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Measuring Tax Burden Efficiency in OECD Countries: An International Comparison

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Measuring Tax Burden Efficiency in OECD Countries: An International Comparison

Abstract

In this paper, we estimate the potential tax burden in a panel data set comprising OECD countries over the period 2000-2021. To this end, we use non-parametric and parametric techniques: Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). In this way, it will be possible for us to identify which countries are close to their potential tax capacity and which are far from it. Moreover, we can determine whether they may sustain an increase (decrease) in their actual tax burden depending on whether the tax effort ratio is lower or higher relatively to other similar countries in the sample. Non-parametric and parametric results coincide rather closely on the positioning of the countries vis-à-vis the production possibility frontier and on their relative distances to the frontier. Efficient countries most of the times are: Belgium, Colombia, Finland, France, Italy, Latvia, Slovak Republic, and Sweden.

JEL-Codes: C140, C230, H200, H210, H300.

Keywords: OECD, tax burden, tax efficiency, Stochastic Frontier Analysis, Data Envelopment Analysis.

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1. Introduction

Taxation is one of the cornerstones of all political regimes (Musgrave, 1987; Brennan and Buchanan, 1980). Taxation is a fundamental component of any modern state, comparable to a fiscal state (Schumpeter, 1918). We are currently immersed in a globalisation that, along with the strength of the large emerging economies, has led to an increase in worldwide competition in which the fiscal framework of the different territories is of great relevance.

The measurement of the tax burden is of great importance for comparative purposes. Moreover, given the significant challenges facing public finances, it is quite relevant to determine whether a country has the capacity to expand its tax revenues through the calculation of tax effort (Pessino and Fenochietto, 2010). In this context, it is crucial to refine the concept of the indicators used and to carry out an appropriate quantification (Cordero et al., 2010).

The tax doctrine has questioned the validity of the tax burden index as a true indicator of the tax sacrifice of a country, which has led to the design of some more sophisticated indicators and, in general, to the introduction of the concept of tax effort as a way to overcome the concept of tax burden (Domingo, 1985). Moreover, a rigorous analysis of fiscal systems requires the application of statistical and econometric techniques, as well as more complex mathematical modelling than just the quotient between two macro-magnitudes, such as tax collection and GDP (Sanz and Romero, 2020).

The tax burden is measured by considering total tax revenues¹ as a percentage of Gross Domestic Product (GDP). This concept shows the share of a country's output that is collected by the government through taxes (Barros et al., 2023) and gives an overview of tax trends across countries (Le, 2012) but ignores the differences in tax capacity between them. In turn, a country's tax effort shows the degree to which an economy makes use of its tax capacity (Bahl 1971) because it is obtained as the ratio of tax burden to (estimated) tax capacity (Bahl, 1971 and Barros et.al, 2023). The problem, as Plasschaert (1962) states, arises when it comes to determining the tax capacity in a given jurisdiction, in order to define tax effort.

The tax capacity reflects a country's ability to pay (Plasschaert 1962) and refers to the predicted tax-to-gross domestic product ratio that can be estimated empirically, taking into account a country's specific macroeconomic, demographic, and institutional features (Le et al.,

¹ The OECD (2023) defines tax revenues as “the revenues collected from taxes on income and profits, social security contributions, taxes levied on goods and services, payroll taxes, taxes on the ownership and transfer of property, and other taxes”. Compulsory social security contributions paid to general government are treated as taxes (OECD, 2023) although they are not, in a narrow sense, because they present some similar features that make them comparable to taxes when it comes to calculating the tax burden.

2012).

According to Cordero et al. (2010), the concept of tax burden is something objective and clearly defined, while that of tax effort is more subjective and has connotations that make it much more difficult to evaluate in a satisfactory manner. Tax effort indicators are fundamentally calculated by comparing actual collection against potential collections (Cyan et. al., 2013), i.e., as the ratio of the effective tax burden to the potential tax burden. Thus, the concept of tax effort depends on the way revenue potential is estimated. Nevertheless, there exist some indicators which are obtained differently, in a direct a very simplistic way, such as the Frank index² and the Bird index³.

Numerous indices have been proposed as a measure of tax effort, but none has obtained a proper degree of consensus to be generally accepted. In fact, several approaches can be used to determine potential revenue for a country. The objective of this study is to estimate the potential tax burden in OECD countries from an efficiency perspective. To this end, we use non-parametric and parametric techniques, computing a Data Envelopment Analysis (DEA) model and a Stochastic Frontier Analysis (SFA) model.

We use panel data set comprising the OECD countries over the period 2000-2021 to estimate revenue effort following the above-mentioned models. In this way, it will be possible for us to identify which countries are close to their potential tax capacity and which are far from it, and consequently, we could determine whether they, according to the standards from the estimations, might be subject to an increase (or to a decrease) in their actual tax burden.

The paper is organised as follows. Section two offers a literature review of the related theoretical viewpoints and empirical studies. Section three presents the analytical and econometric methodology. Section four shows the data, and the empirical analysis with a discussion of the main results. Finally, section five provides conclusions, some policy implications, and further lines of research.

2. Literature

Several studies have identified substantial public spending efficiency differences between countries and scope for spending savings. Most public spending efficiency related studies

² The Frank index (Frank, 1959), which is equal to tax burden (T) divided by GDP per capita (GDP/POP), is sometimes used as a proxy for this effort, but it is a meaningless indicator $[(T \times \text{POP})/\text{GDP}^2]$.

³ The Bird index is equal to tax burden divided by disposable income per capita instead of GDP per capita Frank (Bird, 1964).

report that there is room for improvement in terms of government spending efficiency, and this typically implies that more public services could be provided with the same public resources, or conversely, the same level of public resources might be provided with fewer public resources. For OECD and EU countries see, notably the evidence reported by Afonso et al. (2005), Adam et al. (2011), Dutu and Sicari (2016), Afonso and Kazemi (2017), Antonelli and de Bonis (2019), and Afonso et al. (2023)⁴.

There is also a vast amount of theoretical and empirical literature on taxation that proves the increasing attention that this issue has received from both academics and policymakers (Le et al., 2008). Countries need an effective tax system to fund the cost of all the functions of the public sector in the fields of resource allocation, redistribution, stabilisation, and development. According to the World Bank's (1997), taxation and expenditure are key tools for macroeconomic stabilisation, growth, and development of countries. Nevertheless, the majority of developing countries have not been able to obtain enough revenues for crucial public infrastructures and human development services (World Bank, 2005). This could be due to the fact that a high fiscal burden can be perceived as an obstacle to economic development and growth (Afonso and Jalles, 2014). In general, the major challenges facing public finances in all countries raise the question of whether adequate use is being made of available tax capacity and whether there is scope for raising tax revenues to meet public spending needs.

There has been a long-standing discussion regarding the drivers of tax revenues and tax effort as rising tax revenues, when the level of tax effort is not high enough, is considered a key factor of fiscal policy (Barros et al., 2023). Indeed, there is a long list of studies which provide a large number of factors that account for the tax effort (Aigner et al., 1977; Bahl, 1971; Battese and Coelli, 1995; Bird et al., 2008; Gunay and Topal, 2021; Le et al. 2012, Pessino and Fenochietto, 2010; Zárate-Marco and Valles-Gimenez, 2019).

In this sense, among the issues that have worried policymakers in previous decades, factors that affect revenue potential measured as the revenue to GDP have been one of the most relevant ones (Javid and Arif, 2012). As far as tax effort is concerned, in an initial stage, the most significant studies were based on the research conducted by Frank⁵ (1959) and Bird (1964) who were among the first authors to define tax capacity and tax effort.

⁴ Regarding Emerging Markets see, for instance, Afonso et al. (2010), Herrera and Ouedrago (2018), and for Latin American and Caribbean countries see Afonso et al. (2013).

⁵ Due to its simple calculation and the limited information required to calculate it, the Frank index constitutes one of the most traditionally used ways to compare tax systems internationally. However, this index could arise certain absurd results in extreme cases.

All over the world, countries are increasingly acknowledging the fact that the most significant element for economic development is the effectiveness of the revenue system (Javid and Arif, 2012). Building tax capacity is closely linked to the process of economic development and growth (Gaspar et al., 2016).

A wide range of factors such as the level of GDP, openness to trade, and institutional quality modify the tax capacity of a country (Gaspar et al., 2016). All these factors that affect the level of tax revenue of the countries have been analysed for a long time, since the works of Musgrave (1959), Lotz and Morss (1970), Bahl (1971), Bird (1976), Chelliah et al. (1975) and Tait et al. (1979).

