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RESEARCH ARTICLE

Structural Tax Reforms and Public Spending Efficiency

António Afonso[1] · **João Tovar Jalles**[2,3,4] · **Ana Venâncio**[5]

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Abstract

We empirically assess the effects of structural tax reforms on government spending efficiency in a sample of 18 OECD economies over the period 2006–2017. After calculating input spending efficiency scores, we evaluate in a panel setup the relevance for public sector efficiency of narrative tax changes. We find that: i) input efficiency scores average around 0.6–07; ii) increases in tax rates, primarily for PIT, negatively affect public sector efficiency; iii) controlling for endogeneity, increases in tax rates are still associated with lower public sector efficiency, mainly for PIT and increases in tax bases improve public sector efficiency; vi) in expansionary periods, increasing the CIT base and reducing PIT rates, positively affect public sector efficiency; ix) in contrast, during recessions efficiency improves when PIT and VAT bases increase and the CIT rate increases.

Keywords Government spending efficiency · Tax reforms · Data envelopment analysis · Non-parametric estimation · Panel data · Political economy

JEL C14 · C23 · H11 · H21 · H50

✉ António Afonso
aafonso@iseg.ulisboa.pt

Ana Venâncio
avenancio@iseg.ulisboa.pt

1 REM/UECE, ISEG, Universidade de Lisboa, Rua Miguel Lupi 20, 1249-078 Lisbon, Portugal

2 Lisbon School of Economics and Management (ISEG), Research in Economics and Mathematics (REM) and Research Unit On Complexity and Economics (UECE), University of Lisbon, Universidade de Lisboa-ISEG, Rua Miguel Lupi 20, 1200-7811249-078 Lisbon, Portugal

3 Economics for Policy, Nova School of Business and Economics, Universidade Nova de Lisboa, Rua da Holanda 1, 2775-405 Carcavelos, Portugal

4 IPAG Business School, 184 Boulevard Saint-Germain, 75006 Paris, France

5 ADVANCE/CSG, ISEG, Universidade de Lisboa, Miguel Lupi 20, 1249-078 Lisbon, Portugal

1 Introduction

Most countries, through time, have attempted to lift growth by increasing public expenditure, counting that the ensuing income would raise enough revenues to keep the fiscal balance from deteriorating over the long-run. However, several economies have not been able to mobilize revenues through taxation to the same extent as spending went up and, therefore, resorted to internal and external borrowing to finance (growing) deficits. At the same time, according to conventional wisdom, in most countries, larger budget deficits have coincided in the past with less efficient government spending (see, for instance, Afonso et al. 2005).

An interesting avenue of research has linked government spending and public sector efficiency, an issue that has become paramount in a context of scarcer public resources, notably in the aftermath of the 2008–2009 Global Financial Crisis (GFC) and in the current economic and health crisis. The current economic and health crisis, due to the Covid-19 pandemic, has increased concerns over the lack of government capability to satisfy the increased demand for public services. The increase of Covid-19 related expenses and economic stimulus will squeeze most public budgets, endangering fiscal sustainability down the road (and consequently potentially hindering long-term growth). The adverse effect of budget cuts can be partially offset by a more efficiency provision of public services.

Several authors have made efforts to document the degree of government spending inefficiency at the cross-country level but few have tried to explain them. Against this background, a recent paper by Afonso et al. (2021) reported that expenditure efficiency is usually negatively associated with taxation. More specifically, they found that direct and indirect taxes negatively affected government efficiency performance, and the same being true for social security contributions. Nevertheless, such study does not address the issue of specific country tax reforms, notably per tax instrument, which is a contribution of the current paper to the literature. In this paper, we argue that structural tax reforms, and not necessarily aggregated changes in revenue per type of taxes as in Afonso et al. (2021), can affect the public sector performance.

The relevance of tax structures in both developed and developing countries is many fold.[1] The distinction and the choice between different types of taxes such as direct vs indirect taxes, for instance, has been an important field of applied research, regarding notably their respective economic growth (un)friendliness.[2]

[1] Taxation provides resources to the government to perform critical roles such as economic stabilization, allocation and redistribution (Musgrave 1959). This is particularly relevant in the developing world where collecting more taxes from domestic sources can help achieve the Sustainable Development Goals (SDGs). This is the reason why the Addis Ababa Agenda for financing development pays special attention to domestic resource mobilization in emerging and low-income countries and SDG 17.1 tracks country level domestic resource mobilization efforts.

[2] The main channel is that corporate and personal income taxes reduce incentives to raise supply through capital accumulation or productivity enhancements (Schwellnus and Arnold 2008; Vartia 2008; Galindo and Pombo 2011).

In this paper, we contribute to literature by taking a novel view towards the idea that also structural tax reforms, and not necessarily only changes in revenues, can affect the degree of efficiency of the public sector. Tax reforms are needed not only to attain their first objective of raising more revenues, but also secondary objectives such as minimizing their distortionary growth and income distribution effects.[3] We explore yet another previously unexplored channel which is whether such reforms help governments offer public services more or less efficiently. If one observes a decrease in tax revenues, either due to a decline of the tax base or a reduction in a tax rate, and at the end, this can have a direct contractionary effect on the spending side of the government budget. Assuming that the level of public services might still be similar, that would imply an increase in efficiency. Alternatively, an increase in tax revenues through increases in the tax base or rate can increase or not government unnecessary spending.

In this paper we use a new "narrative" database of tax changes put together by Amaglobeli et al. (2018) for a sample of advanced and emerging market economies over the last four decades. We then select all the changes in both tax rates and tax bases of the main tax categories, according to their weight on the total government revenues, namely: personal income taxes (PIT), corporate income taxes (CIT) and value-added taxes (VAT). An important novelty and strength of this database is the precise timing and nature of key legislative tax actions.

Afterwards, we follow a three-step approach. First, we compute composite indicators of government performance. Second, we calculate so-called input efficiency scores for the period 2006–2017. Third, we assess the relevance of the narrative tax changes on the level of the efficiency in a panel setup.

While this new database provides, arguably, an exogenous source for tax reforms, endogeneity can still be a potentially significant concern in our framework since revenue mobilization efforts may not necessarily be exogenous events. We try to address this methodological challenge by controlling for expected economic growth at the time of tax reforms and other possible drivers of government spending efficiency and employing endogeneity robust econometric techniques.

The main findings can be summarized as follows. The average efficiency score throughout the period is around 0.6–07 implying that government spending could be lower by around 30%-40%, on average. We also find a decrease in input efficiency scores around the GFC, and an improvement afterwards.

Regarding the narrative tax base dataset, we observe that countries that increase the tax rates of at least one of the taxes (PIT, CIT or VAT) experience a fall in the level of public sector efficiency. This negative effect seems to operate mainly for PIT. Once endogeneity is controlled for, difference-GMM estimations provide consistent results with earlier findings: i) increasing tax rate reforms worsens public sector efficiency, mainly due to PIT; ii) increasing tax base reforms improve efficiency.

[3] Common reforms include a shift from trade taxes to domestic sales taxes, the rationalization of income taxes and increase of its progressivity. Another commonly considered policy action includes the shift of the revenue mix away from corporate or personal income tax towards consumption (value-added) and property taxes, which could be growth-enhancing.

Finally, we test if the effect of the tax reforms on public sector efficiency varies across different economic environments, such as recession and expansion. The negative effect of reforms that increase the tax rate occurs mainly in expansion periods, particularly for CIT. Similarly, during expansion periods, reforms that decrease the PIT rate are positively associated with efficiency. In contrast, during recession periods we find opposite effects: CIT rate increases improve efficiency and PIT rate decreases worsens efficiency. In terms of tax base reforms, we find that CIT base increases in expansion periods improves efficiency, while in recessions periods, efficiency worsens if CIT tax base increases and it improves when PIT and VAT tax bases increase.

The remainder of the paper is organized as follows. As background, context and motivation for our empirical analysis, Sect. 2 provides an overview of related literature. Section 3 explains the empirical methodology. Section 4 discusses the empirical results. Section 5, concludes and elaborates on policy implications.

2 Literature Review

Previous studies looking specifically to the effectiveness of the public sector (and/or its sub-sectors) have addressed questions such as: are public services satisfactory considering the amount of resources allocated to its activity?; could one have better results using the same amount of resources?; could one obtain the same results with lower expenses?; can one measure cross-country/cross-sector/cross-institution efficiency levels and determine benchmark units?

Afonso and Schuknecht (2019) highlight how governments can improve their overall level of efficiency in terms of the provision of their services, which remains a very topical issue. Indeed, most previous studies reported that government spending efficiency could be enhanced in most OECD countries (see e.g., Afonso et al. 2005, 2010; Afonso and Kazemi 2017). For instance, Adam et al. (2011), looking at a sample of 19 OECD countries between 1980 and 2000, reported that countries with right-wing and strong governments, high voter participation rates and decentralized fiscal systems, were expected to have more efficient public sectors.

Afonso and Gaspar (2007) illustrated numerically that government financing through distortional taxation causes excess burden (deadweight loss) magnifying the costs of inefficiency. Boadway et al. (1994) rightly mentioned that the tax mix poses several challenges to public finance and can lead to different economic outcomes. Related literature also found that higher taxes typically generate negative consequences for growth by affecting consumption and investment decisions (Feldstein 2012).[4]

[4] https://www.wsj.com/articles/SB10000872396390444327204577617421727000592

Earlier theoretical studies on taxation show how higher taxes tend to discourage investment rates (Auerbach and Hasset 1992) as well as labor supply of individuals (Husaman 1985) and productivity growth. Empirically, a number of studies support the hypothesis that distortive taxes hold back growth more than others (Koester and Kormendi 1989; Plosser 1992; Kneller et al. 1999; Gemmell et al. 2011, 2014; Johansson 2016; Drucker et al. 2017). Corporate and personal income taxes are considered more distortionary than consumption or property taxes as shown by Arnold et al. (2011) and Acosta-Ormaechea and Yoo (2019). Similarly, McNabb and LeMay-Boucher (2014) and Drucker et al. (2017) found that reducing the share of income taxes in the revenue mix would raise GDP growth.. Helms (1985) and Mofidi and Stone (1990) found that taxes revenue spent on publicly provided productive inputs tend to enhance growth. Against this background, Afonso et al. (2019) evaluated to what extent the specificities of a tax system (proxied by revenue-to-GDP ratios) could contribute to government spending efficiency. Other authors used endogenous growth models to simulate the effects of tax reforms on economic growth and found that a decrease in the distorting effects of the current tax structure may lead to a permanent increase in economic growth (Engen and Gale 1996).

Ultimately, the link between the two sides of the government budget, that is, revenue and spending, can convey how fiscal policy is set-up in practice. These are, to great extent, policy decisions since one can typically envisage one-way causality from spending (revenue) to revenue (spending), i.e. "spend-and-tax" ("tax-and-spend" – Friedman 1978; Chang et al. 2002) causality, two-way causality (fiscal synchronization hypothesis) or no linkages between revenue and spending (von Furstenberg et al. 1986).

The tax-and-spend hypothesis advocates that tax increases will lead to expenditure increases without reducing the budget deficit. Under the spend-and-tax hypothesis, a government's revenue constraint adjusts to changes in expenditures with some lag. The fiscal synchronization hypothesis suggests that expenditure and revenue decisions are made jointly. Thereby, as advanced by Musgrave (1966), the marginal benefits and the marginal costs of government services are compared by citizens in order to determine the appropriate levels of expenditures and revenues. Payne (1998) found that in most countries the tax-and-spend hypothesis was supported suggesting that any policy to reduce budget deficits via revenues may not result in deficit reduction. On the other hand, Moore and Zanardi (2011) report that central governments in developing countries do not seem to adjust government spending priorities taking into account trade tax revenues-to-GDP ratios, which is would not validate the tax-and-spend hypothesis.

Other studies evaluate the role of individual taxes, such as VAT, as effective tools to reduce central government debt and deficits without increasing government expenditures (Ufier 2017). Understanding the effect of tax reforms on public sector efficiency has been largely ignored in the literature which is exactly the gap this paper aims to bridge. Interestingly, Barone and Mocetti (2011), using Italian municipalities data, find that taxpayers have a better mood vis-à-vis paying taxes if government revenues are spent in a more efficient fashion.

