.592	0.570	0.570	0.562	0.545	0.543	0.550	0.559	0.566	0.573	0.574	0.579	0.538	0.533
Belgium	0.556	0.534	0.545	0.529	0.511	0.512	0.501	0.503	0.522	0.538	0.566	0.563	0.540	0.527
Canada	0.711	0.666	0.732	0.680	0.661	0.648	0.663	0.685	0.759	0.717	0.699	0.702	0.654	0.639
Chile	0.979	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.979	0.992	1.000
Colombia	0.773	0.761	0.769	0.835	0.819	0.810	0.829	0.892	0.901	0.815	0.848	0.862	0.876	0.747
Czech Republic	0.520	0.532	0.557	0.570	0.536	0.542	0.537	0.542	0.577	0.607	0.600	0.641	0.689	0.652
Denmark	0.563	0.534	0.517	0.512	0.483	0.481	0.457	0.464	0.486	0.507	0.519	0.529	0.491	1.000
Finland	0.622	0.597	0.595	0.577	0.540	0.547	0.547	0.535	0.527	0.522	0.545	0.550	0.560	0.567
France	0.550	0.476	0.485	0.487	0.475	0.473	0.468	0.472	0.478	0.498	0.505	0.503	0.483	0.476
Germany	0.628	0.611	0.620	0.613	0.586	0.593	0.624	0.639	0.653	0.670	0.658	0.659	0.600	0.582
Greece	0.496	0.490	0.482	0.476	0.471	0.480	0.472	0.456	0.506	0.517	0.548	0.550	0.556	0.569
Hungary	0.703	0.441	0.474	0.517	0.527	0.527	0.528	0.521	0.527	0.538	0.557	0.629	0.629	0.603
Iceland	0.709	0.642	0.572	0.593	0.628	0.639	0.620	0.660	0.673	0.702	0.717	0.668	0.635	0.601
Ireland	0.682	0.598	0.556	0.518	0.468	0.505	0.600	0.646	0.703	1.000	1.000	0.991	1.000	1.000
Israel	0.574	0.559	0.579	0.622	0.642	0.651	0.672	0.722	0.722	0.685	0.729	0.719	0.693	0.679
Italy	0.477	0.483	0.488	0.500	0.491	0.496	0.495	0.490	0.502	0.525	0.549	0.561	0.581	0.567
Japan	0.753	0.833	0.697	0.696	0.668	0.657	0.641	0.647	0.680	0.704	0.713	0.722	0.674	0.673
Latvia	0.640	0.642	0.618	0.608	0.557	0.573	0.596	0.582	0.608	0.659	0.690	0.719	0.722	0.676
Lithuania	0.630	0.621	0.576	0.568	0.531	0.534	0.572	0.617	0.680	0.702	0.743	0.764	0.790	0.753

(continued on next page)