There is generalised agreement on the fact that the specific realities of countries entail different economic, social, and even institutional factors, which change depending on their level of development. The above-mentioned authors consider a variety of traditional factors such as the economic size of the country, its level of per capita income, commercial openness and specialisation, the productive structure, the degree of urbanisation, the illiteracy rate, the level of formality of the financial system or the degree of openness of the economy. Other factors that have been considered when it comes to explaining fiscal pressure are the existing tax structure (Feenberg and Rosen, 1987) and the government's ability to collect taxes (Eshag, 1983).

With regard to the literature on tax revenue potential there are significant differences. Whereas we can find many studies examining tax revenue potential, mainly in developing countries (Bahl, 1971; Tanzi, 1987; Leuthold, 1991; Gupta, 2007), comparatively, there are few works that analyse institutional and governance quality as a factor influencing tax collection and tax revenue potential.

According to the ideas of Tanzi and Davoodi (1997) and Gupta (2007), it can be said that low tax collection in developing countries results from the existence of these factors as citizens are allowed to unsuitable tax exemptions and there is tax evasion because of a poor tax administration. Consequently, in order to ensure appropriate revenue collection, it is necessary to have legitimate and responsive organisations which abide the law with control of corruption and high-quality bureaucracy to administer them.

Focusing on the economic restrictions that affect the government's capacity to enforce a specific tax rate on a specific tax base, Tanzi (1992) and Burgess and Stern (1993) consider that countries with a higher participation in agriculture and a lower participation in imports-to-GDP usually have lower taxation. Gordon and Li (2009) draw attention to the connection between taxation and formal finance. They defend that companies enjoy some incentives to evade taxes

by doing all their business in cash and in countries where the advantages of using the financial sector are low. Others have manifested that vast informal sectors in impoverished economies are innately difficult to tax, as discussed in the survey by Joshi et al. (2014). La Porta and Shleifer (2014) discussed the desire to avoid taxes as a relevant reason for informality.

Langford and Ohlenburg (2016) quantified the tax capacity for a 27-year panel of 85 non-resource-rich economies, using stochastic frontier analysis (SFA). Their study showed that corruption, law and order, and the level of democratic accountability all play a significant role in determining the extent to which a country's tax take reaches its potential. Mawejje and Sebudde (2019) provided estimates of tax potential and effort, using stochastic frontier methods in a panel of 150 countries around the world. Their results indicated that while there is marked heterogeneity in individual country outcomes, countries that operate closer to their tax potential have high levels of income, large shares of non-agricultural output, large trade shares in GDP, invest more in human capital development, have more developed financial sectors, more stable domestic environments (with low inflation), more urbanized populations, and lower corruption.

This paper attempts to contribute to the literature in this area by analysing in what sense the specific factors considered could influence tax burden and measuring the potential tax burden in OECD countries through parametric and nonparametric techniques. Specifically, we measure tax effort by an SFA model and by a DEA model, and we compare results. Our contribution then provides insights into the efficient and inefficient units, the benchmark groups, and potential avenues for a country's tax efficiency to be improved.

3. Methodology

We use the Generalized Method of Moments (GMM) to determine whether the tax burden is related to the exogenous variables such as the GDP per capita, trade openness, Gini index, unemployment, government expenditure on education, corruption, age dependency old and age dependency young, and to address possible endogeneity problems. Following this, we apply two different methods to analyse how the above factors contribute to efficiency: a non-parametric one, using a Data Envelopment Analysis (DEA) model, and a parametric one through a semi-parametric stochastic frontier analysis (SFA).

3.1. Data Envelopment Analysis (DEA)

The Data Envelopment Analysis (DEA) will be used to compute the tax efficiency scores. DEA is a linear programming method, introduced by Charnes, Cooper, and Rhodes (CCR) in 1978, which identifies the efficient frontier from the linear combination of multiple Decision-

Making Units (DMUs). It is a non-parametric technique that empirically quantifies the relative efficiency of those units. The efficiency is given by the distance from the observed position of the DMU to its production frontier considered as a benchmark to reach (Farrell, 1957). The CCR model assumes constant returns to scale (CRS). Banker, Charnes, and Cooper (BCC model) in 1984 include an additional convexity constraint to allow for variable returns to scale (VRS). In this study we adopt an output orientation⁶ and assume variable-returns to scale (VRS), to account for the fact that countries might not operate at the optimal scale increasing the inputs does not usually result in a proportional increase in output.

DEA⁷ is a deterministic model that provides guidance for inefficient units to become more efficient. Its main advantage lies in the fact that a priori no particular specification is required due to its non-parametric approach (Afonso, et al., 2021). Another consequence of this non-parametric feature is that there is no restriction on data distribution – as deterministic and stochastic parametric methods do –. DEA simultaneously provides both an efficiency score and benchmarking information. Indeed, each inefficient unit can be compared with its peers⁸. For each DMU, in our case each country, we consider the following function:

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

where Y_i is the output measure (tax burden ratio to GDP) and X_i are the relevant inputs (corruption, unemployment, and GDP) for each country.

If $Y_i < f(X_i)$, country i exhibits inefficiency; for the observed inputs levels, the actual output is smaller than the best attainable one (Afonso and Aubyn, 2013) and inefficiency is measured by computing the distance to the theoretical efficiency frontier.

Assuming that there are n DMUs, each producing single output by using m different inputs and the i^{th} DMU produces y_i units of output using x_{ki} units of the k^{th} inputs, the technical efficiency measure is obtained by solving the following linear program for each DMU in the sample (Banker et al., 1984):

⁶ Our analysis relies on assessing how much output quantities can be increased for a given level of input.

⁷ Charnes et al. (1978) originally proposed the efficiency measurement of the DMUs for constant returns to scale (CRS), where all DMUs are operating at their optimal scale. The variable returns to scale (VRS) efficiency measurement model was introduced by Banker et al. (1984) leading to the breakdown of technical efficiency into pure technical efficiency and scale-efficiency in DEA.

⁸ DEA identifies, for each inefficient firm, the closest efficient firms located on the frontier. These efficient firms are called peers or benchmarks.

$$\begin{aligned}
& \text{Max}_{\phi_i, \lambda_i} \phi_i \\
& \text{s. to:} \\
& \sum_{j=1}^n \lambda_j y_j \geq \phi_i y_i \quad (2) \\
& \sum_{j=1}^n \lambda_j x_{kj} \leq x_{ki} \\
& \sum_{j=1}^n \lambda_j = 1 \\
& \lambda_j \geq 0
\end{aligned}$$

where, $k = 1, \dots, m$ inputs; $j = 1, \dots, n$ DMUs; λ_j is the weight of the j^{th} DMU which provides information on the peers of the i^{th} unit, and ϕ_i provides information on the technical efficiency score of the i^{th} unit. ϕ_i is a scalar (that satisfies $1 \leq \phi_i < \infty$), and $\phi_i - 1$ is the proportional increase in outputs that could be achieved by the i^{th} DMU, with input quantities held constant. The value obtained of $1/\phi_i$ denotes the technical efficiency⁹ (TE) score for each DMU, which varies between zero and one. With this $1/\phi_i < 1$, the country is inside the frontier and so it is inefficient, while $\phi = 1$ implies that the country is on the frontier and hence it said to be technically efficient. First and second constraints of the Equation 2 generate a set of “peers” units with which a DMU unit is compared (level of frontier as a benchmark to reach). The vector λ is a $(n \times 1)$ vector of constants that measures the weights used to compute the location of an inefficient DMU if it were to become efficient.

The VRS case is defined by the third constraint ($\sum_{j=1}^n \lambda_j = 1$). This restriction imposes convexity of the frontier, causing the constant returns to scale (CRS) linear programming to become a variable returns. to scale (VRS) one. The frontier level of production for the i^{th} DMU, denoted by, $y^* = \sum_{j=1}^n \lambda_j = \phi_i y_i$. The output-oriented measure of technical efficiency of the i^{th} DMU, denoted by TE_i , can be calculated as: $TE_i = y_i / y_i^* = 1/\phi_i$, and the TE score measures the distance between a country and the efficiency frontier, defined as a linear combination of the best sampled countries (but not necessarily the best possible).

⁹ This is the output-orientated TE score reported by the computer program DEAP Version 2.1 which was written by Tim Coelli.

One of the advantages of DEA lies in its ability to calculate the production possibility frontier without imposing a functional form. However, this method also has some disadvantages. In particular, DEA is very sensitive to outliers, does not take into account data noise and measurement errors, and assumes homogeneity across countries in all aspects except efficiency and input quantities. These limitations demonstrate the importance of validating the robustness of the results using an alternative method. We therefore employ the SFA as an additional method, detailed in the next section.

Both efficiency measurement techniques provide valuable information on the sources of improvement. A relevant result is that both approaches yield similar results and conclusions, which highlights the robustness of our findings and addresses possible shortcomings of other studies that depend more on the methodology used.

3.2. *Stochastic Frontier Analysis (SFA)*

Since its initial development by Aigner et al. (1977) and Meeusen and van den Broeck (1977), stochastic frontier analysis (SFA) has been applied to examine the productivity and efficiency of production units in several economic sectors.