3 Methodology and Data

3.1 Public Sector Performance and Efficiency Scores

The most commonly used approach to compute the efficiency scores is Data Envelopment Analysis (DEA) due to its flexibility and lack of functional restrictions. DEA is a non-parametric technique that uses linear programming to compute the production frontier. It compares the performance of a country with a frontier composed by the best performing countries. Therefore, DEA is modelled under the assumption that countries produce similar sets of outputs, have similar resources and operate in similar environments (Dyson et al. 2001). Public sector efficiency analyses that includes a broader set of countries would violate the homogeneity assumption. A usual advantage of this type of non-parametric approach is the fact that no a priori particular specification is needed, and the selection of the best performers will be delivered via solving the underlying linear program with n inputs and with n outputs. Besides being less susceptive to specification error, DEA also accommodates multiple inputs and outputs and it allows deviations from the efficient frontier due to stochastic influences or measurement errors. Nonetheless, DEA is potentially sensitive to the selection of inputs and outputs.

In this study, we compute the efficiency scores are for all OECD countries between the period of 2006 and 2017. Nevertheless, we afterwards do not consider Mexico because the country is efficient by default, not showing up as a peer of any other countries, in other words, is the only one to use the smallest quantity of a determined input or the only one producing the greatest quantity of a certain output. Formally, for each country i, we have:

$$Y_i = f\left(X_i\right), i = 1, \ldots, 35 \tag{1}$$

where Y (Public Sector Performance, PSP) is the composite output measure, and X is the input measure, namely Public Expenditure (PE) as a percentage of GDP.

Following the related literature, we use a set of metrics to construct a composite of public sector performance (PSP), as suggested by Afonso et al. (2005, 2019). PSP is the average between opportunity and Musgravian indicators.

The opportunity indicators reflect the governments' performance in the administration, education, health and infrastructure sectors. The administration sub-indicator includes the following measures: corruption, burden of government regulation (red tape), judiciary independence, shadow economy and the property rights. To measure the education sub-indicator, we use the secondary school enrolment rate, quality of educational system and PISA scores. For the health sub-indicator, we compile data on the infant survival rate, life expectancy and survival rate from cardiovascular diseases (CVD), cancer, diabetes or chronic respiratory diseases (CRD). The infrastructure sub-indicator is measured by the quality of overall infrastructure.

The Musgravian indicators include three sub-indicators: distribution, stability and economic performance. To measure income distribution and inequality, we use the Gini coefficient. For the stability sub-indicator, we use the coefficient of variation for the 5-year average of GDP growth and standard deviation of 5 years inflation. To measure economic performance, we include the 5-year average of GDP per capita, GDP growth and unemployment rate.

Accordingly, the opportunity and Musgravian indicators result from the average of the measures included in each sub-indicator. To ensure a convenient benchmark, in each year, each sub-indicator measure is first normalized by dividing the value of a specific country by the average of that measure for all the countries in the sample.

Our input measure, Public Expenditure (PE) as a percentage of GDP, weights each area of government expenditure and it is lagged one year. More specifically, we consider government consumption as input for administrative performance, government expenditure in education as input for education performance, health expenditure as input for health performance and public investment as input for infrastructure performance. For the distribution indicator, we consider expenditures on transfers and subsidies. The stability and economic performance are related to the total expenditure. Again, each sub-indicator is first normalized. Tables 8 and 9 in Appendix A provide further information on the sources and variable construction. (Table 10).

To compute the efficiency scores, we adopt an input orientation and assume variable-returns to scale (VRS), to account for the fact that countries might not operate at the optimal scale. The input-oriented approach allows us to evaluate by how much input quantity can be proportionally reduced without changing the output quantities. Alternatively, an output-oriented approach allows us to assess how much output quantities can be proportionally increased without changing the input quantities. The two measures provide the same results under constant returns to scale but give different values under variable returns to scale. Nevertheless, it seems to be more adequate to use an input-oriented setup since the main focus of our analysis relies on decreasing inputs (via both less taxes and less spending).

Returning to Eq. (1), inefficiency occurs when $Y_i < f\left(X_i\right)$, implying that for an observed level of input, the actual output is smaller than the best attainable output. Formally, we solve the following linear programming problem:

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

where y_i is a vector of outputs, x_i is a vector of inputs, θ is the efficiency scores, λ is a vector of constants, and $I1$ is a vector of ones.

Efficiency scores,θ, range from 0 to 1, such that countries performing in the frontier score 1. More specifically, if $\theta < 1$, the country is inside the production frontier (i.e., it is inefficient), and if $\theta = 1$, the country is at the frontier (i.e., it is efficient).

3.2 Panel Analysis

In the second stage, we empirically assess to what extent structural tax reforms have an impact on the previously computed DEA input efficiency scores. This approach allows us to control for non-discretionary socio-political, economic and environmental factors and random shocks. Specifically, we estimate the following reduced-form panel data specification:

$$\theta_{it} = \alpha_t + \alpha_i + S'_{it-1}\beta + Z'_{it-1}\gamma + \varepsilon_{it} \tag{3}$$

where i refers to a given country and t the time period (in years). α_i denotes country fixed effects to control for unobserved heterogeneity such as geography-specific time invariant characteristics. α_t denotes time (year) effects to control for global macroeconomic shocks. ε_{it} is a disturbance term satisfying standard assumptions of zero mean and constant variance.

Our dependent variable, θ_{it}, is the DEA input efficient scores, computed in the previous subsection. The input orientation scores flag that higher efficiency is determined by a country's ability to minimize spending-to GDP ratios by maintaining the same level of public services provision.

Z_{it-1} is a vector of country specific time-varying sociodemographic, macroeconomic and institutional controls that may affect public sector performance. This vector is lagged one year to minimize reverse causality concerns. More specifically, vector Z_{it-1} includes: i) a proxy for the country size, defined as the logarithm of domestic residents to control for the monitoring costs of government's discretional behavior (Grossman et al. 1999); ii) a proxy of economic and technological development given by the logarithm of the number of internet users; iii) a variable related to tourism inflow which might have an impact on the demand of public services (proxied by tourism revenues as share of exports); iv) a measure of fiscal imbalances (proxied by the primary balance and the debt-to-GDP ratio); v) a political dummy identifying if the government´s political ideology is left wing and zero otherwise.

Countries determine the composition of their tax system by making policy changes to tax bases and tax rates. Our key regressors are included in vector S_{it-1}, comprising tax reform variables that capture changes (increases or decreases) in both the tax rate and the tax base of three types of taxes (PIT, CIT and VAT).

Data on structural tax reforms come from Amaglobeli et al. (2018) which is now explored carefully in this paper. This dataset covers 23 advanced and emerging market economies.[5] From this database, we select all the tax reforms that were implemented between 2005 and 2016. When the year of implementation was not available in the database, we considered the year of announcement. Note that to minimize reverse causality concerns, we evaluate the effect of one-year lag reforms on public sector efficiency. The intersection between this tax reform dataset and the sample of 35 countries

[5] The database includes the following countries: Australia, Austria, Brazil, Canada, China, Czech Republic, Denmark, France, Greece, Germany, India, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Poland, Portugal, Spain, Turkey, United Kingdom, and the United States.

for which we have computed input efficiency scores gives a working sample of 18 advanced economies.

Amaglobeli et al. (2018) dataset has several advantages for our own empirical purposes: identifies the precise nature and exact timing of tax actions in key areas of tax policy; identifies the precise tax reforms that underpin what otherwise looks like a gradual improvement in standard tax-to-GDP ratios; identifies reforms that truly led to increases or decreases in revenue, as opposed to just a long list of (small or not economically meaningful) policy changes. The strengths of this "narrative" tax reform database come with one limitation; because two tax reforms in a given area (for example, a change in PIT) can involve different specific actions (for example, rate changes or base changes), only the average impact across historical tax reforms can be estimated. It should be noted that the tax reform database provides no information regarding the current (or past) fiscal stance in the countries under scrutiny, which is not the purpose of this paper.

We focus on the changes in both the tax rates and tax bases of PIT, CIT and VAT. Indeed, in the last year covered in the sample (2016) in the 18 advanced economies, those taxes accounted on average for 54% of total revenues excluding social security and grants (ICTD/UNU-WIDER 2019). To assess whether upward or downward changes have differentiated effects on the level of the government efficiency, we also discriminate between these two policy measures.

Therefore, we define the following independent variables: a set of dummy variables for changes (increases or decreases) in the base and rate of PIT, CIT and VAT in a specific year. For example, the variable *D base increase, t-1*, is a dummy variable equal to one if a country increased the tax base of PIT, CIT or VAT in the previous year and zero otherwise.

Table 1 presents stylized facts on tax reforms for PIT, CIT and VAT in our sample of 18 advanced economies between 2005 and 2016, with two 6-year sub-periods. The vast majority of tax revenue reforms in our sample were in the category of PIT, followed by the CIT, and most reforms were implemented during the period 2005–2010. Over the entire period, we also see that there were a larger share of PIT and CIT policy changes towards base and rate decreases, while the reverse was true for VAT.

Figure 1 provides the number of tax reforms by tax category by country to illustrate the heterogeneity of reform efforts. PIT reforms have been more frequently implemented (close to 50 percent on average across all 18 countries in the sample). In general, fewer major reforms have been implemented in VAT. Some countries were more active in tax reforms that others: on the active side we have countries such as Portugal, Spain and Italy; on the less active side we have countries such as Luxembourg, Czech Republic or the UK.

4 Empirical Results

4.1 Government Efficiency: Stylized Facts

We performed the DEA computations for three models: a baseline model (Model 0), with only one input (PE as percentage of GDP) and one output (PSP); Model 1

Table 1 Number of tax reforms by instrument and sub-period

Tax instrument \ Year	2005–2010	2011–2016	2005–2016
PIT	**82**	**51**	**133**
Rate changes	20	15	35
Increases	*6*	*11*	*17*
Decreases	*14*	*4*	*18*
Base changes	62	36	98
Increases	*21*	*20*	*41*
Decreases	*41*	*16*	*57*
CIT	**49**	**38**	**87**
Rate changes	17	10	27
Increases	*7*	*3*	*10*
Decreases	*10*	*7*	*17*
Base changes	32	28	60
Increases	*13*	*9*	*22*
Decreases	*19*	*19*	*38*
VAT	**19**	**15**	**34**
Rate changes	14	12	26
Increases	*6*	*9*	*15*
Decreases	*8*	*3*	*11*
Base changes	5	3	8
Increases	*2*	*3*	*5*
Decreases	*3*	*0*	*3*

Source: Authors´ computations

with one input, governments' normalized total spending (PE) and two outputs, the opportunity PSP and the so-called "Musgravian" PSP scores; and Model 2 with two inputs, governments' normalized spending on opportunity and on "Musgravian" indicators and one output, total PSP scores. The results obtained from these three models are illustrated respectively on Tables 11, 12 and 13 of Appendix B.

Table 2 provides a summary of the DEA results for the three models using an input-oriented assessment. The average efficiency score throughout the period is around 0.6 for the 1 input and 1 output model (Model 0) and around 0.7 in the alternative models (Models 1 and 2). This implies that some possible efficiency gains could be achieved with around less 30% government spending, on average without changing the PSP.

Figure 2 illustrates the production possibility frontier for the baseline model (Model 0), for 2006 (first year of our sample) and for 2017 (last year of our sample), pinpointing notably the countries that define the frontier: Chile, Korea, and Switzerland. For all the other countries inside the frontier, theoretically there would be room for improvement.