Table A10 (*continued*)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Luxembourg	0.670	0.734	0.657	0.664	0.622	0.618	0.640	0.637	0.671	0.691	0.693	0.693	0.627	0.624
Netherlands	0.681	0.623	0.688	0.739	0.598	0.597	0.614	0.625	0.651	0.675	0.681	0.699	0.700	0.692
New Zealand	0.650	0.578	0.597	0.673	0.643	0.593	0.586	0.660	0.717	0.745	0.750	0.765	1.000	0.698
Norway	0.596	0.568	0.563	0.594	0.531	0.539	0.559	0.565	0.580	0.557	0.525	0.508	0.483	0.477
Poland	0.500	0.500	0.534	0.562	0.560	0.788	0.622	0.537	0.563	0.582	0.622	0.634	0.644	0.617
Portugal	0.484	0.498	0.515	0.516	0.485	0.466	0.504	0.533	0.556	0.593	0.620	0.649	0.641	0.635
Slovakia	0.547	0.572	0.683	0.616	0.566	0.561	0.567	0.568	0.571	0.572	0.557	0.621	0.650	0.627
Slovenia	0.461	0.474	0.506	0.512	0.478	0.461	0.465	0.442	0.464	0.496	0.541	0.583	0.614	0.598
South Korea	1.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000	0.960
Spain	1.000	0.772	0.557	0.542	0.515	0.509	0.517	0.555	0.584	0.622	0.649	0.657	0.674	0.648
Sweden	0.510	0.507	0.525	0.539	0.548	0.550	0.537	0.518	0.521	0.548	0.569	0.560	0.528	0.511
Switzerland	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Turkey	0.662	0.681	0.696	0.705	0.681	0.722	0.738	0.707	0.736	0.761	0.764	0.738	0.760	0.721
UK	0.665	0.616	0.592	0.596	0.567	0.574	0.592	0.608	0.642	0.667	0.682	0.687	0.644	0.633
US	0.802	0.716	0.707	0.684	0.653	0.645	0.665	0.711	0.830	0.803	0.810	0.824	0.805	0.764
Average	0.662	0.633	0.628	0.640	0.617	0.624	0.628	0.637	0.656	0.673	0.685	0.693	0.691	0.687
Std. Dev.	0.149	0.146	0.138	0.151	0.156	0.158	0.154	0.158	0.148	0.147	0.143	0.137	0.153	0.156
Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min.	0.461	0.441	0.474	0.476	0.468	0.461	0.457	0.442	0.464	0.496	0.505	0.503	0.483	0.476
Obs.	35	35	35	35	35	35	35	35	35	35	35	35	35	35

Source: Afonso et al. (2022b).