In contrast to deterministic frontier approaches and Data Envelopment Analysis (DEA) models, the stochastic frontier allows for the variance observed in a country's tax capacity to be attributed not only to inefficiencies in the tax system but also to incomplete model specification or country heterogeneity. This comparative advantage is important when analysing the tax burden, given that the complexity of the factors involved in its calculation is such that the factors which can be observed in practice make up only a small proportion of the whole. Consequently, whatever deviation that exists from potential tax revenue will contain a strong stochastic component, the identification of which will prove to be essential when drawing conclusions regarding possible sources of inefficiency.

We estimate tax effort according to stochastic frontier analysis (SFA). This model allows to separate random noise in the error term from the actual efficiency score. For each Decision-Making Unit (DMU), in our case each country, we consider the following function:

$$T_{it} = f(X_{it}; \beta) \cdot \xi_{it} \cdot e^{v_{it}}, i = 1, \dots, n \quad (3)$$

where T_{it} is the tax burden obtainable for country i at time t , $f(X_{it}; \beta)$ represents a scenario without inefficiency where tax policy is perfectly applied to maximize tax revenues and there are no random shocks to collection, X is a vector of inputs used to generate tax revenue, while β is the vector of parameters to be estimated.

This equation shows that any deviations from potential revenue are due to technical inefficiencies, ξ_{it} , and stochastic (random) shocks, $e^{v_{it}}$. A standard econometric representation of this equation is obtained by following the approach in Aigner et al. (1977), which will serve as the platform for the analysis carried out in this paper. Given $\xi_{it} = e^{-u_{it}}$, considering the above expressions and taking natural logarithms, we can obtain this equation:

$$\ln T_{it} = \ln f(X_{it}; \beta) + v_{it} - u_{it} \quad (4)$$

where $v_{it} - u_{it}$ is the composite error term, $v_{it} \sim N[0, \sigma_v^2]$ represents the random error and $u_{it} \sim N^+[0, \sigma_u^2]$ is the inefficiency term. Furthermore, we assume both components of the compound disturbance to be independent and identically distributed (i.i.d.) across observations.

Other alternative specifications can be considered for the inefficiency term, such as the truncated normal, two-parameter gamma, or exponential distributions. The selection among these specifications depends on the judgment of the researcher, as we do not have an objective criterion for selection. However, according to Battese and Coelli (1988), the semi-normal distribution is the most useful formulation we can use.

To measure the efficiency of each OECD countries we propose the tax effort (TE) concept, defined as the ratio of current tax revenues to the tax capacity represented by the estimated tax frontier:

$$TE_{it} = \frac{T_{it}}{T_{it}^*} = \frac{f(X_{it}; \beta) \cdot \xi_{it} \cdot e^{v_{it}}}{f(X_{it}; \beta) \cdot e^{v_{it}}} = \xi_{it} = e^{-u_{it}} \quad (5)$$

where ξ_{it} is the level of efficiency for each DMU and must be in the interval (0,1]. If $\xi_{it} = 1$, tax authorities are collecting the potential tax revenue, given the determinants factors captured in X . When $\xi_{it} < 1$, there is inefficiency in the process of tax collection, and tax revenue is less than potential.

4. Empirical Analysis

4.1. Data

To determine how the factors on which the tax burden depends influence in it, we use a panel data set that covers the OECD countries over the period 2000-2021. Therefore, we use as our dependent variable the tax burden, and as explanatory variables we base our choice in previous studies on the tax effort, whose literature is prolific. In this sense, among the variables that can initially be considered, we can mention the following:

GDP per capita

The Gross Domestic Product (GDP) per capita, expressed in constant 2015 international US dollars, is included in the model as a proxy for the level of development of a country.

As richer countries tend to collect more revenues, and similarly, countries tend to collect more revenues as they become more affluent, the sign of the coefficient on GDP per capita is expected to be positive (Le et. al., 2008). In addition to this, a high level of development brings more demand for public expenditure (Tanzi 1987) and a higher level of tax capacity to pay for that higher expenditure (Pessino and Fenochietto, 2010). Regarding to the direction of causation between tax capacity and the level of development, it is commonly assumed that income causes taxes (Tanzi and Zee, 2000). We retrieve our GDP per capita data in World Development Indicators, from the World Bank.

Trade openness

This variable reflects the degree of openness of an economy and can be calculated as imports plus exports as a percent of GDP. As Gupta (2007) notes, the impact of trade liberalisation on revenue mobilization can be ambiguous. When a country starts to liberalise its economy by reducing import and export taxes and increasing exports (often subject to a zero rate of VAT), it is possible that revenue may decline. Additionally, many nations (such as those in Central America and some parts of Asia) that have opened their economies have exempted their exports from income tax. Conversely, as Keen and Simone (2004) suggest, revenue might rise if trade liberalisation is accompanied by enhancements in customs procedures. Furthermore, reductions in tariffs and export taxes are often offset by compensatory measures, which can prevent an immediate drop in revenue. In the medium term, it is anticipated that revenue collection will increase due to higher VAT receipts from imports and enhanced economic activity. We obtain this data in World Development Indicators, from the World Bank.

Gini Index

The variable used to analyse the income distribution and inequality is the Gini Index. A better income distribution should facilitate collection as well as voluntary taxpayer compliance (Pessino and Fenochietto, 2010). These authors demonstrated the negative relationship between tax revenue as percent of GDP and Gini coefficient. Gini index is expressed on a scale from 1 (perfect inequality) to 0 (perfect equality) and transformed to $(1 - \text{Gini}) \times 100$. In this way, a higher index reflects more equality. The data can be consulted in Solt (2020).

Unemployment

Research suggests that unemployment and taxation are interconnected, with complex effects on the economy. Higher unemployment rates can lead to increased tax burdens as governments raise public transfer expenditures to support the unemployed (Celikay, 2020). Conversely, corporate taxation can impact unemployment levels, with studies showing that higher effective average corporate tax rates significantly increase unemployment (Zirgulis & Sarapovas, 2017). In turn, the unemployment rate is associated with the output gap, which may reflect the influence of the business cycle on tax collection levels. A negative relationship between the unemployment rate and the tax burden is to be expected. Unemployment rate, as a percentage of total labour force. The reciprocal value ($1/x$) is used, so a higher index implies lower unemployment, i.e. higher employment. The data are disposable the World Economic Outlook (WEO) database from International Monetary Fund.

Government expenditure on education

Another demographic component of a country's revenue capacity is the level of education, but its effect is ambiguous. On the one hand, when people are better educated, they have fewer problems to understand the relationship between public goods provision and the necessity of paying taxes to finance them (Pessino and Fenochietto, 2010). The more educated the workforce, the more value-added in the economy that can be taxed due to a larger formal sector and higher income (Langford and Ohlenburg, 2016). On the other hand, people with a higher level of education could find some ways on how to avoid paying taxes, and consequently, a negative effect of education on revenue collection should be expected (Cyan et al., 2013). Although both of these effects are possible, the first one is perhaps the more likely. We employ government expenditure on education data reported in World Development Indicators, from the World Bank.

Corruption

According to empirical evidence, a high level of corruption reduces revenues collection (Abed and Gupta, 2002). Bird et al. (2008) consider that taxpayers who have to face corruption are less inclined to pay taxes. Corruption also dissuades foreign investment, which affects economy activity and the tax base in a negative way. The level of corruption is measured with the Corruption is measured with the Corruption Perceptions Index (CPI). Corruption is expressed on a scale from 100 (Perceived to have low levels of corruption) to 0 (highly corrupt). The data corresponds to Transparency International's Corruption Perceptions Index (CPI).

Age dependency ratio (old and young)

As per the definition of the World Bank (2006), age dependency, measured as the ratio of dependents (people younger than 15 or older than 64) to the working-age population (those aged 15-64), is expected to have a negative effect on the tax base (Le et al., 2008). The higher the age dependency ratio, the lower the productive population and hence the narrower the tax base. Following these expectations, it is reasonable to predict that there is a negative correlation between both demographic features (population growth and age dependency ratio), and the tax and fiscal revenue collections. However, both younger population groups, and especially the elderly, require a considerable amount of public expenditure, which may force the imposition of higher tax burdens. The data of these two indicators can be found in the World Development Indicators, from the World Bank.

The definition and sources of the independent variables are presented in Table A1 of Appendix A (see that same appendix for matrix correlation and descriptive statistics).

4.2. Determinants of tax burden

As derived through the methodology presented in the previous section, we report in Table 1 the GMM results, to deal with potential endogeneity.