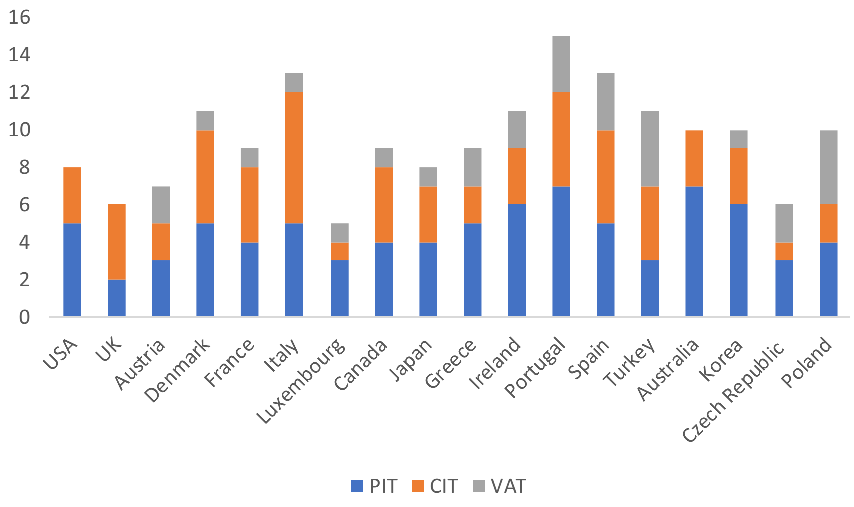
Since we are interested in evaluating to what extent the changes in the tax structures impinge on the input efficiency scores throughout time, we report in Fig. 3 the development of the input efficiency scores for some countries (for model 2, as an example). Interestingly, we observe some drop in input efficiency scores around

Table 2 Summary of DEA results (input efficiency scores)

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Model 0	Efficient	2	3	3	3	3	3	2	3	3	3	2	2
	Name	CHE; KOR	CHE; CHL; KOR	CHE; CHL; KOR	AUS; CHL; KOR	AUS; CHL; KOR	AUS; CHL; KOR	AUS; KOR	AUS; CHL; KOR	CHE; CHL; KOR	CHL; IRL; KOR	CHL; KOR	CHL; KOR
	Average	0.64	0.62	0.60	0.61	0.59	0.58	0.58	0.59	0.65	0.64	0.65	0.66
	Median	0.60	0.58	0.55	0.58	0.55	0.54	0.54	0.55	0.62	0.61	0.64	0.65
	Min	0.46	0.43	0.41	0.45	0.42	0.41	0.40	0.41	0.43	0.43	0.46	0.46
	Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Stdev	0.16	0.16	0.16	0.14	0.15	0.15	0.15	0.15	0.17	0.15	0.13	0.14
Model 1	Efficient	3	3	3	3	3	3	4	3	4	3	2	2
	Name	CHE; CHL; KOR	CHE; CHL; KOR	CHE; CHL; KOR	AUS; CHL; KOR	AUS; CHL; KOR	AUS; CHL; KOR	AUS; CHL; KOR; TUR	AUS; CHL; KOR	CHE; CHL; KOR; USA	CHL; IRL; KOR	CHL; KOR	CHL; KOR
	Average	0.70	0.67	0.65	0.68	0.66	0.66	0.66	0.68	0.73	0.72	0.73	0.73
	Median	0.66	0.63	0.60	0.65	0.61	0.63	0.63	0.66	0.70	0.70	0.71	0.73
	Min	0.52	0.47	0.47	0.54	0.51	0.50	0.49	0.48	0.50	0.52	0.53	0.50
	Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Stdev	0.15	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.15	0.13	0.12	0.13
Model 2	Efficient	3	4	5	4	4	4	4	4	3	4	4	4
	Name	CHE; ESP; KOR	CHE; CHL; ESP; KOR	CHE; CHL; KOR; NLD; SVK	AUS; CHE; CHL; KOR	AUS; CHE; CHL; KOR	AUS; CHE; CHL; KOR	AUS; CHE; CHL; KOR	AUS; CHE; CHL; KOR	CHE; CHL; KOR	CHE; CHL; IRL; KOR	CHE; CHL; IRL; KOR	CHE; CHL; IRL; KOR
	Average	0.71	0.68	0.68	0.67	0.65	0.65	0.66	0.68	0.70	0.71	0.71	0.73
	Median	0.67	0.65	0.63	0.64	0.60	0.61	0.63	0.63	0.67	0.70	0.69	0.72
	Min	0.49	0.43	0.47	0.50	0.49	0.48	0.50	0.50	0.48	0.53	0.52	0.52

Table 2 (continued)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Stdev	0.16	0.16	0.16	0.14	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.13



Source: Authors´ computations.

Fig. 1 Number of tax reforms by country (18 advanced economies, 2005–2016)

the GFC, while afterwards some improvement takes place. Here one can think of a possible correlation between the need to implement fiscal consolidations measures in the aftermath of the crisis, notably a decrease in government spending, and the ensuing increase in the measured efficiency scores (plausible if rather the same level of services offered by the government is kept).

4.2 Effects of Structural Tax Reforms on Government Efficiency

4.2.1 Baseline

In this sub-section we present the baseline results from estimating Eq. (3) using Simar and Wilson´s (2007) approach. This method is described by the authors as a superior approach to alternatives such as OLS since this type of naïve estimators ignores that estimated DEA efficiency scores are calculated from a common sample of data and treating them as if they were independent observations is not appropriate as problems related to serial correlation arise. The Simar and Wilson (2007) procedure takes this (and other pitfalls) into account by constructing an underlying data generating process consistent with a two-stage estimation process implying a truncated regression model.[6] This is a reduced-form exercise aimed at quantifying

[6] In Table 14 in Appendix C, we present the results for Ordinary Least Squares (OLS) with robust standard errors clustered at the country level (with country fixed effects, which is equivalent to a FE model) and Beck and Katz´s (1995) panel-corrected standard error (PCSE) estimator. This latter estimator is robust to the possibility of non-spherical errors and allow for better inference from linear models estimated in a panel environment. Concerned about autocorrelation of the disturbances, a common AR(1) process is assumed. We find consistent results.

the effects of tax reforms of different types on the degree of public sector efficiency. Although they do not yet directly address endogeneity, these estimates provide a benchmark.

Table 3 presents the results using DEA efficiency scores based on Model 2 as dependent variable.[7] In Specification (1) of this table, all three types of tax reforms (PIT, CIT and VAT) are combined into several dummy measures evaluating if a country increased or decreased the tax base or it increased or decreased the tax rate. Specifications (2), (3) and (4) present the estimated results separately for each type of tax reform, PIT, CIT and VAT respectively. Specification (5) presents the results considering all types of the reforms.

We observe that countries that increased the tax rate experienced a fall in the level of public sector efficiency. One can consider that higher tax rates (and tax revenues) might feed in into the tax-and-spend causality. Hence, governments might also increase the spending side of their budgets, without necessarily relevant increases in public sector provision.[8] The negative effect of tax rate increases on public sector efficiency seems to operate for all three taxes, however, it is only significant for PIT (in Specifications 2 and 5). We also find a positive and significant effect of reforms that decrease the tax base on efficiency. When we disaggregate reforms by type of taxes, we find that public sector efficiency is positively affected by a decrease on the VAT base (in Specifications 2 and 5).

As far as other explanatory variables are concerned, we find that an increase on country's primary balance, possibly through a reduction on public expenditures.

Next, we conduct several sensitivity and robustness analyses.

4.2.2 Sensitivity and Robustness

We performed sensitivity analysis to inspect if a given country is driving the results. That is, we dropped one country at a time and inspect the stability of the tax reforms effects on public sector efficiency. We see that the magnitudes of the tax reforms dummies do not change much, and the negative statistical significance coefficient of tax rate increases also hold for each country. Results are available upon request.

Additionally, tax reforms could be implemented because of concerns regarding the future evolution of economic activity. To address this issue, we control for the expected values in *t-1* of future real GDP growth. These are taken from the fall issue of the *IMF World Economic Outlook* for year *t-1*. We observe that resulting estimates are in line with those presented in Table 3.

[7] Recall that Model 2 uses two inputs, governments' normalized spending on opportunity and on "Musgravian" indicators and one output, total PSP scores. We also estimated our baseline results using alternative DEA-based models, namely Model 0 (one input and one output) and Model 1 (one input and two outputs) as discussed earlier. We continue to find a negative effect of tax rate increases on efficiency in both estimators supporting the tax-and-spend causality. Additionally, we find a positive a significant effect of tax base decreases on efficiency.

[8] The spend-and-tax relationship was addressed by Chang et al. (2002) and Kollias and Paleologou (2006).

Table 3 Baseline Estimation: Simar-Wilson, Model 2

Specification	(1)	(2)	(3)	(4)	(5)
Estimator	Simar Wilson				
Population (log), t-1	0.267	0.288	0.164	0.092	0.181
	(0.201)	(0.206)	(0.205)	(0.185)	(0.196)
Debt (% GDP), t-1	0.109***	0.115***	0.093**	0.084**	0.106***
	(0.036)	(0.037)	(0.038)	(0.034)	(0.036)
Primary balance, t-1	0.577***	0.561***	0.576***	0.542***	0.582***
	(0.145)	(0.143)	(0.143)	(0.129)	(0.132)
Internet users (log), t-1	0.057	0.059	0.043	0.020	0.020
	(0.060)	(0.060)	(0.060)	(0.055)	(0.057)
Tourism revenues (% exports), t-1	-0.474	-0.400	-0.276	-0.207	-0.350
	(0.439)	(0.443)	(0.469)	(0.424)	(0.412)
Left political orientation, t-1	-0.004	-0.003	-0.005	-0.007	-0.005
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)
D base increasing, t-1	-0.003				
	(0.008)				
D base decreasing, t-1	0.015*				
	(0.008)				
D rate increasing, t-1	-0.027***				
	(0.009)				
D rate decreasing, t-1	0.010				
	(0.009)				
D base increasing PIT, t-1		-0.014			-0.013
		(0.009)			(0.009)
D base decreasing PIT, t-1		0.003			0.008
		(0.009)			(0.009)
D rate increasing PIT, t-1		-0.024**			-0.025**
		(0.012)			(0.011)
D rate decreasing PIT, t-1		0.027**			0.005
		(0.012)			(0.012)
D base increasing CIT, t-1			0.002		0.003
			(0.011)		(0.010)
D base decreasing CIT, t-1			0.002		0.003
			(0.010)		(0.009)
D rate increasing CIT, t-1			-0.007		0.005
			(0.014)		(0.013)
D rate decreasing CIT, t-1			0.002		-0.006
			(0.015)		(0.014)
D base increasing VAT, t-1				-0.001	-0.000
				(0.019)	(0.018)
D base decreasing VAT, t-1				0.187***	0.179***
				(0.040)	(0.041)
D rate increasing VAT, t-1				-0.013	-0.015

Table 3 (continued)

Specification	(1)	(2)	(3)	(4)	(5)
				(0.012)	(0.013)
D rate decreasing VAT, t-1				0.012	0.018
				(0.015)	(0.016)
Observations	144	144	144	144	144

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

Another important concern is that tax reforms might have different degrees of magnitude. For that purpose, we distinguish between major and minor tax reforms. Our data considers a major reform when the rate changes by at least 1 percentage point or when, in absence of quantitative information, in the text describing the reform it is mentioned that the change was major. For each year and country, we compute the percentage of major reforms implemented by each type of tax reform (tax rate or tax base increasing or decreasing). Then, we transform this variable into dummy variable equaling one if more than 2/3 of reforms were major and zero otherwise. In addition, we included a new variable to evaluate if a country implemented a major reform in a given year (independently of the type of reform). The results are presented in Table 4. We find that major tax base increases in PIT and decreases in VAT negatively and positively affect public sector efficiency, respectively (Specification 4).

The models that we have been estimating are all reduced-form and therefore do not allow making causal statements or even quantifying the clean effect of tax reforms on public sector efficiency. Adding covariates partly corrects for these biases, but endogeneity can still arise from other omitted variables (unobserved heterogeneity and selection effects), measurement errors in variables, and reverse causality (simultaneity). Because causality can run in both directions, some of the right-hand-side regressors may be correlated with the error term. Preliminary investigation revealed that the dependent variable was serially correlated such that we are required to use a dynamic panel approach to get consistent estimates of Eq. (3).

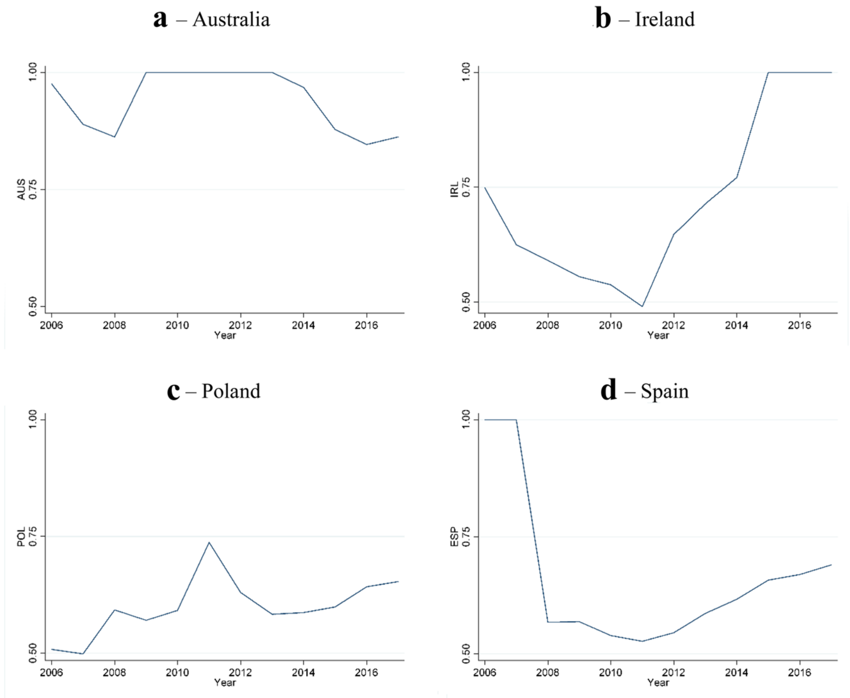
Therefore, we employ a dynamic panel estimator, the Generalized Moments Method (GMM) estimator by Arellano and Bond (1991). Dynamic estimators have the following advantages: i) greater control of endogeneity; ii) greater control of possible collinearity between explanatory variables; and iii) greater effectiveness in controlling effects caused by the absence of relevant explanatory variables for the results. GMM estimators are unbiased and compared with OLS or fixed-effects (within-group) estimators, exhibit the smallest bias and variance (Arellano and Bond 1991). The GMM estimator can only be considered valid if:

In the vertical axis we have the total Public Sector Performance (PSP) composite indicator (refer to section 3.1 for details).
Source: Authors´ computations.