Table A11

Descriptive Statistics for the output-oriented efficiency scores, model 0.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Australia	0.902	0.872	0.882	1.000	1.000	1.000	1.000	1.000	0.899	0.822	0.853	0.860	0.923	1.000
Austria	0.926	0.883	0.864	0.839	0.784	0.748	0.532	0.539	0.759	0.705	0.759	0.699	0.756	0.837
Belgium	0.813	0.816	0.701	0.752	0.734	0.686	0.510	0.544	0.732	0.700	0.736	0.679	0.774	0.889
Canada	0.917	0.865	0.949	0.801	0.784	0.740	0.579	0.624	0.901	0.732	0.806	0.743	0.772	0.836
Chile	0.854	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.546	0.626	1.000
Colombia	0.633	0.626	0.679	0.720	0.713	0.783	0.787	0.859	0.801	0.628	0.556	0.455	0.510	0.616
Czech Republic	0.745	0.748	0.761	0.720	0.667	0.616	0.392	0.451	0.675	0.680	0.680	0.687	0.743	0.811
Denmark	0.888	0.851	0.712	0.810	0.734	0.672	0.474	0.526	0.774	0.733	0.773	0.774	0.831	0.987
Finland	0.864	0.867	0.758	0.830	0.762	0.714	0.442	0.498	0.709	0.653	0.723	0.694	0.756	0.849
France	0.933	0.852	0.727	0.754	0.718	0.684	0.480	0.530	0.732	0.680	0.724	0.702	0.698	0.776
Germany	0.833	0.789	0.791	0.796	0.775	0.737	0.521	0.558	0.800	0.741	0.783	0.740	0.772	0.809
Greece	0.774	0.763	0.600	0.662	0.450	0.279	n.a.	0.056	0.467	0.450	0.491	0.491	0.554	0.639
Hungary	0.874	0.610	0.595	0.644	0.560	0.524	0.341	0.426	0.642	0.590	0.594	0.628	0.685	0.765
Iceland	0.866	0.888	0.821	0.796	0.616	0.634	0.449	0.562	0.730	0.766	0.846	0.757	0.868	0.883
Ireland	0.862	0.840	0.519	0.706	0.614	0.556	0.368	0.485	0.806	1.000	0.754	0.859	0.938	1.000
Israel	0.683	0.710	0.771	0.748	0.831	0.822	0.702	0.792	0.790	0.690	0.777	0.712	0.774	0.872
Italy	0.750	0.716	0.552	0.646	0.593	0.530	0.250	0.321	0.543	0.513	0.547	0.558	0.619	0.691
Japan	0.827	0.940	0.646	0.761	0.738	0.639	0.513	0.596	0.727	0.724	0.743	0.688	0.720	0.860
Latvia	0.761	0.766	0.377	0.668	0.407	0.531	0.429	0.420	0.568	0.621	0.652	0.580	0.635	0.707
Lithuania	0.742	0.758	0.675	0.697	0.529	0.573	0.466	0.478	0.688	0.623	0.700	0.621	0.654	0.762
Luxembourg	0.930	0.931	0.733	0.851	0.844	0.760	0.500	0.653	0.858	0.789	0.837	0.757	0.802	0.866
Netherlands	0.807	0.876	0.952	0.947	0.847	0.775	0.487	0.510	0.745	0.712	0.739	0.719	0.828	0.902
New Zealand	0.858	0.828	0.679	0.812	0.773	0.722	0.590	0.659	0.830	0.767	0.914	0.775	1.000	0.893
Norway	0.850	0.860	0.773	0.868	0.791	0.748	0.640	0.653	0.861	0.820	0.771	0.744	0.772	0.834
Poland	0.644	0.652	0.750	0.777	0.851	0.904	0.732	0.652	0.656	0.620	0.648	0.626	0.724	0.829
Portugal	0.680	0.688	0.712	0.655	0.623	0.505	0.216	0.316	0.581	0.565	0.613	0.640	0.701	0.820
Slovakia	0.720	0.714	0.823	0.709	0.693	0.607	0.474	0.443	0.618	0.622	0.610	0.585	0.654	0.698
Slovenia	0.759	0.756	0.827	0.760	0.644	0.577	0.305	0.395	0.653	0.594	0.639	0.629	0.717	0.790
South Korea	1.000	1.000	1.000	1.000	1.000	1.000	0.992	1.000	1.000	1.000	1.000	1.000	1.000	0.907
Spain	0.952	0.900	0.718	0.676	0.591	0.518	0.239	0.266	0.580	0.586	0.622	0.584	0.656	0.750
Sweden	0.852	0.846	0.688	0.815	0.858	0.770	0.491	0.596	0.778	0.821	0.826	0.716	0.752	0.828
Switzerland	1.000	1.000	1.000	1.000	0.952	0.934	0.772	0.834	1.000	1.000	1.000	0.874	0.877	0.934
Turkey	0.639	0.600	0.555	0.644	0.694	0.747	0.663	0.730	0.720	0.682	0.682	0.611	0.554	0.572
UK	0.896	0.864	0.655	0.789	0.733	0.649	0.515	0.571	0.816	0.742	0.790	0.713	0.719	0.805
US	0.856	0.846	0.733	0.735	0.700	0.642	0.542	0.589	0.910	0.806	0.838	0.759	0.805	0.877
Average	0.825	0.815	0.742	0.782	0.731	0.695	0.541	0.575	0.753	0.719	0.744	0.692	0.748	0.825
Std. Dev.	0.097	0.105	0.139	0.104	0.141	0.154	0.197	0.202	0.129	0.132	0.123	0.109	0.115	0.103
Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min.	0.633	0.600	0.377	0.644	0.407	0.279	0.216	0.056	0.467	0.450	0.491	0.455	0.510	0.572
Obs.	35	35	35	35	35	35	34	35	35	35	35	35	35	35

Source: Afonso et al. (2022b).