To analyse the impact of the determinants of the tax burden on it, we estimate a model with 11 specifications, in which the tax burden is the dependent variable. As explanatory variables of the tax burden, we sequentially introduce its determinants (the natural logarithm of GDP per capita, trade openness, the Gini index, the unemployment rate, government expenditure on education, the level of corruption, the old-age dependency ratio, and the youth dependency ratio) for models (1) to (8), respectively. Models (9) to (11) include all variables except the old-age and youth dependency ratios, which are introduced separately in models (10) and (11).

Empirical evidence suggests that the determinants of the tax burden mentioned above are statistically significant at the 1% level. However, not all of them affect it similarly. There is a positive relationship between the tax burden and the following variables: the natural logarithm of GDP per capita, trade openness, Gini index, government expenditure on education, the level of corruption, and the old-age dependency ratio. In contrast, the unemployment rate and the youth dependency ratio show a negative and statistically significant influence on the tax burden.

In model 9, the variables trade openness and corruption do not appear significant. In turn, in model 10, which includes the variables from model 9 and additionally considers the old-age dependency ratio as an explanatory variable, the relationship between this dependency ratio and

the tax burden is positive and significant at the 1% level, while the relationships with the other variables are similar to those found in the previous model. Model 11 adds the youth dependency ratio as an explanatory variable to model 9. The relationship between this variable and the tax burden is statistically significant at the 1% level, and the results for the remaining variables are analogous to those observed in model 9.

Table 1 – Determinants of the tax burden (GMM)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
<i>GDPpc</i>	6.781*** (0.028)								1.095*** (0.100)	0.977*** (0.103)	1.090*** (0.100)
<i>Trade</i>		0.053*** (0.000)							-0.000 (0.001)	0.001 (0.001)	-0.000 (0.001)
<i>Gini</i>			0.910*** (0.003)						0.873*** (0.008)	0.836*** (0.011)	0.845*** (0.010)
<i>Unemp</i>				-3.218*** (0.087)					-21.717*** (0.555)	-20.846*** (0.587)	-21.001*** (0.578)
<i>Exp_educ</i>					3.380*** (0.029)				1.149*** (0.043)	1.232*** (0.046)	1.232*** (0.046)
<i>Corruption</i>						0.167*** (0.002)			0.001 (0.004)	0.001 (0.004)	0.000 (0.004)
<i>Old</i>							1.089*** (0.004)			0.058*** (0.013)	
<i>Young</i>								-0.464*** (0.002)			-0.033*** (0.007)
Constant	-36.456*** (0.278)	27.611*** (0.039)	-30.629*** (0.223)	33.004*** (0.028)	15.759*** (0.150)	21.754*** (0.132)	9.220*** (0.088)	46.549*** (0.061)	-39.795*** (0.761)	-38.143*** (0.845)	-37.429*** (0.930)
Obs	1,724	1,699	1,577	1,428	1,336	1,024	1,795	1,795	872	872	872

Notes: *, **, and *** indicate the level of significance of 10%, 5% and 1%, respectively. In brackets we report the robust standard errors.

4.3. Non-parametric analysis

In a DEA model, the factors used (inputs and outputs) have a direct impact on the efficiency score. The choice of the variables corruption, unemployment and GDP pc as inputs is due to the fact that these variables are not only statistically significant but also because they are consistent in terms of the countries that are on the frontier over the years considered. Moreover, for instance, the perception of corruption allows us to study how a variable that a government could influence through voice and accountability can serve as an instrument to be more or less efficient in fiscal terms.

We report in Table 2 the output-oriented, variable returns to scale, technical efficiency scores for each country for the years 2000, 2008, 2010, and 2021. Eleven among the 38 countries analysed were estimated as efficient, being in the efficiency frontier, in 2000 and 2010, and ten in 2008 and 2021. The data in Table 4 reveal that the number of countries classified as efficient remained relatively consistent over time. Indeed Colombia, France, Hungary and Italy are always on the frontier, plus Belgium, Finland, Lithuania, Latvia, Poland, Slovak Republic, and Sweden in 2000. In 2008, the difference with respect to 2000 is that Finland, Lithuania and the Slovak Republic are no longer efficient, and countries such as Denmark, Spain and Mexico are considered as benchmark units. In 2010 the frontier is composed of the same countries as in 2008, excluding Belgium, Poland and Sweden and including Estonia, Greece and Latvia. Regarding 2021, the composition of the frontier is kept as in 2010, excepting Estonia and Latvia that will be replaced by Poland and Turkey. Moreover, apart from Mexico in 2008, 2010 and 2021, no other country shows up as efficient by default¹⁴, as can be seen by the listing of the respective peers, also reported in Table 2.

In addition, it is worth noting the improvement in technical efficiency over the sample period for the countries Denmark, Spain, Greece, and Turkey. The first two countries reached the efficiency frontier in 2008, Greece in 2010, and all three remain there until 2021, by which time Turkey will also have reached it. For its part, Poland was a benchmark unit in 2000 and 2008, ceased to be one in 2010, and became efficient again in 2021.

¹⁴ Ideally, the more units included in the sample the better the explanatory power of the DEA model; there will be fewer units found efficient by default.

Table 2. Output-oriented DEA VRS technical efficiency scores (output: tax burden; inputs: corruption, unemployment, and GDP pc)

Country	2000	Peers	Rank	2008	Peers	Rank	2010	Peers	Rank	2021	Peers	Rank
Australia	0.633	SWE BEL	31	0.602	DNK BEL	34	0.566	DNK ITA	35	0.649	DNK FRA	35
Austria	0.903	SWE BEL	14	0.94	HUN DNK BEL	12	0.936	ITA DNK HUN	16	0.95	DNK FRA	13
Belgium	1	BEL	1	1	BEL	1	0.995	DNK HUN ITA FRA	12	0.925	DNK FRA	14
Canada	0.711	FIN SWE SVK	27	0.714	DNK SWE BEL	30	0.712	HUN DNK FRA	30	0.748	DNK FRA	31
Switzerland	0.557	BEL SWE	36	0.581	BEL DNK	36	0.581	ITA DNK	34	0.607	FRA DNK	36
Chile	0.523	HUN POL SWE	37	0.57	HUN COL ESP	38	0.532	DNK HUN	38	0.655	GRC COL POL	34
Colombia	1	COL	1	1	COL	1	1	COL	1	1	COL	1
Costa Rica	0.607	HUN LTU	32	0.675	COL HUN	31	0.647	COL HUN	32	0.775	POL GRC COL	26
Czech Republic	0.877	ITA HUN SVK	16	0.828	BEL ITA HUN	21	0.834	DNK HUN ITA	20	0.872	FRA GRC	19
Germany	0.798	FRA SWE ITA SVK	21	0.846	FRA BEL	19	0.825	DNK ITA HUN	22	0.859	FRA DNK	20
Denmark	0.937	SWE	12	1	DNK	1	1	DNK	1	1	DNK	1
Spain	0.859	FIN SVK	17	1	ESP	1	1	ESP	1	1	ESP	1
Estonia	0.881	SVK SWE POL	15	0.771	DNK HUN	25	1	EST	1	0.828	FRA GRC	22
Finland	1	FIN	1	0.936	DNK SWE BEL	13	0.936	FRA DNK	16	0.953	DNK FRA	12
France	1	FRA	1	1	FRA	1	1	FRA	1	1	FRA	1
United Kingdom	0.671	HUN SWE BEL	29	0.734	DNK BEL	29	0.735	DNK ITA HUN	28	0.746	DNK FRA	32
Greece	0.858	SWE HUN ITA SVK	18	0.89	ITA HUN COL	16	1	GRC	1	1	GRC	1
Hungary	1	HUN	1	1	HUN	1	1	HUN	1	1	HUN	1
Ireland	0.67	SWE BEL	30	0.666	SWE DNK BEL	32	0.796	FRA EST	26	0.454	FRA DNK	38
Iceland	0.725	BEL SWE	25	0.769	DNK BEL	26	0.738	DNK FRA	27	0.771	FRA DNK	27
Israel	0.824	FIN ITA SVK	20	0.783	ESP HUN FRA	24	0.717	HUN DNK ITA	29	0.751	ITA FRA	30
Italy	1	ITA	1	1	ITA	1	1	ITA	1	1	ITA	1
Japan	0.575	SWE BEL HUN	34	0.629	DNK BEL HUN	33	0.619	DNK ITA HUN	33	0.764	FRA GRC	28
Korea	0.569	ITA SVK	35	0.571	BEL ITA HUN	37	0.548	DNK ITA HUN	37	0.687	FRA GRC ITA	33
Lithuania	1	LTU	1	0.875	ITA POL COL	17	0.955	LVA EST HUN	13	0.827	GRC POL	23
Luxembourg	0.763	SWE BEL	23	0.793	DNK BEL	23	0.805	DNK ITA	25	0.826	DNK FRA	24
Latvia	1	LVA	1	0.745	HUN ESP COL	28	1	LVA	1	0.826	GRC COL POL	24
Mexico	0.512	COL LVA	38	1	MEX	1	1	MEX	1	1	MEX	1
Netherlands	0.752	BEL SWE	24	0.814	HUN DNK BEL	22	0.81	ITA DNK HUN	23	0.844	FRA DNK	21
Norway	0.841	SWE BEL	19	0.934	BEL DNK	14	0.937	DNK ITA	15	0.903	FRA DNK	17
New Zealand	0.68	SWE HUN	28	0.76	DNK HUN	27	0.708	DNK HUN	31	0.758	FRA DNK	29
Poland	1	POL	1	1	POL	1	0.887	HUN COL	18	1	POL	1
Portugal	0.725	BEL HUN SWE	25	0.839	ESP FRA HUN	20	0.809	ITA EST FRA HUN	24	0.88	FRA GRC	18
Slovak Republic	1	SVK	1	0.982	ESP HUN COL	11	0.864	EST ITA LVA HUN	19	0.907	GRC POL	16
Slovenia	0.928	BEL SWE ITA HUN	13	0.897	DNK BEL HUN	15	0.946	DNK ITA HUN	14	0.914	FRA GRC ITA	15
Sweden	1	SWE	1	1	SWE	1	1	DNK FRA	1	0.973	FRA GRC	11
Turkey	0.791	LVA LTU COL	22	0.857	HUN ESP COL	18	0.832	COL HUN	21	1	TUR	1
United States	0.602	SWE BEL	33	0.588	BEL	35	0.564	FRA EST	36	0.597	FRA ITA	37
Average	0.81		0.81	0.831			0.838			0.849		
Countries on the frontier	11		11	10			11			10		
Max	1		1	1			1			1		
Min	0.512		0.512	0.57			0.532			0.454		