Fig. 2 Production Possibility Frontier (Input Efficiency Scores, model 0)

i) the restrictions, a consequence of use of the instruments, are valid; and ii) there is no second-order autocorrelation.[9]

[9] To test the validity of the restrictions, we use the Hansen test. The null hypothesis indicates that the restrictions imposed by using the instruments are valid. By non rejecting the null hypothesis, we conclude that the restrictions are valid, and the results robust.We test for the existence of first and second-order autocorrelation. The null hypothesis is that there is no autocorrelation. Non rejecting the null hypothesis of non-existence of second-order autocorrelation, we conclude that the results are robust. For the results of the GMM estimator to be considered robust, the restrictions imposed by use of the instruments have to be valid and there can be no second-order autocorrelation.



Note: in the vertical axis we report the DEA input efficiency scores using VRS (refer to refer to section 3.1 for details).
Source: Authors´ computations.

Fig. 3 Input efficiency scores (model 2)

Table 5 shows the results for the first difference GMM estimator using the full model.[10] Consistent with the previous results, we continue to find that countries that implemented reforms that increase the tax rate are associated with a decrease on public sector efficiency. This decrease in efficiency is mainly due to reforms on PIT (in Specifications 2 and 5) and on VAT (in Specification 5). In contrast to previous results, efficiency is positively affected by reforms that increase the tax base, mainly due to reforms in PT (in Specification 5). As for the control variables, we find that lag efficiency and primary balance positively and statistically affect public sector efficiency.

We investigated the stability of GMM results and checked whether the coefficients of interest varied in size, sign and significance with two sets of sensitivity checks. Specifically, we i) dropped non-significant covariates one at a time; and ii) assessed if estimates were sensitive to the choice of lags or the choice of instruments. On the first test, we believe it is preferable to keep insignificant variables in to avoid any possible omitted variable bias, but if the covariates in

[10] We also estimated Eq. (3) with a system GMM estimator and the tenor of the results was very similar to the difference GMM. These are available in Table 15 of Appendix C.

Table 4 Baseline Estimation: Simar-Wilson, Model 2 and Major Reform

Specification	(1)	(2)	(3)	(4)
Estimator	Simar Wilson			
D base increasing PIT, t-1	0.018			0.024
	(0.019)			(0.020)
D base decreasing PIT, t-1	0.031*			0.037**
	(0.017)			(0.017)
D rate increasing PIT, t-1	-0.050*			-0.059**
	(0.028)			(0.027)
D rate decreasing PIT, t-1	0.014			0.042
	(0.035)			(0.034)
D base increasing CIT, t-1		0.027		0.027
		(0.040)		(0.034)
D base decreasing CIT, t-1		-0.017		-0.015
		(0.019)		(0.018)
D rate increasing CIT, t-1		-0.038		-0.006
		(0.042)		(0.045)
D base increasing VAT, t-1			-0.006	0.006
			(0.037)	(0.034)
D rate increasing VAT, t-1			-0.032	-0.035
			(0.021)	(0.026)
Major PIT, t-1	0.024*			-0.011
	(0.014)			(0.015)
Major CIT, t-1		0.009		0.036**
		(0.017)		(0.016)
Major VAT, t-1			0.028	-0.004
			(0.044)	(0.041)
D base increasing PIT, t-1* Major PIT, t-1	-0.052**			-0.031
	(0.021)			(0.021)
D base decreasing PIT, t-1* Major PIT, t-1	-0.043**			-0.044**
	(0.020)			(0.022)
D rate increasing PIT, t-1* Major PIT, t-1	0.012			-0.033
	(0.037)			(0.037)
D rate decreasing PIT, t-1* Major PIT, t-1	0.023			0.046
	(0.031)			(0.029)
D base increasing CIT, t-1* Major CIT, t-1		0.021		-0.003
		(0.024)		(0.022)
D base decreasing CIT, t-1* Major CIT, t-1		-0.033		-0.041
		(0.043)		(0.035)
D rate increasing CIT, t-1* Major CIT, t-1		-0.005		-0.021
		(0.017)		(0.016)
D rate decreasing CIT, t-1* Major CIT, t-1		0.029		0.020
		(0.044)		(0.047)
D base increasing VAT, t-1* Major VAT, t-1			0.165**	0.188***

Table 4 (continued)

Specification	(1)	(2)	(3)	(4)
			(0.065)	(0.064)
D base decreasing VAT, t-1* Major VAT, t-1			-0.021	0.010
			(0.058)	(0.056)
D rate increasing VAT, t-1* Major VAT, t-1			-0.014	0.028
			(0.040)	(0.039)
D rate decreasing VAT, t-1*Major VAT, t-1			0.005	0.026
			(0.046)	(0.044)
Observations	144	144	144	144

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

question do not add information, then their exclusion should not affect the coefficients of the remaining variables. This is exactly what we found when we re-estimated Eq. (3) by difference-GMM dropping sequentially each of the insignificant covariates. On the second test, lag choice, it is well-known that GMM instrument-generating process can create "too many instruments," in the sense that some may be "weak" leading to inefficient estimates (Roodman 2009). We re-ran the GMM models with shorter lags (one year, instead of two) and with a shorter set of instruments (in particular, we excluded country-specific time dummies from the instrument set). Here too, the point estimates of the coefficients were not statistically different from the results in Table 5.

A weakness of GMM estimators is that their properties hold when N is large, so they can be severely biased and imprecise in panel data with a small number of cross-sectional units. This is often the case in most macro panels, such as the one employed in this paper. Mindful of this we use the Least Squares Dummy Variable Corrected (LSDC-C) procedure which is based upon the bias approximations derived in Bruno (2005), who extends the result by Kiviet (1999) and Bun and Kiviet (2003) to unbalanced panels. Earlier Monte Carlo studies (Arellano and Bond 1991; Kiviet 1995; Judson and Owen 1999) demonstrate that LSDV, although inconsistent, has a relatively small variance compared to GMM estimators. Hence, LSDV-C emerges as a good alternative estimator for dynamic panel data models with small N and strictly exogenous regressors. That said, one should not forget an important limitation of the procedure: as opposed to GMM estimators, no version of LSDV-C is applicable in the presence of endogenous, or even only weakly exogenous, regressors.

Table 6 shows the results using the full model. We continue to find that reforms associated with tax rate increases negatively affect government efficiency, but the effect is only statistically significant for PIT and VAT (in Specifications 2 and 5). Consistent with Simar-Wilson results, we also find that a decrease on the VAT base positively affects efficiency (in Specifications 2 and 5).

Table 5 Robustness Estimation: Endogeneity Difference GMM, Model 2

Specification	(1)	(2)	(3)	(4)	(5)
Estimator	Difference GMM				
Lagged dependent variable	0.464***	0.489***	0.485***	0.508***	0.504***
	(0.066)	(0.083)	(0.083)	(0.092)	(0.087)
Population (log), t-1	-0.042	-0.040	-0.380	0.163	0.164
	(0.427)	(0.377)	(0.430)	(0.309)	(0.377)
Debt (% GDP), t-1	0.159**	0.145*	0.138*	-0.042	0.157**
	(0.057)	(0.070)	(0.072)	(0.080)	(0.066)
Primary balance, t-1	0.920***	0.842***	0.843***	1.017***	0.861***
	(0.165)	(0.164)	(0.180)	(0.339)	(0.139)
Internet users (log), t-1	0.144	0.108	0.195*	0.131	0.063
	(0.106)	(0.095)	(0.097)	(0.102)	(0.092)
Tourism revenues (% exports), t-1	-0.942	-0.925	-0.399	0.040	-0.780
	(0.561)	(0.633)	(0.480)	(0.701)	(0.465)
Left political orientation, t-1	0.024	0.031*	0.030	0.029	0.028
	(0.017)	(0.018)	(0.018)	(0.024)	(0.019)
D base increasing, t-1	0.025*				
	(0.014)				
D base decreasing, t-1	0.011				
	(0.010)				
D rate increasing, t-1	-0.038***				
	(0.013)				
D rate decreasing, t-1	0.023				
	(0.014)				
D base increasing PIT, t-1		0.022			0.026*
		(0.014)			(0.013)
D base decreasing PIT, t-1		-0.005			-0.003
		(0.015)			(0.010)
D rate increasing PIT, t-1		-0.044***			-0.039***
		(0.012)			(0.011)
D rate decreasing PIT, t-1		0.024			0.020
		(0.042)			(0.017)
D base increasing CIT, t-1			0.015		0.003
			(0.016)		(0.012)
D base decreasing CIT, t-1			-0.005		-0.007
			(0.012)		(0.013)
D rate increasing CIT, t-1			-0.022		-0.020
			(0.014)		(0.015)
D rate decreasing CIT, t-1			-0.011		-0.002
			(0.015)		(0.011)
D base increasing VAT, t-1				0.021	0.012
				(0.015)	(0.036)
D base decreasing VAT, t-1				0.164	0.094

Table 5 (continued)

Specification	(1)	(2)	(3)	(4)	(5)
				(0.103)	(0.058)
D rate increasing VAT, t-1				0.011	-0.025*
				(0.020)	(0.013)
D rate decreasing VAT, t-1				-0.000	-0.005
				(0.056)	(0.017)
Observations	144	144	144	144	144
Hansen (p-value)	0.323	0.122	0.336	0.961	0.111
AR2 (p-value)	0.490	0.143	0.156	0.257	0.159
AR1 (p-value)	0.019	0.017	0.014	0.024	0.0173

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Hansen test evaluates the validity of the instrument set, i.e., tests for over-identifying restrictions. AR(1) and AR(2) are the Arellano–Bond autocorrelation tests of first and second order (the null is no autocorrelation), respectively. Country and time fixed effects omitted for reasons of parsimony. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

Finally, we explore the role of business cycle conditions in affecting the effect of tax reforms on public sector efficiency. Equation 3 is transformed to allow tax reforms´ effects to vary with the state of the economy, as follows:

$$\theta_{i,t} - \theta_{i,t-1} = \alpha_t + \alpha_i + \rho^L \times F(z_{i,t})S_{i,t-1} + \rho^H \times (1 - F(z_{i,t}))S_{i,t-1} + Z_{it-1}{}'\gamma + \varepsilon_{it} \quad (4)$$

with $F\left(z_{it}\right) = \frac{\exp(-\gamma z_{it})}{1+\exp(-\gamma z_{it})}, \gamma > 0$, in which z_{it} is an indicator of the state of the economy (the real GDP growth) normalized to have zero mean and unit variance. The weights assigned to each regime vary between 0 and 1 according to the weighting function $F(.)$, so that $F\left(z_{it}\right)$ can be interpreted as the probability of being in a given state of the economy. The coefficients ρ^L and ρ^H capture the public sector efficiency impact of tax reforms in cases of extreme recessions ($F\left(z_{it}\right) \approx 1$ when z goes to minus infinity) and booms ($1 - F\left(z_{it}\right) \approx 1$ when z goes to plus infinity), respectively.[11] This approach is inspired by the smooth transition autoregressive (STAR) model developed by Granger and Teräsvirta (1993).

Table 7 shows the results of estimating the state contingent Eq. (4) using difference-GMM estimators. During an expansion period, reforms that increase the tax base positively affect public sector efficiency. Considering the type of taxes, this positive effect is mostly driven by CIT (in Specification 3). Efficiency also increases when a country decreases the VAT tax base (in Specification 3 and 5). Public sector performance also improves when the PIT rate decreases (in Specification 2). In

[11] We choose $\gamma = 1.5$, following Auerbach and Gorodnichenko (2012, 2013), so that the economy spends about 20 percent of the time in a recessionary regime—defined as $F\left(z_{it}\right) > 0.8$. Our results hardly change when using alternative values of the parameter γ, between 1 and 6. Note that $F\left(z_{it}\right)$=0.5 is the cutoff between weak and strong economic activity.