Table A12
Descriptive Statistics for the output-oriented efficiency scores, model 1.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Australia	0.931	0.883	0.882	1.000	1.000	1.000	1.000	1.000	0.926	0.823	0.856	0.860	0.924	1.000
Austria	0.926	0.883	0.864	0.839	0.784	0.748	0.532	0.539	0.759	0.705	0.759	0.699	0.756	0.837
Belgium	0.813	0.816	0.701	0.752	0.734	0.686	0.510	0.544	0.732	0.700	0.736	0.679	0.774	0.889
Canada	0.917	0.865	0.949	0.804	0.785	0.740	0.579	0.624	0.901	0.732	0.806	0.743	0.773	0.836
Chile	0.857	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Colombia	0.651	0.649	0.713	0.721	0.713	0.788	0.790	0.864	0.876	0.649	0.563	0.455	0.510	0.626
Czech Republic	0.745	0.748	0.761	0.720	0.667	0.616	0.392	0.451	0.675	0.680	0.680	0.687	0.745	0.811
Denmark	0.888	0.851	0.712	0.810	0.734	0.672	0.474	0.526	0.774	0.733	0.773	0.774	0.831	0.987
Finland	0.864	0.867	0.758	0.830	0.762	0.714	0.442	0.498	0.709	0.653	0.723	0.694	0.756	0.849
France	0.933	0.852	0.727	0.754	0.718	0.684	0.480	0.530	0.732	0.680	0.724	0.702	0.698	0.776
Germany	0.833	0.789	0.791	0.809	0.781	0.753	0.550	0.574	0.800	0.741	0.783	0.740	0.774	0.814
Greece	0.774	0.763	0.600	0.662	0.450	0.279	n.a.	0.057	0.467	0.450	0.491	0.491	0.554	0.644
Hungary	0.874	0.610	0.595	0.646	0.563	0.537	0.356	0.428	0.642	0.590	0.594	0.628	0.686	0.765
Iceland	0.867	0.888	0.821	0.796	0.616	0.634	0.449	0.562	0.730	0.766	0.846	0.757	0.868	0.883
Ireland	0.863	0.840	0.519	0.706	0.614	0.556	0.368	0.486	0.806	1.000	1.000	0.859	1.000	1.000
Israel	0.683	0.710	0.771	0.748	0.838	0.845	0.734	0.804	0.792	0.693	0.779	0.712	0.775	0.872
Italy	0.750	0.716	0.552	0.646	0.593	0.533	0.255	0.322	0.543	0.513	0.547	0.558	0.622	0.700
Japan	0.827	0.940	0.646	0.780	0.749	0.661	0.531	0.596	0.727	0.724	0.743	0.688	0.723	0.868
Latvia	0.791	0.794	0.388	0.673	0.407	0.537	0.431	0.420	0.568	0.621	0.652	0.580	0.638	0.708
Lithuania	0.772	0.768	0.675	0.697	0.529	0.573	0.466	0.483	0.713	0.627	0.706	0.621	0.656	0.767
Luxembourg	0.930	0.931	0.733	0.869	0.852	0.775	0.534	0.656	0.858	0.789	0.837	0.757	0.805	0.877
Netherlands	0.807	0.876	0.952	0.947	0.847	0.775	0.487	0.510	0.745	0.712	0.739	0.719	0.828	0.902
New Zealand	0.858	0.828	0.679	0.813	0.773	0.722	0.590	0.659	0.839	0.769	0.919	0.775	1.000	0.903
Norway	0.850	0.860	0.773	0.868	0.791	0.748	0.640	0.653	0.861	0.820	0.771	0.744	0.772	0.834
Poland	0.644	0.652	0.750	0.777	0.851	0.904	0.732	0.652	0.656	0.620	0.648	0.626	0.727	0.831
Portugal	0.680	0.688	0.712	0.655	0.623	0.505	0.216	0.316	0.581	0.565	0.613	0.640	0.704	0.832
Slovakia	0.720	0.714	0.823	0.720	0.693	0.614	0.484	0.455	0.618	0.622	0.610	0.585	0.655	0.700
Slovenia	0.759	0.756	0.827	0.760	0.644	0.577	0.305	0.395	0.653	0.594	0.639	0.629	0.718	0.790
South Korea	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.910
Spain	0.952	0.900	0.718	0.676	0.591	0.518	0.239	0.272	0.580	0.587	0.622	0.584	0.661	0.764
Sweden	0.852	0.846	0.688	0.815	0.858	0.770	0.491	0.596	0.778	0.821	0.826	0.716	0.752	0.828
Switzerland	1.000	1.000	1.000	1.000	0.979	0.993	0.895	0.931	1.000	1.000	1.000	0.874	0.882	0.946
Turkey	0.662	0.619	0.568	0.645	0.712	0.783	0.744	0.749	0.772	0.702	0.688	0.611	0.555	0.577
UK	0.896	0.864	0.655	0.789	0.733	0.649	0.515	0.571	0.816	0.742	0.790	0.713	0.720	0.808
US	0.933	0.897	0.765	0.763	0.700	0.642	0.550	0.623	1.000	0.866	0.853	0.759	0.807	0.890
Average	0.832	0.819	0.745	0.785	0.734	0.701	0.552	0.581	0.761	0.723	0.752	0.704	0.761	0.829
Std. Dev.	0.096	0.103	0.138	0.104	0.142	0.157	0.204	0.207	0.134	0.133	0.131	0.118	0.123	0.102
Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min.	0.644	0.610	0.388	0.645	0.407	0.279	0.216	0.057	0.467	0.450	0.491	0.455	0.510	0.577
Obs.	35	35	35	35	35	35	34	35	35	35	35	35	35	35