An opposite development can be observed for other countries. In this sense, Belgium and Sweden are on the frontier only in 2000 and 2008, while Latvia is on it only for the 2000 and 2010. Countries such as Finland, Slovakia, and Lithuania are reference units only in 2000. Something similar happens to Estonia and Denmark, which take part in the frontier in 2010 and will remain there only for this year.

The previous results also show that the capacity to improve output is rather stable over time. On average, the OECD countries could theoretically increase their output (tax burden) by 19% in 2000, by 16.9% in 2008, by 16.2% in 2010, and by 15.1% in 2021 to become efficient, with the existing mix of inputs at each time.

For instance, in 2000, Spain had an efficiency score of 85.9% with an effective tax burden of 33.05%. To be on the frontier, its projected output value¹⁵ should have been 37.71%. The effective tax burden could theoretically increase by 14.1% while keeping inputs unchanged. In this way, the tax effort, obtained by comparing the effective tax effort to the potential tax effort, would be equal to unity. For the rest of years, Spain is on the frontier and is thus deemed efficient.

We can also see that in 2000, Spain's peers were Finland and the Slovak Republic. Therefore, Spain is away from the efficient frontier because Finland, which has a tax burden of 45.76%, perceives the level of corruption in the public sector as very low (100), while in Spain, with a tax burden of 33.05%, this perception of corruption amounts to 75. Moreover, the level of unemployment is higher in Spain (13.86%) than in Finland (9.88%), where GDP per capita is also higher.

Another example is the case of Portugal in 2000, which had an efficiency score of 72.5% with an actual tax burden of 30.92%, so its potential tax burden could have reached 39.42%. For the years 2008, 2010, and 2021, this country had efficiency scores of 83.9%, 80.9%, and 88%, respectively. Taking into account that for each of these years the level of the tax burden was 31.74%, 30.37%, and 35.31%, we can conclude that the respective tax burdens could theoretically have been somewhat higher, around 36.85%, 36.17%, and 39.54% for the years mentioned above.

¹⁵ Since output-oriented DEA model, the capacity to improve output by 14.1% ($100 - 85.9$) is calculated according to the projected value based on the original output $[(37.71 - 33.05) / 37.71] \times 100 = 14.1\%$.

Table 3. Input-oriented DEA VRS technical efficiency scores (output: tax burden; inputs: corruption, unemployment, and GDP pc)

Country	2000	Rank	Peers	2008	Rank	Peers	2010	Rank	Peers	2021	Rank	Peers
Australia	0.816	35	COL LTU	0.813	35	HUN COL	0.813	35	COL HUN	0.847	34	GRC POL COL
Austria	0.908	20	SWE HUN	0.930	20	DNK HUN	0.948	18	DNK HUN	0.963	17	FRA GRC
Belgium	1.000	1	BEL	1.000	1	BEL	0.996	12	FRA DNK HUN ITA	0.952	21	FRA GRC
Canada	0.847	30	LTU HUN	0.849	31	HUN COL	0.856	32	HUN COL	0.893	30	GRC COL POL
Switzerland	0.772	38	COL LTU	0.779	38	COL HUN	0.785	38	HUN COL	0.812	37	POL COL
Chile	0.927	19	COL LTU	0.923	22	HUN COL	0.920	23	COL HUN	0.934	23	COL POL GRC
Colombia	1.000	1	COL	1.000	1	COL	1.000	1	COL	1.000	1	COL
Costa Rica	0.947	15	LTU COL	0.947	14	COL HUN	0.946	19	COL HUN	0.968	12	COL GRC
Czech Republic	0.943	17	POL LTU LVA	0.937	17	COL HUN	0.946	19	ITA HUN COL	0.967	14	GRC POL COL
Germany	0.870	25	HUN SWE POL	0.896	24	HUN ESP COL	0.880	25	HUN COL	0.923	24	POL GRC
Denmark	0.945	16	HUN SWE	1.000	1	DNK	1.000	1	DNK	1.000	1	DNK
Spain	0.884	23	HUN POL SWE	1.000	1	ESP	1.000	1	ESP	1.000	1	ESP
Estonia	0.954	14	LTU HUN	0.931	19	HUN COL	1.000	1	EST	0.954	20	GRC POL COL
Finland	1.000	1	FIN	0.920	23	DNK BEL HUN	0.940	21	DNK HUN	0.959	19	FRA GRC
France	1.000	1	FRA	1.000	1	FRA	1.000	1	FRA	1.000	1	FRA
United Kingdom	0.837	32	LTU HUN	0.849	31	HUN COL	0.857	30	HUN COL	0.891	31	GRC POL COL
Greece	0.906	21	LTU HUN POL	0.940	15	ITA HUN COL POL	1.000	1	GRC	1.000	1	GRC
Hungary	1.000	1	HUN	1.000	1	HUN	1.000	1	HUN	1.000	1	HUN
Ireland	0.824	34	COL LTU	0.829	34	HUN COL	0.857	30	LVA HUN COL	0.775	38	POL COL
Iceland	0.844	31	HUN LTU	0.842	33	HUN COL	0.848	34	HUN COL	0.882	33	GRC POL COL
Israel	0.871	24	HUN POL SWE	0.878	25	ESP COL HUN	0.871	26	HUN COL	0.890	32	GRC POL COL
Italy	1.000	1	ITA	1.000	1	ITA	1.000	1	ITA	1.000	1	ITA
Japan	0.830	33	COL LTU	0.851	30	COL HUN	0.855	33	HUN COL	0.910	26	POL COL
Korea	0.869	26	LVA LTU COL	0.865	28	COL HUN	0.861	29	HUN COL	0.896	29	COL POL
Lithuania	1.000	1	LTU	0.960	13	POL HUN COL	0.993	13	COL LVA HUN	0.963	17	GRC POL COL
Luxembourg	0.790	37	HUN LTU	0.793	37	HUN COL	0.802	37	HUN COL	0.843	35	POL COL GRC
Latvia	1.000	1	LVA	0.940	15	HUN COL	1.000	1	LVA	0.965	15	GRC COL POL
Mexico	0.970	13	COL	1.000	1	MEX	1.000	1	MEX	1.000	1	MEX
Netherlands	0.851	29	HUN LTU	0.861	29	HUN COL	0.868	27	HUN COL	0.911	25	POL GRC
Norway	0.855	27	SWE HUN	0.877	26	DNK HUN	0.914	24	DNK HUN	0.907	27	GRC FRA
New Zealand	0.855	27	HUN LTU	0.870	27	HUN COL	0.865	28	HUN COL	0.900	28	POL COL GRC
Poland	1.000	1	POL	1.000	1	POL	0.982	14	HUN COL	1.000	1	POL
Portugal	0.891	22	LTU HUN	0.934	18	ESP COL HUN	0.924	22	COL HUN LVA	0.968	12	GRC POL COL
Slovak Republic	1.000	1	SVK	0.990	11	ESP HUN COL	0.960	16	GRC HUN COL LVA	0.979	11	GRC COL POL
Slovenia	0.938	18	HUN POL SWE	0.929	21	HUN COL	0.958	17	HUN DNK	0.964	16	GRC POL
Sweden	1.000	1	SWE	1.000	1	SWE	1.000	1	DNK FRA	0.939	22	GRC FRA
Turkey	0.973	12	LTU COL	0.962	12	HUN COL	0.977	15	HUN COL	1.000	1	TUR
United States	0.805	36	COL LTU	0.808	36	HUN COL	0.808	36	HUN COL LVA	0.829	36	POL COL GRC
Average	0.914			0.919			0.927			0.936		
Countries on the frontier	11			10			11			10		
Max	1.000			1.000			1.000			1.000		
Min	0.772			0.779			0.785			0.775		

If we focus on Portugal in the year 2000, we can observe that the fiscal pressure of its peers is higher, namely Belgium with 43.85%, Hungary with 38.52% and Sweden with 50.03%,

compared to Portugal with 30.92%. In Sweden, with a value of 94, the perception of corruption is more favourable than in the case of Portugal 64. Moreover, its unemployment rate is lower than Portugal's, 15.76% compared to 21.19%, and its GDP per capita is also higher, 41.177,2 for Sweden, and 18.795,0 for Portugal.