Table 6 Robustness Estimation: Dynamic Estimator LSDV-C, Model 2

Specification	(1)	(2)	(3)	(4)	(5)
Estimator	LSDV-C				
Lagged dependent variable	0.522***	0.515***	0.543***	0.506***	0.506***
	(0.055)	(0.055)	(0.055)	(0.054)	(0.076)
Population (log), t-1	0.279	0.281	0.230	0.276	0.305
	(0.264)	(0.259)	(0.272)	(0.252)	(0.252)
Debt (% GDP), t-1	0.214***	0.216***	0.211***	0.213***	0.218***
	(0.050)	(0.046)	(0.048)	(0.048)	(0.045)
Primary balance, t-1	0.729***	0.724***	0.682***	0.761***	0.744***
	(0.158)	(0.153)	(0.160)	(0.158)	(0.184)
Internet users (log), t-1	0.010	0.005	-0.017	-0.008	0.009
	(0.072)	(0.066)	(0.067)	(0.071)	(0.081)
Tourism revenues (% exports), t-1	-0.824	-0.862*	-0.744	-0.704	-1.033
	(0.528)	(0.506)	(0.557)	(0.559)	(0.666)
Left political orientation, t-1	0.004	0.007	0.005	0.007	0.011
	(0.013)	(0.013)	(0.013)	(0.012)	(0.013)
D base increasing, t-1	0.010				
	(0.012)				
D base decreasing, t-1	0.012				
	(0.012)				
D rate increasing, t-1	-0.035***				
	(0.011)				
D rate decreasing, t-1	0.009				
	(0.015)				
D base increasing PIT, t-1		0.012			0.020
		(0.013)			(0.013)
D base decreasing PIT, t-1		0.002			0.012
		(0.011)			(0.015)
D rate increasing PIT, t-1		-0.047***			-0.046***
		(0.015)			(0.017)
D rate decreasing PIT, t-1		0.008			-0.009
		(0.015)			(0.020)
D base increasing CIT, t-1			-0.011		-0.020
			(0.020)		(0.015)
D base decreasing CIT, t-1			-0.008		-0.018
			(0.013)		(0.014)
D rate increasing CIT, t-1			-0.014		0.002
			(0.022)		(0.022)
D rate decreasing CIT, t-1			0.005		-0.001
			(0.019)		(0.022)
D base increasing VAT, t-1				0.006	0.007
				(0.034)	(0.030)
D base decreasing VAT, t-1				0.107***	0.115***

Table 6 (continued)

Specification	(1)	(2)	(3)	(4)	(5)
				(0.036)	(0.038)
D rate increasing VAT, t-1				-0.022*	-0.024*
				(0.014)	(0.014)
D rate decreasing VAT, t-1				-0.002	-0.008
				(0.026)	(0.017)
Observations	162	162	162	162	162

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

contrast, reforms that increase the tax rate negatively affect efficiency, particularly on CIT (in Specification 3).

Turning to recession periods, efficiency improves when a country increases the PIT (in Specification 2) and VAT tax bases (in Specification 4) and increases the

Table 7 Robustness Estimation: State-contingent, Model 2

Specification	(1)	(2)	(3)	(4)	(5)
Estimator	Difference GMM				
Lagged dependent variable	0.519***	0.470***	0.421***	0.469***	0.523***
	(0.078)	(0.084)	(0.094)	(0.142)	(0.102)
Population (log), t-1	-0.068	-0.113	-0.072	0.215	-0.014
	(0.345)	(0.396)	(0.408)	(0.244)	(0.377)
Debt (% GDP), t-1	0.158***	0.130	0.190***	0.178***	0.125*
	(0.051)	(0.086)	(0.050)	(0.050)	(0.062)
Primary balance, t-1	0.971***	1.115***	1.119***	1.175***	1.069***
	(0.144)	(0.111)	(0.195)	(0.200)	(0.134)
Internet users (log), t-1	0.040	0.073	0.020	0.120	0.017
	(0.092)	(0.086)	(0.090)	(0.094)	(0.104)
Tourism revenues (% exports), t-1	-0.007	-0.761	-0.268	0.429	-0.332
	(0.469)	(0.502)	(0.565)	(0.482)	(0.419)
Left political orientation, t-1	0.022	0.039*	0.036*	0.028*	0.040*
	(0.015)	(0.020)	(0.021)	(0.014)	(0.023)
D base increasing, t-1*recession	-0.022				
	(0.023)				
D base increasing, t-1*expansion	0.063**				
	(0.024)				
D base decreasing, t-1*recession	0.001				
	(0.024)				
D base decreasing, t-1*expansion	0.021				
	(0.024)				

Table 7 (continued)

Specification	(1)	(2)	(3)	(4)	(5)
D rate increasing, t-1*recession	-0.001				
	(0.025)				
D rate increasing, t-1*expansion	-0.072*				
	(0.035)				
D rate decreasing, t-1*recession	-0.015				
	(0.023)				
D rate decreasing, t-1*expansion	0.039				
	(0.038)				
D base increasing PIT, t-1 *recession		0.038*			0.044
		(0.019)			(0.027)
D base increasing PIT, t-1 *expansion		0.004			0.027
		(0.035)			(0.037)
D base decreasing PIT, t-1 *recession		0.010			-0.018
		(0.022)			(0.024)
D base decreasing PIT, t-1*expansion		-0.024			0.018
		(0.042)			(0.037)
D rate increasing PIT, t-1 *recession		-0.052			-0.042
		(0.033)			(0.032)
D rate increasing PIT, t-1*expansion		-0.039			-0.041
		(0.036)			(0.038)
D rate decreasing PIT, t-1*recession		-0.145*			-0.048
		(0.077)			(0.051)
D rate decreasing PIT, t-1*expansion		0.219**			0.061
		(0.103)			(0.048)
D base increasing CIT, t-1 *recession			-0.087**		-0.053
			(0.035)		(0.052)
D base increasing CIT, t-1 *expansion			0.126***		0.061
			(0.043)		(0.042)
D base decreasing CIT, t-1*recession			-0.031		-0.030*
			(0.025)		(0.015)
D base decreasing CIT, t-1*expansion			0.017		0.031
			(0.031)		(0.022)
D rate increasing CIT, t-1*recession			0.054**		0.034
			(0.019)		(0.025)
D rate increasing CIT, t-1*expansion			-0.058**		-0.040
			(0.027)		(0.032)
D rate decreasing CIT, t-1t*recession			-0.009		0.042
			(0.023)		(0.035)
D rate decreasing CIT, t-1*expansion			0.023		-0.060*
			(0.030)		(0.033)
D base increasing VAT, t-1 *recession				0.051**	-0.121

Table 7 (continued)

Specification	(1)	(2)	(3)	(4)	(5)
				(0.020)	(0.084)
D base increasing VAT, t-1 *expansion				-0.010	0.064
				(0.026)	(0.039)
D base decreasing VAT, t-1*recession				0.000	-2.032***
				(0.000)	(0.405)
D base decreasing VAT, t-1*expansion				0.317***	0.827***
				(0.015)	(0.136)
D rate increasing VAT, t-1*recession				0.039*	0.012
				(0.022)	(0.025)
D rate increasing VAT, t-1*expansion				-0.044	-0.064
				(0.037)	(0.048)
D rate decreasing VAT, t-1*recession				-0.009	0.003
				(0.015)	(0.022)
D rate decreasing VAT, t-1*expansion				0.099	0.018
				(0.074)	(0.050)
Observations	144	144	144	144	144
Hansen (p-value)	0.626	0.865	0.398	0.992	0.991
AR2 (p-value)	0.401	0.680	0.144	0.382	0.730
AR1 (p-value)	0.012	0.018	0.14	0.05	0.02

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Hansen test evaluates the validity of the instrument set, i.e., tests for over-identifying restrictions. AR(1) and AR(2) are the Arellano–Bond autocorrelation tests of first and second order (the null is no autocorrelation), respectively. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

CIT and VAT tax rate (in Specification 3 and 4, respectively). Nevertheless, efficiency diminishes when a country increases the CIT tax base (in Specification 3) and decreases the PIT tax rate.

We also considered recessions obtained by applying the Harding and Pagan (2002) algorithm to identify economic turning points and use alternative estimator procedures (PCSE and System-GMM). Results remain qualitatively similar.[12]

5 Conclusion

We evaluate the effects of structural tax reforms on government spending efficiency in a sample of 18 OECD economies over the period 2006–2017. We begin by computing, via data envelopment analysis, government spending efficiency measures for each country and year in our sample. Then, we empirically assess in a reduced-form regression the relevance of arguably exogenous structural tax reforms on these efficiency measures.

[12] The results are available on Table 16 and Table 17 of Appendix C.

The main findings of our study can be summarized as follows. The average efficiency score throughout the period is around 0.6–07 implying government spending could theoretically be lower by around 30–40%, whilst maintaining the same level of PSP. The countries delineating the production possibility frontier are Chile, Korea, and Switzerland. In addition, we find a decline in input efficiency scores around the GFC, and an improvement afterwards.

We observe that countries that increased the tax rates of at least one of the taxes (PIT, CIT or VAT) experience a fall in the level of public sector efficiency. Indeed, governments might increase also the spending side of their budgets, without necessarily relevant increases in public sector provision. The negative effect of an increase of tax rates on public sector efficiency seems to operate mainly on PIT.

Accounting for endogeneity, the results of the difference-GMM estimations are consistent with the previous results: i) reforms that increase the tax rate are associated with a decrease on public sector efficiency, mainly due through PIT; ii) reforms that increase the tax base for positively affect public sector efficiency.

Finally, we test if the effect of the tax reforms on public sector efficiency varies across different economic environments, such as recession and expansion. The negative effect of reforms that increase the tax rate occurs mainly in expansion periods, particularly for CIT. Similarly, during expansion periods, reforms that decrease the PIT rate are positively associated with efficiency. In contrast, during recession periods we find opposite effects: CIT rate increases improve efficiency and PIT rate decreases worsens efficiency. In terms of tax base reforms, we find that CIT base increases in expansion periods improves efficiency, while in recessions periods, efficiency worsens if CIT base increases and it improves when PIT and VAT bases increase.

Our results leave some questions open for future research. Perhaps most importantly, cross-country public sector efficiency differences go way beyond the tax reform areas covered in this paper and include, among others, reforms in areas such as pension, unemployment insurance schemes and healthcare systems. A more systematic investigation of their aggregate effects on public sector efficiency would, therefore, be welcomed. In addition, the effect of tax reforms on efficiency outcomes is likely to vary across countries depending on their specific structural characteristics, particularly those of a political economy nature.[13] Further investigating these could shed light on the extent and underlying drivers of cross-country heterogeneity in the government efficiency impacts of reforms more generally. Importantly, it should be noted that the tax reform database used in our empirical analysis provides no information regarding the current (or past) fiscal stance of the countries under scrutiny. Whether the increased revenue from raising certain tax rates is used for reducing fiscal deficits, paying off debt or increasing public spending in a certain area (e.g. health or education) is beyond the scope of the paper. This deals with a social planner´s objective function which can have multiple (and often) conflicting goals (e.g. efficiency vs equity). These considerations might be better discussed in future research. Lastly, this paper did not elaborate on tax efficiency considerations nor did it look at whether the tax composition resulting from tax reforms was optimal from a welfare point of view. This could also be an avenue of future research.

[13] Political barriers are in part responsible for a reliance on narrow technocratic reforms which are being ineffective at raising more revenues.