Source: Afonso et al. (2022b).

Table A13
Descriptive Statistics for the output-oriented efficiency scores, model 2.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Australia	0.923	0.911	0.897	1.000	1.000	1.000	1.000	1.000	0.922	0.873	0.857	0.930	0.952	1.000
Austria	0.945	0.945	0.943	0.933	0.919	0.910	0.903	0.906	0.904	0.893	0.885	0.875	0.878	0.902
Belgium	0.869	0.870	0.865	0.855	0.846	0.850	0.852	0.857	0.855	0.846	0.866	0.843	0.880	0.928
Canada	0.920	0.904	0.978	0.901	0.904	0.898	0.899	0.896	0.910	0.877	0.861	0.863	0.889	0.898
Chile	0.978	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.949	0.858	1.000
Colombia	0.673	0.640	0.707	0.720	0.724	0.785	0.795	0.895	0.892	0.663	0.658	0.678	0.667	0.659
Czech Republic	0.769	0.755	0.782	0.763	0.762	0.767	0.768	0.754	0.754	0.764	0.758	0.772	0.813	0.836
Denmark	0.963	0.952	0.938	0.927	0.919	0.925	0.892	0.886	0.900	0.899	0.893	0.890	0.923	1.000
Finland	0.976	0.967	0.966	0.952	0.943	0.951	0.958	0.966	0.955	0.940	0.954	0.954	0.974	0.986
France	0.942	0.892	0.889	0.878	0.878	0.877	0.869	0.874	0.860	0.859	0.851	0.846	0.853	0.851
Germany	0.925	0.926	0.917	0.902	0.897	0.890	0.901	0.908	0.902	0.898	0.880	0.883	0.893	0.882
Greece	0.788	0.804	0.707	0.708	0.696	0.686	0.683	0.701	0.705	0.696	0.683	0.684	0.722	0.730
Hungary	0.930	0.711	0.682	0.692	0.710	0.709	0.711	0.721	0.726	0.704	0.678	0.704	0.735	0.771
Iceland	0.960	0.934	0.917	0.931	0.926	0.911	0.906	0.898	0.890	0.895	0.888	0.879	0.931	0.925
Ireland	0.865	0.858	0.802	0.819	0.821	0.835	0.872	0.881	0.878	1.000	1.000	0.990	1.000	1.000
Israel	0.816	0.802	0.780	0.777	0.838	0.853	0.840	0.860	0.816	0.764	0.793	0.809	0.851	0.895
Italy	0.769	0.748	0.668	0.687	0.688	0.687	0.690	0.732	0.717	0.696	0.703	0.702	0.746	0.770
Japan	0.905	0.988	0.875	0.879	0.879	0.883	0.881	0.884	0.897	0.897	0.887	0.881	0.909	0.928
Latvia	0.795	0.827	0.686	0.712	0.712	0.706	0.719	0.740	0.751	0.748	0.728	0.709	0.755	0.769
Lithuania	0.752	0.799	0.710	0.735	0.722	0.722	0.739	0.746	0.745	0.748	0.748	0.736	0.761	0.800
Luxembourg	0.941	0.972	0.881	0.907	0.905	0.888	0.896	0.903	0.909	0.901	0.886	0.879	0.902	0.923
Netherlands	0.929	0.921	0.992	0.973	0.914	0.919	0.937	0.939	0.946	0.951	0.938	0.942	0.962	0.972