As we can observe in the Table 3, the efficiency frontier is the same in an input or an output orientation under VRS, but technical efficiency scores have different values. However, Coelli and Perelman (1999) note that, in many instances, the choice of orientation has only a minor influence upon the technical efficiency scores calculated when VRS is assumed.

We conduct a sensitivity analysis using alternative specifications in the DEA calculations. First, we include only unemployment and corruption as inputs. Second, we include corruption and GDP (the results are reported in Tables B1 and B2 in the Online Appendix B).

Using a specification with two inputs, unemployment and corruption, several countries still show up the frontier in the same years as in the initial specification, such as Belgium, Denmark, Estonia, Finland, France, Greece, Italy, Latvia, Mexico, the Slovak Republic, and Sweden. Regarding Colombia, it remains efficient in all periods except in 2010. Now Hungary is a reference unit but only in 2008 and 2021 (not in all periods as before). Spain continues on the frontier in 2008 and 2010 (previously also in 2021). Additionally, Lithuania, Poland, and Turkey no longer belong to the efficiency frontier, while Japan and the United States enter it in the last period (2021).

Considering corruption and GDP, some countries appear on the frontier without changing the reference period. This is the case for Belgium, Colombia, Denmark, Greece, Hungary, Italy, Lithuania, Mexico, Poland, and the Slovak Republic. However, France is now efficient only in the last period, while Latvia and Sweden are efficient in the first period (as before) but no longer in 2008 and 2010. Additionally, Estonia, Spain, Finland, and Turkey are no longer on the efficiency frontier.

For the case of unemployment and corruption as inputs, the number of countries on the frontier ranges from eight in 2000 to nine in 2021, while if the inputs considered are corruption and GDP, this range goes from nine to eight. In both cases, the number of countries on the frontier is similar in number and composition. Indeed, in the former, in 2000, the countries composing the frontier were Belgium, Colombia, Finland, France, Italy, Latvia, Slovak Republic and Sweden, while in the latter Finland and France were replaced by Hungary, Lithuania and Poland. For the year 2021, in the first case, countries such as Colombia, Denmark, France, Greece, Hungary, Italy, Japan, Mexico and United States made up the frontier, while in the second one Japan and United State were swapped by Poland.

In addition to previous sensitivity analysis performed, to check the robustness of our results, we provide the estimations of the output and input oriented DEA model for the periods 2000-2021, considering the initial combination of inputs under variable returns scale (see Table B3 and B4 in the Online Appendix B).

4.4. Parametric analysis

Regarding our SFA, we use the following form of the frontier production function:

$$\ln T_{it} = \beta_0 + \beta_1 \ln \text{Corrup}_{it} + \beta_2 \ln \text{Unemp}_{it} + \beta_3 \ln \text{GDPpc}_{it} + v_{it} - u_{it} \quad (6)$$

where i and t index are countries and time, T_{it} is tax burden, Corrup, Unemp, GDP pc are, respectively, corruption, unemployment, and GDP pc.

The method of maximum likelihood is proposed for simultaneous estimation of the parameters of the stochastic frontier and the model for the technical inefficiency effects. The estimation of Equation 6 produces estimates for the following parameters: the β_s , the coefficients associated to the inputs. We report in Table 4 the results for the stochastic frontier estimation.¹⁶ We observe that the inefficiency component of the model is statistically significant at the 1% level. Indeed, the LR statistic equals 20.22, and the critical value at 1% for a mixed chi-square distribution with 2 degrees of freedom is 12.810 (according to the tabulation of Kodde and Palm, 1986). The gamma value (γ) of the MLEs of stochastic frontier production model is 0.983. This value is statistically significant and LR test will be greater than critical square value. Therefore, the null hypothesis of no technical efficiency will be rejected.

Table 4. Stochastic frontier estimation results

	Coefficient	SE	t-Statistic
Production function			
Constant	-2.194	0.362	-6.05***
lnCorrup	0.156	0.064	2.45*
lnUnemp	-0.086	0.032	-2.70**
lnGDPpc	0.122	0.032	3.81***
Inefficiency			
Sigma-squared	0.135	0.018	7.32***
Gamma	0.984	0.012	82.81***
LR statistic ($\gamma = 0$) [#]	20.22		
No. of observations	152		
No. of cross sections	38		

[#]Notes: The LR statistic critical value at 10 % for a mixed chi-square distribution with 2 degrees of freedom is 12.810, according to the tabulation of Kodde and Palm (1986). *, ** and *** denote levels of significance indication of 10%, 5% and 1%, respectively.

¹⁶ The model is estimated by maximum likelihood using the software Frontier, version 4.1c, written by Tim Coelli, available at <https://economics.uq.edu.au/cepa/software>.

Having determined that the statistical relationship between the tax burden and the variables corruption, unemployment and GDP pc is robust and significant, we study efficiency on the basis of these variables according to an SFA model.

The tax level to GDP pc elasticity is positive and highly significant. Hence if the GDP pc increases by 1%, it could increase the tax burden by 12.19%. The tax level to unemployment elasticity is also significant, but negative. A 1% increase in unemployment results in 8.63% decrease in the output. In turn, the effect of a lower level of corruption is positive and significant, a 1% decrease in corruption imply to a 15.57% increase in the output (variable corruption is measured from 0 to 100, the higher the index the lower the level of corruption). This implies that the GDP pc, unemployment rate and corruption variables are important contributors to improving the technical efficiency of the tax burden in OECD countries.

Table 5 presents the stochastic frontier estimates of technical efficiency per year, while Fig. 1 depicts the volatility in these efficiency measures per country. Notably, there are high correlations between the technical efficiency estimates derived from SFA (Table 5) and the Data Envelopment Analysis (DEA) efficiency scores reported earlier (Table 2). This suggests that a similar group of countries is nearer to the efficient production frontier.

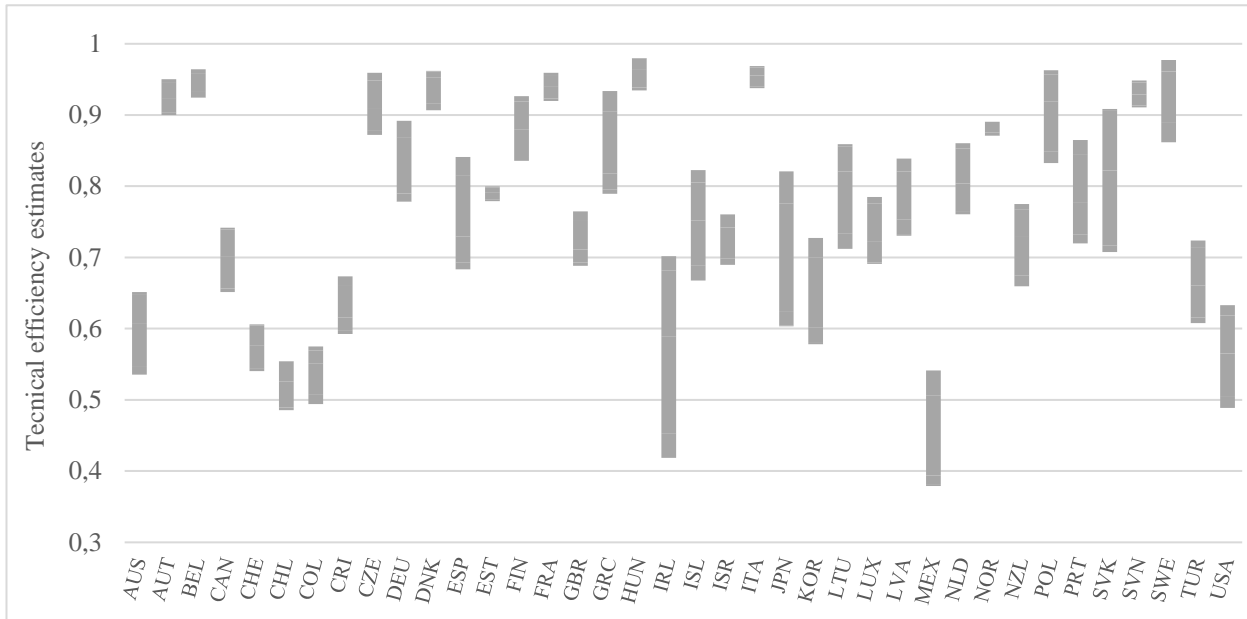
Moreover, the patterns for countries such as Austria, Belgium, the Czech Republic, Denmark, Finland, France, Greece, Hungary, Italy, Norway, Poland, Slovenia, and Sweden (towards the frontier) and Australia, Canada, Switzerland, Chile, Costa Rica, the United Kingdom, Ireland, Iceland, Japan, and Korea (away from the frontier) are also confirmed by the stochastic analysis. Indeed, as we have already mentioned in the DEA model (output- and input-oriented), France, Hungary, and Italy are on the frontier in all the years considered (2000, 2008, 2010, and 2021), plus Finland and the Slovak Republic in the first year, Belgium in the first two, Sweden in the first three, Greece in the last two years, Denmark in the last three, and Poland in the years 2000, 2008, and 2021.