Appendix A

Table 8 DEA Output Components

Sub Index	Variable	Source	Series
Opportunity Indicators			
Administration	Corruption	Transparency International's Corruption Perceptions Index (CPI) (2006-2017)	Corruption on a scale from 10 (Perceived to have low levels of corruption) to 0 (highly corrupt), 2006–2011; Corruption on a scale from 100 (Perceived to have low levels of corruption) to 0 (highly corrupt), 2012–2017
	Red Tape	World Economic Forum: The Global competitiveness Report (2006–2017)	Burden of government regulation on a scale from 7 (not burdensome at all) to 1 (extremely burdensome)
	Judicial Independence	World Economic Forum: The Global competitiveness Report (2006–2017)	Judicial independence on a scale from 7 (entirely independent) to 1 (heavily influenced)
	Property Rights	World Economic Forum: The Global competitiveness Report (2006–2017)	Property rights on a scale from 7 (very strong) to 1 (very weak)
	Shadow Economy	Schneider (2016) (2006–2016)	Shadow economy measured as percentage of official GDP. Reciprocal value 1/x
Education	Secondary School Enrolment	World Bank, World Development Indicators (2006–2017)	Ratio of total enrolment in secondary education
	Quality of Educational System	World Economic Forum: The Global competitiveness Report (2006–2017)	Quality of educational system on a scale from 7 (very well) to 1 (not well at all)
	PISA scores	PISA Report (2003, 2006, 2009, 2012, 2015)	Simple average of mathematics, reading and science scores for the years 2015, 2012, 2009; Simple average of mathematics and reading for the year 2003. For the missing years, we assumed that the scores were the same as in the previous years
Health	Infant Survival Rate	World Bank, World Development Indicators (2006–2017)	Infant survival rate = (1000-IMR)/1000. IMR is the infant mortality rate measured per 1000 lives birth in a given year

Table 8 (continued)

Sub Index	Variable	Source	Series
	Life Expectancy	World Bank, World Development Indicators (2006–2017)	Life expectancy at birth, measured in years
	CVD, cancer, diabetes or CRD Survival Rate	World Health Organization, Global Health Observatory Data Repository (2000, 2005, 2010, 2015, 2016)	CVD, cancer and diabetes survival rate = 100-M. M is the mortality rate between the ages 30 and 70. For the missing years, we assumed that the scores were the same as in the previous years
Public Infrastructure	Infrastructure Quality	World Economic Forum: The Global competitiveness Report (2006–2017)	Infrastructure quality on a scale from 7 (extensive and efficient) to 1 (extremely underdeveloped)
Standard Musgravian Indicators			
Distribution	Gini Index	Eurostat, OECD (2006–2016)	Gini index on a scale from 1(perfect inequality) to 0 (perfect equality). Transformed to 1-Gini
Stabilization	Coefficient of Variation of Growth	IMF World Economic Outlook (WEO database) (2006–2017)	Coefficient of variation = standard deviation/mean of GDP growth based on 5 year data. GDP constant prices (percent change). Reciprocal value 1/x
	Standard Deviation of Inflation	IMF World Economic Outlook (WEO database) (2006–2017)	Standard deviation of inflation based on 5-year consumer prices (percent change) data. Reciprocal value 1/x
Economic Performance	GDP per Capita	IMF World Economic Outlook (WEO database) (2006–2017)	GDP per capita based on PPP, current international dollar
	GDP Growth	IMF World Economic Outlook (WEO database) (2006–2017)	GDP constant prices (percent change)
	Unemployment	IMF World Economic Outlook (WEO database) (2006–2017)	Unemployment rate, as a percentage of total labor force. Reciprocal value 1/x

For Chile, Iceland, Israel, South Korea and Mexico, we use the data available in Medina and Schneider (2017)

For Switzerland, we were only able to collect data for the period between 2009 and 2016

Table 9 Input Components

Sub Index	Variable	Source	Series
Opportunity Indicators			
Administration	Government Consumption	IMF World Economic Outlook (WEO database) (2005–2016)	General government final consumption expenditure (% of GDP) at current prices
Education	Education Expenditure	UNESCO Institute for Statistics (2005–2016)	Expenditure on education (% of GDP)
Health	Health Expenditure	OECD database (2005–2016)	Expenditure on health (% of GDP)
Public Infrastructure	**Public Investment**	European Commission, AMECO (2005–2016)	General government gross fixed capital formation (% of GDP) at current prices
Standard Musgravian Indicators			
Distribution	Social Protection Expenditure	OECD database (2005–2016)	Aggregation of the social transfers (% of GDP)
Stabilization/ Economic Performance	Government Total Expenditure	OECD database (2005–2016)	Total expenditure (% of GDP)

From IMF World Economic Outlook (WEO database), we retrieved data for Greece for the period between 2006 and 2012 and for the USA for the period 2005 and 2007

We were not able to collect data on the following countries: Australia, Canada, Mexico, New Zealand, Chile, Israel and South Korea

From IMF World Economic Outlook (WEO database), we retrieved data for New Zealand for the period 2005 and 2012. For Turkey, we retrieve data from European Commission, AMECO database. For Chile and Iceland, we were only able to collect data for the period between 2013 and 2016. For Turkey, we were only able to get data for the period between 2009 and 2015. We were not able to collect data for Canada

From IMF World Economic Outlook (WEO database), we retrieved data for Canada for the period between 2005 and 2012 and for New Zealand for the period 2009 and 2012. For Turkey, we retrieve data from European Commission, AMECO database. We were not able to collect data for Mexico. For Chile and Iceland, we were only able to collect data for the period between 2013 and 2016. For New Zealand, we were only able to collect data for the period between 2009 and 2016. For Japan, we were only able to collect data for the period between 2005 and 2016

Appendix B

Table 10 Second-stage regression variables´ definition and source

Variable	Definition	Source
D base decreasing, t-1	Dummy variable equalling one if a country reduced the tax base of PIT, CIT or VAT in the previous year and zero otherwise	Amaglobeli et al. (2018)
D base increasing, t-1	Dummy variable equalling one if a country increased the tax base of PIT, CIT or VAT in the previous year and zero otherwise	
D rate decreasing, t-1	Dummy variable equalling one if a country reduced the tax rate of PIT, CIT or VAT in the previous year and zero otherwise	
D rate increasing, t-1	Dummy variable equalling one if a country increased the tax rate of PIT, CIT or VAT in the previous year and zero otherwise	
D base decreasing PIT, t-1	Dummy variable equalling one if a country reduced the tax base of PIT in the previous year and zero otherwise	
D base increasing PIT, t-1	Dummy variable equalling one if a country increased the tax base of PIT in the previous year and zero otherwise	
D rate decreasing PIT, t-1	Dummy variable equalling one if a country reduced the tax rate of PIT in the previous year and zero otherwise	
D rate increasing PIT, t-1	Dummy variable equalling one if a country increased the tax rate of PIT in the previous year and zero otherwise	
D base decreasing CIT, t-1	Dummy variable equalling one if a country reduced the tax base of CIT in the previous year and zero otherwise	
D base increasing CIT, t-1	Dummy variable equalling one if a country increased the tax base of CIT in the previous year and zero otherwise	
D rate decreasing CIT, t-1	Dummy variable equalling one if a country reduced the tax rate of CIT in the previous year and zero otherwise	
D rate increasing CIT, t-1	Dummy variable equalling one if a country increased the tax rate of CIT in the previous year and zero otherwise	
D base decreasing VAT, t-1	Dummy variable equalling one if a country reduced the tax base of VAT in the previous year and zero otherwise	
D base increasing VAT, t-1	Dummy variable equalling one if a country increased the tax base of VAT in the previous year and zero otherwise	
D rate decreasing VAT, t-1	Dummy variable equalling one if a country reduced the tax rate of VAT in the previous year and zero otherwise	
D rate increasing VAT, t-1	Dummy variable equalling one if a country increased the tax rate of VAT in the previous year and zero otherwise	
Population (log), t-1	Logarithm of previous year domestic residents	World Bank World Development Indicators
Internet users, t-1	Number of internet users in the previous year	World Bank World Development Indicators

Table 10 (continued)

Variable	Definition	Source
Tourism revenues (% exports), t-1	Share of tourism revenues in exports in the previous year	World Bank World Development Indicators
Primary balance, t-1	Government net borrowing or net lending, excluding interest payments on consolidated government liabilities (OECD 2011)	IMF WEO
Debt (%GDP), t-1	Share of public debt in GDP in the previous year	IMF WEO
Left political orientation, t-1	Dummy variable equal one if the government is from the left political ideology, and zero otherwise	Database of Political Institutions

Table 11 Input-oriented DEA VRS Efficiency Scores Model 0

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
AUS	0.88	0.77	0.80	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.93	0.76	0.75	0.76
AUT	0.62	0.52	0.48	0.50	0.48	0.47	0.48	0.48	0.51	0.51	0.54	0.54
BEL	0.47	0.50	0.49	0.51	0.50	0.49	0.47	0.47	0.48	0.50	0.53	0.54
CAN	0.80	0.64	0.77	0.61	0.58	0.55	0.56	0.57	0.82	0.66	0.65	0.65
CHE	**1.00**	**1.00**	**1.00**	0.81	0.72	0.69	0.66	0.67	**1.00**	0.84	0.73	0.71
CHL	0.99	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
CZE	0.54	0.55	0.57	0.61	0.57	0.58	0.58	0.58	0.61	0.64	0.66	0.72
DEU	0.47	0.49	0.50	0.55	0.52	0.51	0.52	0.53	0.60	0.58	0.60	0.59
DNK	0.53	0.46	0.41	0.46	0.42	0.41	0.40	0.41	0.44	0.45	0.48	0.48
ESP	0.93	0.77	0.55	0.57	0.54	0.53	0.53	0.55	0.58	0.61	0.64	0.67
EST	0.64	0.65	0.62	0.58	0.53	0.58	0.61	0.58	0.62	0.65	0.66	0.65
FIN	0.52	0.51	0.46	0.51	0.46	0.45	0.44	0.42	0.43	0.43	0.46	0.46
FRA	0.60	0.44	0.41	0.45	0.44	0.43	0.43	0.42	0.45	0.45	0.48	0.47
GBR	0.79	0.64	0.56	0.58	0.55	0.53	0.54	0.54	0.65	0.61	0.63	0.64
GRC	0.51	0.50	0.50	0.50	0.49	0.51	0.50	0.50	0.50	0.55	0.56	0.57
HUN	0.49	0.43	0.47	0.53	0.55	0.54	0.54	0.54	0.55	0.56	0.57	0.65
IRL	0.66	0.63	0.56	0.52	0.51	0.45	0.53	0.57	0.71	**1.00**	0.91	0.92
ISL	0.61	0.65	0.52	0.54	0.58	0.58	0.59	0.59	0.62	0.64	0.69	0.62
ISR	0.55	0.55	0.58	0.64	0.68	0.67	0.68	0.75	0.69	0.70	0.74	0.75
ITA	0.49	0.48	0.50	0.52	0.51	0.51	0.52	0.51	0.52	0.54	0.57	0.58
JPN	0.64	0.90	0.60	0.64	0.60	0.59	0.55	0.55	0.58	0.60	0.64	0.63
KOR	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.97	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
LTU	0.66	0.65	0.60	0.61	0.56	0.57	0.59	0.66	0.71	0.75	0.79	0.80

Table 11 (continued)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LUX	0.70	0.73	0.54	0.58	0.54	0.52	0.54	0.54	0.73	0.63	0.64	0.63
LVA	0.68	0.65	0.65	0.66	0.60	0.58	0.62	0.62	0.64	0.69	0.72	0.74
NLD	0.52	0.59	0.79	0.67	0.54	0.51	0.50	0.50	0.54	0.56	0.59	0.60
NOR	0.54	0.54	0.50	0.58	0.51	0.51	0.51	0.51	0.62	0.53	0.51	0.48
NZL	0.59	0.55	0.54	0.61	0.59	0.56	0.50	0.65	0.78	0.66	0.69	0.70
POL	0.51	0.49	0.52	0.56	0.58	0.63	0.60	0.57	0.59	0.60	0.64	0.65
PRT	0.48	0.50	0.52	0.54	0.52	0.48	0.51	0.54	0.54	0.56	0.61	0.64
SVK	0.57	0.58	0.67	0.67	0.60	0.60	0.60	0.61	0.62	0.62	0.59	0.66
SVN	0.49	0.49	0.54	0.55	0.52	0.50	0.50	0.50	0.48	0.53	0.58	0.62
SWE	0.46	0.44	0.43	0.48	0.47	0.46	0.45	0.43	0.46	0.48	0.50	0.49
TUR	0.67	0.66	0.69	0.74	0.76	0.79	0.82	0.78	0.83	0.84	0.88	0.87
USA	0.72	0.67	0.60	0.62	0.60	0.60	0.61	0.63	0.93	0.66	0.68	0.66
Count	2	3	3	3	3	3	2	3	3	3	2	2
Average	0.64	0.62	0.60	0.61	0.59	0.58	0.58	0.59	0.65	0.64	0.65	0.66
Median	0.60	0.58	0.55	0.58	0.55	0.54	0.54	0.55	0.62	0.61	0.64	0.65
Min	0.46	0.43	0.41	0.45	0.42	0.41	0.40	0.41	0.43	0.43	0.46	0.46
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Stdev	0.16	0.16	0.16	0.14	0.15	0.15	0.15	0.15	0.17	0.15	0.13	0.14