(continued on next page)

Table A13 (*continued*)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New Zealand	0.880	0.855	0.835	0.873	0.877	0.875	0.891	0.900	0.901	0.892	0.922	0.881	1.000	0.933
Norway	0.899	0.887	0.868	0.906	0.860	0.857	0.886	0.880	0.882	0.878	0.861	0.868	0.887	0.902
Poland	0.666	0.662	0.857	0.814	0.913	0.978	0.780	0.751	0.712	0.714	0.709	0.711	0.781	0.832
Portugal	0.799	0.791	0.783	0.792	0.793	0.794	0.810	0.820	0.830	0.821	0.803	0.816	0.837	0.860
Slovakia	0.722	0.723	0.934	0.736	0.726	0.687	0.689	0.674	0.679	0.695	0.688	0.676	0.723	0.735
Slovenia	0.763	0.764	0.873	0.806	0.781	0.762	0.766	0.761	0.753	0.750	0.746	0.740	0.794	0.821
South Korea	1.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000	0.908
Spain	1.000	0.992	0.784	0.777	0.788	0.793	0.807	0.817	0.804	0.797	0.790	0.786	0.818	0.820
Sweden	0.900	0.912	0.911	0.922	0.934	0.920	0.898	0.897	0.880	0.881	0.896	0.895	0.920	0.912
Switzerland	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Turkey	0.649	0.660	0.635	0.663	0.723	0.768	0.770	0.789	0.722	0.703	0.703	0.701	0.700	0.718
UK	0.897	0.875	0.838	0.843	0.846	0.862	0.874	0.876	0.874	0.875	0.879	0.866	0.898	0.875
US	0.922	0.894	0.887	0.880	0.867	0.860	0.866	0.880	0.932	0.896	0.898	0.920	0.947	0.939
Average	0.869	0.861	0.851	0.848	0.849	0.852	0.850	0.857	0.851	0.840	0.837	0.836	0.862	0.877
Std. Dev.	0.099	0.103	0.104	0.100	0.095	0.095	0.091	0.089	0.091	0.099	0.101	0.098	0.093	0.090
Max.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Min.	0.649	0.640	0.635	0.663	0.688	0.686	0.683	0.674	0.679	0.663	0.658	0.676	0.667	0.659
Obs.	35	35	35	35	35	35	35	35	35	35	35	35	35	35

Source: Afonso et al. (2022b).

Table A14

Average values of fiscal sustainability coefficients by country during the 2007–2020 period.

	β	σ		β	σ
Australia	−0.223	−0.089	Latvia	0.483	0.052
Austria	0.462	0.061	Lithuania	0.255	0.749
Belgium	−0.109	−0.002	Luxembourg	0.280	−0.004
Canada	0.207	0.124	Netherlands	0.564	−0.031
Chile	0.309	0.080	New Zealand	0.435	0.003
Colombia	0.999	0.109	Norway	−0.232	−0.017
Czech Republic	0.208	0.063	Poland	0.645	−0.010
Denmark	0.015	−0.110	Portugal	0.476	0.025
Finland	0.426	0.002	Slovakia	0.518	0.168
France	0.547	−0.020	Slovenia	0.112	−0.095
Germany	0.161	0.073	South Korea	0.887	−0.047
Greece	0.934	0.010	Spain	0.936	0.042
Hungary	0.310	0.191	Sweden	1.005	−0.234
Iceland	0.647	0.007	Switzerland	0.719	0.037
Ireland	0.327	−0.002	Turkey	0.762	0.117
Israel	0.586	0.067	UK	0.342	−0.030
Italy	0.539	0.167	US	−0.256	−0.042
Japan	−0.030	−0.004			

Notes: Values obtained from the estimation of equations (1) and (2) in an expanding window approach. Additionally, it is important to mention that the results of time-varying fiscal sustainability and fiscal reaction function coefficients should be explored. These time-varying results do not generate consensus in the literature, even when they are computed using other approaches as the Schlicht (2021) method or a rolling window approach.

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