Table 5. Stochastic frontier estimation results

Country	2000	2008	2010	2021	Average	Ranking
AUS	0.6513	0.5788	0.5355	0.6366	0.6006	32
AUT	0.9502	0.9132	0.8999	0.9340	0.9243	7
BEL	0.9643	0.9417	0.9242	0.9257	0.9390	5
CAN	0.7417	0.6712	0.6517	0.7309	0.6988	27
CHE	0.6059	0.5532	0.5405	0.6005	0.5750	34
CHL	0.4854	0.5507	0.5003	0.5542	0.5226	37
COL	0.4944	0.5749	0.5490	0.5525	0.5427	36
CRI	0.6136	0.6735	0.5927	0.6186	0.6246	31
CZE	0.8719	0.8886	0.8436	0.9308	0.8837	10
DEU	0.7993	0.7780	0.7806	0.8919	0.8125	15
DNK	0.9621	0.9468	0.9065	0.9589	0.9436	3
ESP	0.7343	0.7239	0.6832	0.8412	0.7456	22
EST	0.7892	0.7928	0.7792	0.7998	0.7902	18
FIN	0.9266	0.8630	0.8355	0.8953	0.8801	11
FRA	0.9461	0.9330	0.9200	0.9593	0.9396	4
GBR	0.7164	0.7058	0.6885	0.7645	0.7188	26
GRC	0.8217	0.7895	0.8145	0.9335	0.8398	13
HUN	0.9799	0.9759	0.9505	0.9348	0.9603	1
IRL	0.7020	0.6226	0.5567	0.4189	0.5750	33
ISL	0.8227	0.7510	0.6675	0.7527	0.7485	21
ISR	0.7606	0.7257	0.6897	0.7591	0.7338	23
ITA	0.9377	0.9619	0.9686	0.9491	0.9543	2
JPN	0.6078	0.6395	0.6034	0.8211	0.6679	28
KOR	0.5857	0.6179	0.5781	0.7273	0.6272	30
LTU	0.8590	0.8456	0.7121	0.7962	0.8032	17
LUX	0.7849	0.6989	0.6910	0.7466	0.7304	24
LVA	0.8389	0.7385	0.7307	0.7674	0.7689	20
MEX	0.3790	0.3900	0.3982	0.5415	0.4272	38
NLD	0.8295	0.7783	0.7608	0.8603	0.8072	16
NOR	0.8787	0.8905	0.8709	0.8721	0.8780	12
NZL	0.7184	0.7415	0.6594	0.7751	0.7236	25
POL	0.9005	0.9379	0.8323	0.9629	0.9084	8
PRT	0.7865	0.7691	0.7196	0.8648	0.7850	19
SVK	0.9085	0.7467	0.7074	0.8981	0.8152	14
SVN	0.9485	0.9208	0.9110	0.9370	0.9293	6
SWE	0.9775	0.9111	0.8690	0.8620	0.9049	9
TUR	0.7239	0.6390	0.6831	0.6081	0.6635	29
USA	0.6330	0.5552	0.4886	0.5754	0.5631	35
Mean	0.7799	0.7562	0.7235	0.7884		
Correlation ^{&}	0.7934	0.6187	0.6512	0.6403		

[&]Note: correlations with the DEA output-oriented TE scores in Table 4.

Fig. 1. SFA efficiency scores (2000, 2008, 2010, 2021)



According to Fig. 1, we can observe that the volatility of the technical efficiency measures in the years 2000, 2008, 2010, and 2021 (shown in Table 5) is much higher in countries such as Ireland, ranging from 0.4189 in 2021 to 0.7020 in 2000, than in other countries such as Norway, where it ranges from 0.8905 in 2008 to 0.8709 in 2010.

5. Conclusions

In this paper we assess tax burden efficiency in a panel of OECD countries, using a non-parametric approach by computing DEA and a parametric one by resorting to SFA. To this end, the study considers one output —tax burden— and three inputs —unemployment, corruption, and Gross Domestic Product per capita (GDP)— for the years 2000, 2008, 2010, and 2021. The results demonstrate robustness across both non-parametric and parametric methods. A contribution of this paper is thus to address the measurement of tax effort through two different approaches which give concordant results.

The countries that mostly show up as more efficient are, and closer to the production possibility frontier are: Belgium, Colombia, Finland, France, Italy, Latvia, Slovak Republic, and Sweden.

Our results show that improving the level of corruption is an essential factor to explain the tax burden efficiency. More specifically, comparing countries with their peers, we can observe that countries with a lower level of perception of corruption have higher tax burden. If this improvement in the level of corruption is accompanied by a lower unemployment rate and/or a

higher GDP pc, the difference in tax burden levels is even more pronounced than if corruption had not improved. Indeed, in order to explain international differences in tax burden we should consider not only variables representing the state of economy and tax handles, but also institutional factors such as corruption which also determine tax effort to a significant extent. If taxpayers believe that they live in a state in which corruption is rampant and trust in authority low, the willingness to vote for higher levels of taxation and comply with their tax obligations will decrease. In sum, the main policy implication of our overall set of results point to the crucial of decreasing the perception (and reality) of corruption to be more efficient in terms of tax burden, which it may not take longer nor be necessarily more difficult than changing the opportunities for tax handles and economic structure.

In this paper, based on the statistical analysis conducted, a set of significant variables has been selected to provide an explanation of the determination and evolution of tax burden levels. A detailed analysis focused on the experience of each country is beyond the scope of this paper. Other variables with a potentially significant impact, such as the degree of international tax competitiveness, the reaction of economic agents to tax measures, the resources of the tax administration, or the connection between taxation and social benefits, warrant consideration.

Regarding future work developments, a possible step further could be also to study the impact of factors such as financial education, also with a focus on tax education, on the efficiency of the tax system. Encouraging ‘voluntary’ compliance with tax obligations is currently a fundamental objective of tax administrations. In this way, we will be able to assess and calibrate the role that financial education can play in this respect, and which, supposedly, should translate into higher levels of tax burden.

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Appendix A: Data

Table A1: Variables and sources.

Variable	Source	Series
Tax revenue	OECD (1965-2021)	The tax burden is measured by taking the total tax revenues received as a percentage of GDP.
GDP per capita (Constant 2015 US\$)	World Bank, World Development Indicators (1960-2022)	GDP per capita is gross domestic product divided by midyear population. Transformed to ln GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2015 U.S. dollars.
Trade	World Bank, World Development Indicators (1960-2022)	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
Gini Index	Solt, Frederick. 2020. "Measuring Income Inequality Across Countries and Over Time: The Standardized World Income Inequality Database." <i>Social Science Quarterly</i> 101(3):1183-1199. SWIID Version 9.3, June 2022. (1960-2022)	Gini index on a scale from 1 (perfect inequality) to 0 (perfect equality). (Transformed to $1 - \text{Gini}$) $\times 100$
Unemployment	IMF World Economic Outlook (WEO database) (1980-2022)	Unemployment rate, as a percentage of total labour force. Reciprocal value $1/x$
Government expenditure on education, total	World Bank, World Development Indicators (1960-2022)	General government expenditure on education (current, capital, and transfers) is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government. General government usually refers to local, regional and central governments.
Corruption	Transparency International's Corruption Perceptions Index (CPI) (2003 - 2022)	Corruption on a scale from 100 (Perceived to have low levels of corruption) to 0 (highly corrupt).
Age dependency ratio, old (% of working-age population)	World Bank, World Development Indicators (1960-2022)	Age dependency ratio, old, is the ratio of older dependents--people older than 64--to the working-age population--those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population.
Age dependency ratio, young (% of working-age population)	World Bank, World Development Indicators (1960-2022)	Age dependency ratio, young, is the ratio of younger dependents--people younger than 15--to the working-age population--those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population.