Table 12 Input-oriented DEA VRS Efficiency Scores Model 1

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
AUS	0.94	0.81	0.85	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.96	0.77	0.75	0.76
AUT	0.72	0.63	0.58	0.60	0.60	0.59	0.59	0.61	0.62	0.64	0.66	0.64
BEL	0.55	0.59	0.56	0.61	0.61	0.61	0.58	0.58	0.60	0.62	0.64	0.64
CAN	0.81	0.66	0.77	0.65	0.63	0.61	0.61	0.63	0.83	0.69	0.68	0.68
CHE	**1.00**	**1.00**	**1.00**	0.83	0.75	0.74	0.72	0.71	**1.00**	0.86	0.75	0.73
CHL	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
CZE	0.55	0.55	0.59	0.66	0.61	0.64	0.64	0.66	0.70	0.71	0.69	0.78
DEU	0.60	0.62	0.61	0.69	0.64	0.63	0.63	0.65	0.70	0.69	0.70	0.69
DNK	0.60	0.53	0.47	0.54	0.51	0.50	0.49	0.50	0.51	0.53	0.55	0.53
ESP	0.94	0.79	0.57	0.63	0.61	0.61	0.62	0.70	0.76	0.80	0.79	0.83
EST	0.65	0.68	0.67	0.59	0.58	0.65	0.66	0.60	0.65	0.68	0.67	0.67
FIN	0.60	0.61	0.54	0.61	0.58	0.57	0.55	0.53	0.54	0.55	0.57	0.56
FRA	0.67	0.52	0.48	0.55	0.54	0.54	0.53	0.53	0.55	0.57	0.60	0.57
GBR	0.92	0.72	0.63	0.68	0.67	0.64	0.63	0.66	0.72	0.69	0.71	0.70
GRC	0.57	0.53	0.56	0.60	0.59	0.65	0.68	0.69	0.69	0.73	0.73	0.72

Table 12 (continued)

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
HUN	0.55	0.47	0.54	0.68	0.70	0.68	0.67	0.68	0.68	0.64	0.61	0.76
IRL	0.67	0.64	0.56	0.56	0.59	0.54	0.62	0.67	0.79	**1.00**	0.96	0.94
ISL	0.67	0.72	0.57	0.60	0.58	0.59	0.62	0.61	0.63	0.64	0.71	0.64
ISR	0.58	0.55	0.59	0.68	0.73	0.72	0.72	0.78	0.73	0.75	0.77	0.78
ITA	0.59	0.55	0.60	0.66	0.65	0.67	0.67	0.69	0.72	0.75	0.77	0.77
JPN	0.67	0.94	0.65	0.74	0.71	0.69	0.63	0.64	0.65	0.67	0.70	0.68
KOR	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
LTU	0.68	0.66	0.62	0.65	0.65	0.64	0.65	0.74	0.79	0.84	0.84	0.86
LUX	0.74	0.81	0.60	0.67	0.63	0.62	0.64	0.68	0.87	0.77	0.78	0.75
LVA	0.70	0.67	0.72	0.67	0.68	0.69	0.68	0.65	0.68	0.75	0.76	0.80
NLD	0.56	0.61	0.79	0.70	0.58	0.56	0.56	0.57	0.59	0.62	0.64	0.63
NOR	0.57	0.58	0.51	0.61	0.55	0.57	0.57	0.56	0.64	0.55	0.53	0.50
NZL	0.62	0.56	0.57	0.62	0.60	0.56	0.54	0.67	0.82	0.68	0.73	0.71
POL	0.61	0.56	0.60	0.64	0.66	0.72	0.66	0.66	0.70	0.70	0.73	0.77
PRT	0.52	0.53	0.57	0.63	0.61	0.55	0.61	0.69	0.72	0.75	0.77	0.81
SVK	0.66	0.63	0.77	0.77	0.71	0.72	0.70	0.74	0.75	0.73	0.62	0.75
SVN	0.56	0.54	0.59	0.62	0.60	0.59	0.60	0.61	0.59	0.61	0.66	0.72
SWE	0.53	0.52	0.49	0.55	0.55	0.55	0.51	0.48	0.50	0.52	0.54	0.52
TUR	0.88	0.80	0.84	0.95	0.93	0.98	**1.00**	0.89	0.93	0.97	0.99	0.97
USA	0.87	0.79	0.73	0.69	0.60	0.61	0.61	0.64	**1.00**	0.82	0.81	0.79
Count	3	3	3	3	3	3	4	3	4	3	2	2
Average	0.70	0.67	0.65	0.68	0.66	0.66	0.66	0.68	0.73	0.72	0.73	0.73
Median	0.66	0.63	0.60	0.65	0.61	0.63	0.63	0.66	0.70	0.70	0.71	0.73
Min	0.52	0.47	0.47	0.54	0.51	0.50	0.49	0.48	0.50	0.52	0.53	0.50
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Stdev	0.15	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.15	0.13	0.12	0.13

Table 13 Input-oriented DEA VRS Efficiency Scores Model 2

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
AUS	0.98	0.89	0.86	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.97	0.88	0.85	0.86
AUT	0.67	0.63	0.65	0.64	0.62	0.61	0.62	0.63	0.63	0.63	0.61	0.62
BEL	0.61	0.58	0.59	0.58	0.55	0.56	0.55	0.55	0.57	0.58	0.59	0.59
CAN	0.80	0.74	0.78	0.76	0.73	0.71	0.73	0.74	0.84	0.79	0.74	0.75
CHE	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
CHL	0.99	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
CZE	0.54	0.56	0.58	0.61	0.57	0.58	0.58	0.58	0.61	0.64	0.66	0.72
DEU	0.68	0.65	0.67	0.67	0.63	0.62	0.66	0.69	0.70	0.72	0.68	0.70
DNK	0.65	0.61	0.58	0.59	0.55	0.55	0.51	0.51	0.54	0.56	0.56	0.57
ESP	**1.00**	**1.00**	0.57	0.57	0.54	0.53	0.55	0.59	0.62	0.66	0.67	0.69
EST	0.65	0.65	0.62	0.59	0.53	0.59	0.62	0.61	0.67	0.71	0.69	0.70
FIN	0.72	0.69	0.69	0.67	0.62	0.63	0.64	0.63	0.61	0.59	0.61	0.62
FRA	0.60	0.53	0.53	0.54	0.53	0.52	0.52	0.53	0.53	0.54	0.52	0.52
GBR	0.79	0.68	0.64	0.64	0.62	0.62	0.65	0.67	0.70	0.72	0.72	0.74
GRC	0.51	0.51	0.50	0.50	0.49	0.51	0.50	0.50	0.50	0.55	0.56	0.57
HUN	0.57	0.43	0.47	0.53	0.55	0.54	0.54	0.54	0.55	0.56	0.57	0.66
IRL	0.75	0.63	0.59	0.56	0.54	0.49	0.65	0.71	0.77	**1.00**	**1.00**	**1.00**
ISL	0.83	0.73	0.70	0.70	0.77	0.76	0.78	0.76	0.77	0.78	0.80	0.72
ISR	0.61	0.56	0.58	0.64	0.68	0.67	0.68	0.76	0.70	0.70	0.76	0.77
ITA	0.49	0.49	0.50	0.52	0.51	0.51	0.52	0.51	0.52	0.54	0.57	0.58
JPN	0.87	1.00	0.78	0.78	0.74	0.74	0.69	0.72	0.76	0.77	0.76	0.77
KOR	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
LTU	0.66	0.67	0.60	0.61	0.56	0.57	0.59	0.66	0.72	0.75	0.79	0.80
LUX	0.71	0.81	0.69	0.71	0.67	0.66	0.71	0.72	0.76	0.78	0.74	0.75
LVA	0.68	0.67	0.65	0.66	0.60	0.58	0.62	0.62	0.64	0.69	0.72	0.74
NLD	0.78	0.70	**1.00**	0.74	0.67	0.67	0.71	0.72	0.75	0.76	0.76	0.79
NOR	0.66	0.61	0.58	0.65	0.57	0.57	0.59	0.62	0.64	0.62	0.55	0.55
NZL	0.75	0.63	0.63	0.72	0.71	0.69	0.65	0.80	0.81	0.83	0.82	0.83
POL	0.51	0.50	0.59	0.57	0.59	0.74	0.63	0.58	0.59	0.60	0.64	0.65
PRT	0.50	0.51	0.53	0.54	0.52	0.48	0.52	0.57	0.60	0.63	0.63	0.68
SVK	0.57	0.59	**1.00**	0.67	0.60	0.60	0.60	0.61	0.62	0.63	0.59	0.66
SVN	0.49	0.50	0.55	0.55	0.52	0.50	0.50	0.50	0.48	0.53	0.58	0.62
SWE	0.55	0.54	0.56	0.59	0.60	0.60	0.56	0.54	0.54	0.56	0.58	0.59
TUR	0.67	0.66	0.69	0.74	0.76	0.80	0.82	0.80	0.84	0.85	0.88	0.87
USA	0.92	0.81	0.79	0.75	0.71	0.72	0.73	0.80	0.97	0.81	0.80	0.84
Count	3	4	5	4	4	4	4	4	3	4	4	4
Average	0.71	0.68	0.68	0.67	0.65	0.65	0.66	0.68	0.70	0.71	0.71	0.73
Median	0.67	0.65	0.63	0.64	0.60	0.61	0.63	0.63	0.67	0.70	0.69	0.72
Min	0.49	0.43	0.47	0.50	0.49	0.48	0.50	0.50	0.48	0.53	0.52	0.52
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Stdev	0.16	0.16	0.16	0.14	0.15	0.15	0.15	0.15	0.15	0.14	0.14	0.13

Appendix C

Table 14 Alternative Estimation for input efficiency scores: OLS and PCSE, Model 2

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Estimator	OLS	PCSE	OLS	PCSE	OLS	PCSE	OLS	PCSE	OLS	PCSE
Population (log), t-1	0.944	0.038***	0.992*	0.052***	0.840	0.054***	0.799	0.054***	0.861	0.053***
	(0.565)	(0.011)	(0.572)	(0.012)	(0.555)	(0.011)	(0.586)	(0.009)	(0.547)	(0.009)
Debt (% GDP), t-1	0.168	0.012	0.171	-0.083***	0.149	-0.095***	0.156	-0.100***	0.166	-0.091***
	(0.156)	(0.020)	(0.150)	(0.031)	(0.156)	(0.028)	(0.163)	(0.025)	(0.147)	(0.024)
Primary balance, t-1	1.821***	1.089***	1.828***	1.003***	1.830***	0.931***	1.781***	0.904**	1.887***	1.024***
	(0.265)	(0.345)	(0.269)	(0.345)	(0.319)	(0.347)	(0.264)	(0.377)	(0.305)	(0.357)
Internet users (log), t-1	0.242*	0.333***	0.253*	0.315***	0.229*	0.328***	0.229*	0.328***	0.195	0.322***
	(0.130)	(0.081)	(0.128)	(0.064)	(0.128)	(0.061)	(0.134)	(0.059)	(0.125)	(0.061)
Tourism revenues (% exports), t-1	-0.264	-0.423	-0.379	0.048	-0.043	0.093	-0.179	0.080	-0.287	0.077
	(1.078)	(0.318)	(1.145)	(0.278)	(1.169)	(0.248)	(0.996)	(0.249)	(1.149)	(0.253)
Left political orientation, t-1	0.028	-0.010	0.033	-0.023	0.025	-0.034	0.027	-0.041	0.029	-0.035
	(0.026)	(0.018)	(0.027)	(0.023)	(0.027)	(0.024)	(0.027)	(0.026)	(0.026)	(0.026)
D base increasing, t-1	-0.011	-0.004								
	(0.019)	(0.012)								
D base decreasing, t-1	0.017	0.006								
	(0.013)	(0.011)								
D rate increasing, t-1	-0.043**	-0.025**								
	(0.019)	(0.012)								
D rate decreasing, t-1	-0.009	0.006								
	(0.017)	(0.013)								
D base increasing PIT, t-1			-0.019	-0.008					-0.012	-0.007
			(0.019)	(0.013)					(0.020)	(0.017)
D base decreasing PIT, t-1			0.000	0.000					0.004	0.000
			(0.015)	(0.012)					(0.016)	(0.016)

Table 14 (continued)

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
D rate increasing PIT, t-1			-0.048*	-0.024					-0.047**	-0.025
			(0.024)	(0.019)					(0.022)	(0.024)
D rate decreasing PIT, t-1			0.005	-0.006					-0.014	-0.016
			(0.027)	(0.019)					(0.024)	(0.021)
D base increasing CIT, t-1					-0.021	-0.012			-0.025	-0.016
					(0.025)	(0.019)			(0.024)	(0.022)
D base decreasing CIT, t-1					0.011	-0.001			0.010	0.004
					(0.018)	(0.015)			(0.022)	(0.017)
D rate increasing CIT, t-1					-0.017	-0.007			0.001	-0.003
					(0.024)	(0.019)			(0.020)	(0.022)
D rate decreasing CIT, t-1					-0.014	-0.000			-0.014	0.005
					(0.029)	(0.022)			(0.023)	(0.023)
D base increasing VAT, t-1							0.030	0.003	0.026	-0.003
							(0.028)	(0.030)	(0.028)	(0.032)
D base decreasing VAT, t-1							0.104*	0.077*	0.126*	0.097**
							(0.058)	(0.040)	(0.067)	(0.040)
D rate increasing VAT, t-1							-0.030**	-0.021	-0.023	-0.022
							(0.014)	(0.021)	(0.017)	(0.019)
D rate decreasing VAT, t-1							-0.026	0.006	-0.023	0.005
							(0.018)	(0.026)	0.861	0.053***
Observations	180	180	180	180	180	180	180	180	180	180
R-squared	0.904	0.839	0.903	0.423	0.900	0.411	0.904	0.409	0.910	0.428

The dependent variable is the logarithm of the efficiency score using DEA-based Model 2 – refer to main text for details. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Robust standard errors clustered at the country level in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

Table 15 Robustness Estimation: Endogeneity System GMM, Model 2

Specification	(1)	(2)	(3)	(4)	(5)
Estimator	System GMM				
Lagged dependent variable	0.933***	0.937***	0.942***	0.916***	
	(0.026)	(0.025)	(0.025)	(0.050)	
Population (log), t-1	-0.000	0.002	-0.001	-0.006	
	(0.006)	(0.006)	(0.007)	(0.009)	
Debt (% GDP), t-1	0.006	0.002	0.008	0.032	
	(0.016)	(0.017)	(0.017)	(0.035)	
Primary balance, t-1	0.131	0.147	0.050	0.192	
	(0.131)	(0.127)	(0.122)	(0.164)	
Internet users (log), t-1	0.016	0.020	0.041	0.034	
	(0.031)	(0.036)	(0.045)	(0.048)	
Tourism revenues (% exports), t-1	0.124	0.032	0.185	-0.008	
	(0.127)	(0.118)	(0.143)	(0.230)	
Left political orientation, t-1	-0.021	-0.023	-0.022	-0.050**	
	(0.014)	(0.015)	(0.015)	(0.019)	
D base increasing, t-1	0.032**				
	(0.015)				
D base decreasing, t-1	-0.011				
	(0.015)				
D rate increasing, t-1	-0.025*				
	(0.012)				
D rate decreasing, t-1	0.015				
	(0.014)				
D base increasing PIT, t-1		0.043**			
		(0.017)			
D base decreasing PIT, t-1		-0.033*			
		(0.018)			
D rate increasing PIT, t-1		-0.013			
		(0.014)			
D rate decreasing PIT, t-1		0.013			
		(0.047)			
D base increasing CIT, t-1			-0.002		
			(0.017)		
D base decreasing CIT, t-1			0.023*		
			(0.013)		
D rate increasing CIT, t-1			-0.052**		
			(0.020)		
D rate decreasing CIT, t-1			-0.005		
			(0.015)		
D base increasing VAT, t-1				0.027*	
				(0.015)	
D base decreasing VAT, t-1				0.078	

Table 15 (continued)

Specification	(1)	(2)	(3)	(4)	(5)
				(0.114)	
D rate increasing VAT, t-1				0.011	
				(0.026)	
D rate decreasing VAT, t-1				0.057	
Observations	162	162	162	162	
Hansen (p-value)	0.545	0.677	0.761	0.698	
AR2 (p-value)	0.797	0.370	0.380	0.176	
AR1 (p-value)	0.007	0.008	0.020	0.011	

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Hansen test evaluates the validity of the instrument set, i.e., tests for over-identifying restrictions. AR(1) and AR(2) are the Arellano–Bond autocorrelation tests of first and second order (the null is no autocorrelation), respectively. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

Table 16 Robustness Estimation: State-contingent, System GMM, Model 2

Specification	(1)	(2)	(3)	(4)
Estimator	System GMM			
Lagged dependent variable	0.945***	0.956***	0.921***	0.924***
	(0.029)	(0.024)	(0.028)	(0.054)
Population (log), t-1	0.001	0.000	0.001	-0.001
	(0.006)	(0.007)	(0.007)	(0.008)
Debt (% GDP), t-1	0.011	0.007	0.014	0.024
	(0.018)	(0.016)	(0.020)	(0.033)
Primary balance, t-1	0.161*	0.240***	0.118	0.367**
	(0.094)	(0.083)	(0.093)	(0.152)
Internet users (log), t-1	0.061	0.054	0.071	0.050
	(0.052)	(0.044)	(0.055)	(0.058)
Tourism revenues (% exports), t-1	0.151	0.091	0.108	0.015
	(0.126)	(0.106)	(0.164)	(0.213)
Left political orientation, t-1	-0.023*	-0.019	-0.028*	-0.045**
	(0.013)	(0.013)	(0.015)	(0.017)
D base increasing, t-1*recession	0.000			
	(0.030)			
D base increasing, t-1*expansion	0.049			
	(0.030)			
D base decreasing, t-1*recession	-0.017			
	(0.022)			
D base decreasing, t-1*expansion	0.007			
	(0.042)			

Table 16 (continued)

Specification	(1)	(2)	(3)	(4)
D rate increasing, t-1*recession	0.023			
	(0.020)			
D rate increasing, t-1*expansion	-0.065			
	(0.040)			
D rate decreasing, t-1*recession	0.002			
	(0.024)			
D rate decreasing, t-1*expansion	0.026			
	(0.046)			
D base increasing PIT, t-1 *recession		0.026		
		(0.032)		
D base increasing PIT, t-1 *expansion		0.054		
		(0.059)		
D base decreasing PIT, t-1 *recession		0.004		
		(0.026)		
D base decreasing PIT, t-1*expansion		-0.056		
		(0.064)		
D rate increasing PIT, t-1 *recession		0.005		
		(0.015)		
D rate increasing PIT, t-1*expansion		-0.028		
		(0.069)		
D rate decreasing PIT, t-1*recession		-0.046		
		(0.059)		
D rate decreasing PIT, t-1*expansion		0.067		
		(0.129)		
D base increasing CIT, t-1 *recession			0.069*	
			(0.037)	
D base increasing CIT, t-1 *expansion			-0.085	
			(0.053)	
D base decreasing CIT, t-1*recession			-0.031	
			(0.024)	
D base decreasing CIT, t-1*expansion			0.063***	
			(0.021)	
D rate increasing CIT, t-1*recession			-0.049	
			(0.036)	
D rate increasing CIT, t-1*expansion			-0.096**	
			(0.033)	
D rate decreasing CIT, t-1t*recession			-0.006	
			(0.034)	
D rate decreasing CIT, t-1*expansion			0.004	
			(0.044)	
D base increasing VAT, t-1 *recession				0.057
				(0.053)

Table 16 (continued)

Specification	(1)	(2)	(3)	(4)
D base increasing VAT, t-1 *expansion				-0.011
				(0.027)
D base decreasing VAT, t-1*recession				-3.054
				(2.933)
D base decreasing VAT, t-1*expansion				1.132
				(0.817)
D rate increasing VAT, t-1*recession				0.055*
				(0.027)
D rate increasing VAT, t-1*expansion				-0.064
				(0.066)
D rate decreasing VAT, t-1*recession				0.009
				(0.024)
D rate decreasing VAT, t-1*expansion				0.223
				(0.145)
Observations	162	162	162	162
R-squared				
Hansen (p-value)	0.988	0.989	0.977	0.983
AR2 (p-value)	0.731	0.432		
AR1 (p-value)	0.008	0.007		

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Hansen test evaluates the validity of the instrument set, i.e., tests for over-identifying restrictions. AR(1) and AR(2) are the Arellano–Bond autocorrelation tests of first and second order (the null is no autocorrelation), respectively. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

Table 17 Robustness Estimation: State-contingent, PCSE, Model 2

Specification	(1)	(2)	(3)	(4)	(5)
Estimator	PCSE	PCSE	PCSE	PCSE	PCSE
Population (log), t-1	1.144**	1.281**	1.048*	0.942	1.123*
	(0.534)	(0.552)	(0.546)	(0.561)	(0.563)
Debt (% GDP), t-1	0.251*	0.282**	0.246*	0.243*	0.283**
	(0.120)	(0.119)	(0.122)	(0.137)	(0.119)
Primary balance, t-1	1.669***	1.701***	1.586***	1.622***	1.635***
	(0.236)	(0.242)	(0.229)	(0.215)	(0.227)
Internet users (log), t-1	0.264	0.267	0.255	0.165	0.224
	(0.181)	(0.174)	(0.185)	(0.183)	(0.173)
Tourism revenues (% exports), t-1	-1.412	-1.193	-1.232	-0.978	-1.596
	(1.116)	(1.048)	(1.102)	(1.018)	(1.123)
Left political orientation, t-1	0.028	0.039	0.030	0.023	0.039
	(0.029)	(0.032)	(0.030)	(0.030)	(0.031)
D base increasing, t-1*recession	0.017				
	(0.023)				
D base increasing, t-1*expansion	0.008				
	(0.028)				
D base decreasing, t-1*recession	-0.005				
	(0.031)				
D base decreasing, t-1*expansion	0.024				
	(0.023)				
D rate increasing, t-1*recession	-0.082*				
	(0.040)				
D rate increasing, t-1*expansion	0.003				
	(0.033)				
D rate decreasing, t-1*recession	0.024				
	(0.028)				
D rate decreasing, t-1*expansion	-0.025				
	(0.040)				
D base increasing PIT, t-1 *recession		0.037			0.038
		(0.027)			(0.044)
D base increasing PIT, t-1 *expansion		-0.028			0.006
		(0.043)			(0.042)
D base decreasing PIT, t-1 *recession		-0.005			-0.006
		(0.033)			(0.035)
D base decreasing PIT, t-1*expansion		-0.004			0.014
		(0.036)			(0.031)
D rate increasing PIT, t-1 *recession		-0.104*			-0.082*
		(0.051)			(0.041)
D rate increasing PIT, t-1*expansion		0.011			-0.019
		(0.064)			(0.056)
D rate decreasing PIT, t-1*recession		-0.020			0.004

Table 17 (continued)

Specification	(1)	(2)	(3)	(4)	(5)
		(0.049)			(0.040)
D rate decreasing PIT, t-1*expansion		0.058			-0.020
		(0.070)			(0.045)
D base increasing CIT, t-1 *recession			-0.011		0.006
			(0.051)		(0.043)
D base increasing CIT, t-1 *expansion			0.022		0.000
			(0.048)		(0.050)
D base decreasing CIT, t-1*recession			-0.051**		-0.054**
			(0.024)		(0.022)
D base decreasing CIT, t-1*expansion			0.024		0.012
			(0.030)		(0.027)
D rate increasing CIT, t-1*recession			-0.033		-0.011
			(0.026)		(0.023)
D rate increasing CIT, t-1*expansion			0.021		0.018
			(0.032)		(0.036)
D rate decreasing CIT, t-1t*recession			0.007		0.037
			(0.030)		(0.039)
D rate decreasing CIT, t-1*expansion			-0.003		-0.019
			(0.049)		(0.042)
D base increasing VAT, t-1 *recession				0.007	-0.064
				(0.086)	(0.085)
D base increasing VAT, t-1 *expansion				-0.037	0.001
				(0.028)	(0.038)
D base decreasing VAT, t-1*recession				-1.675***	-1.632***
				(0.264)	(0.278)
D base decreasing VAT, t-1*expansion				0.779***	0.762***
				(0.102)	(0.090)
D rate increasing VAT, t-1*recession				-0.041	-0.024
				(0.026)	(0.032)
D rate increasing VAT, t-1*expansion				0.008	-0.011
				(0.019)	(0.030)
D rate decreasing VAT, t-1*recession				0.032	0.040
				(0.021)	(0.030)
D rate decreasing VAT, t-1*expansion				-0.097***	-0.116***
				(0.017)	(0.036)
Observations	162	162	162	162	162
R-squared	0.944	0.944	0.940	0.946	0.954

Dependent variable is the level of the efficiency score using DEA-based Model 2 – refer to main text for details. Country and time fixed effects omitted for reasons of parsimony. Constant term estimated but omitted. Standard errors in parenthesis. *, **, *** denote statistical significance at the 10, 5 and 1 percent levels, respectively

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