Table A2: Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
taxburden	1795	31.418	8.512	9.047	50.286
trade	1903	74.348	49.141	5.727	388.12
gini	1788	0.684	0.071	0.468	0.806
corruption	1064	65.365	21.084	0.000	100
age dependency old	2394	18.999	6.858	5.748	51.194
age dependency young	2394	36.171	14.583	16.313	95.840
unemp	1535	0.239	0.761	0.036	24.390
real_gdppc	1983	26778.588	19507.86	1027.655	112417.880
exp_educ	1364	4.972	1.245	1.113	8.614
lnreal_gdppc	1983	9.898	0.842	6.935	11.630
gini100	1788	68.355	7.140	46.800	80.600

Table A3: Matrix correlation.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) taxburden	1.000								
(2) trade	0.302	1.000							
(3) corruption	0.403	0.073	1.000						
(4) age_dep_old	0.662	0.314	0.319	1.000					
(5) age_dep_young	-0.600	-0.392	-0.236	-0.752	1.000				
(6) unemp	-0.104	0.046	0.250	-0.026	0.023	1.000			
(7) exp_educ	0.543	0.049	0.428	0.199	-0.214	-0.050	1.000		
(8) lnreal_gdppc	0.572	0.362	0.759	0.652	-0.689	0.203	0.437	1.000	
(9) gini100	0.714	0.295	0.429	0.517	-0.555	0.094	0.359	0.584	1.000

Online Appendix B: Additional Estimates

Table B1: Output-oriented DEA VRS technical efficiency scores (output: tax burden; inputs: unemployment and corruption)

Country	2000	Rank	Peers	2008	Rank	Peers	2010	Rank	Peers	2021	Rank	Peers
Australia	0.633	31	SWE BEL	0.602	33	BEL DNK	0.566	33	DNK ITA	0.832	24	JPN FRA
Austria	0.903	12	SWE BEL	0.939	11	BEL DNK	0.932	14	DNK ITA	0.950	11	FRA DNK
Belgium	1.000	1	BEL	1.000	1	BEL	0.994	10	FRA DNK ITA	0.925	14	DNK FRA
Canada	0.709	25	FRA FIN SWE	0.711	30	SWE DNK BEL	0.705	28	DNK FRA	0.750	30	DNK FRA
Switzerland	0.557	35	BEL SWE	0.581	35	BEL DNK	0.581	32	ITA DNK	0.607	35	DNK FRA
Chile	0.430	38	FIN FRA ITA	0.520	38	FRA ESP	0.456	38	FRA DNK ITA	0.501	37	FRA ITA
Colombia	1.000	1	COL	1.000	1	COL	0.560	35	GRC	1.000	1	COL
Costa Rica	0.500	37	BEL ITA	0.566	36	BEL ITA	0.538	36	FRA ESP ITA	0.585	36	FRA ITA
Czech Republic	0.837	18	ITA SVK	0.794	22	BEL ITA	0.766	24	DNK ITA	0.837	23	ITA GRC
Germany	0.796	21	FRA SWE ITA	0.846	18	BEL FRA	0.808	18	DNK ITA	0.848	21	DNK FRA
Denmark	0.937	9	SWE	1.000	1	DNK	1.000	1	DNK	1.000	1	DNK
Spain	0.859	15	FIN SVK	1.000	1	ESP	1.000	1	ESP	0.873	18	FRA ITA
Estonia	0.828	19	FIN SVK	0.726	29	BEL ITA	1.000	1	EST	0.735	32	DNK FRA
Finland	1.000	1	FIN	0.936	12	SWE DNK BEL	0.936	13	FRA DNK	0.939	12	FRA DNK
France	1.000	1	FRA	1.000	1	FRA	1.000	1	FRA	1.000	1	FRA
United Kingdom	0.670	27	SWE BEL	0.734	28	BEL DNK	0.731	26	DNK ITA	0.777	28	JPN FRA
Greece	0.848	16	ITA FIN SVK	0.890	15	ITA COL HUN	1.000	1	GRC	1.000	1	GRC
Hungary	0.920	11	BEL ITA	1.000	1	HUN	0.978	11	LVA ESP ITA	1.000	1	HUN
Ireland	0.670	27	SWE BEL	0.666	31	SWE DNK BEL	0.796	22	FRA EST	0.454	38	DNK FRA
Iceland	0.725	24	SWE BEL	0.769	25	BEL DNK	0.738	25	DNK FRA	0.771	29	DNK FRA
Israel	0.824	20	ITA FIN SVK	0.783	24	HUN FRA ESP	0.706	27	FRA DNK ITA	0.824	26	ITA JPN USA
Italy	1.000	1	ITA	1.000	1	ITA	1.000	1	ITA	1.000	1	ITA
Japan	0.571	33	SWE BEL	0.621	32	BEL	0.598	31	DNK ITA	1.000	1	JPN
Korea	0.569	34	ITA SVK	0.558	37	BEL ITA	0.526	37	DNK ITA	0.684	34	FRA ITA
Lithuania	0.875	14	FIN ITA SVK	0.825	20	ITA COL	0.922	15	LVA ESP ITA	0.741	31	FRA ITA
Luxembourg	0.763	22	SWE BEL	0.793	23	BEL DNK	0.805	19	DNK ITA	0.826	25	DNK FRA
Latvia	1.000	1	LVA	0.745	26	ESP COL HUN	1.000	1	LVA	0.711	33	FRA ITA
Mexico	0.512	36	COL LVA	1.000	1	MEX	1.000	1	MEX	1.000	1	MEX
Netherlands	0.752	23	SWE BEL	0.812	21	BEL SWE DNK	0.802	21	DNK ITA	0.841	22	FRA DNK
Norway	0.841	17	SWE BEL	0.934	14	BEL DNK	0.937	12	DNK ITA	0.931	13	DNK FRA
New Zealand	0.650	30	SWE	0.738	27	DNK SWE	0.677	29	DNK	0.880	17	JPN FRA
Poland	0.930	10	FIN ITA SVK	0.936	12	ITA COL HUN	0.785	23	FRA ESP ITA	0.866	20	ITA
Portugal	0.696	26	SWE BEL	0.834	19	FRA HUN ESP	0.804	20	ESP FRA ITA	0.812	27	FRA ITA
Slovak Republic	1.000	1	SVK	0.982	10	ESP COL HUN	0.863	17	LVA ESP ITA	0.870	19	ITA GRC
Slovenia	0.887	13	BEL ITA	0.865	16	BEL ITA	0.876	16	DNK ITA	0.892	16	FRA ITA
Sweden	1.000	1	SWE	1.000	1	SWE	1.000	1	FRA DNK	0.920	15	DNK FRA
Turkey	0.661	29	SVK ITA	0.856	17	HUN ESP COL	0.668	30	LVA ESP ITA	0.982	10	GRC MEX COL
United States	0.602	32	SWE BEL	0.588	34	BEL	0.564	34	FRA EST	1.000	1	USA
Average Countries on the frontier	0.788	8		0.82	9		0.806	9		0.846	9	
Max	1.000			1.000			1.000			1.000		
Min	0.430			0.520			0.456			0.454		

Table B2: Output-oriented DEA VRS technical efficiency scores (output: tax burden; inputs: corruption and GDP pc)

Country	2000	Rank	Peers	2008	Rank	Peers	2010	Rank	Peers	2021	Rank	Peers
Australia	0.633	31	SWE BEL	0.602	34	DNK BEL	0.566	35	DNK ITA	0.649	34	FRA DNK
Austria	0.903	14	BEL SWE	0.940	10	DNK BEL HUN	0.936	12	ITA DNK HUN	0.950	9	DNK FRA
Belgium	1.000	1	BEL	1.000	1	BEL	0.992	7	ITA DNK HUN	0.925	11	DNK FRA
Canada	0.702	27	HUN SWE	0.711	30	DNK HUN	0.711	29	HUN DNK	0.744	32	DNK FRA
Switzerland	0.557	36	SWE BEL	0.581	36	BEL DNK	0.581	34	DNK ITA	0.607	36	DNK FRA
Chile	0.500	38	LTU HUN	0.557	38	HUN COL	0.532	38	HUN DNK	0.646	35	POL COL
Colombia	1.000	1	COL	1.000	1	COL	1.000	1	COL	1.000	1	COL
Costa Rica	0.607	32	HUN LTU	0.675	31	HUN COL	0.647	31	HUN COL	0.764	27	COL POL
Czech Republic	0.877	15	HUN ITA SVK	0.828	15	BEL ITA HUN	0.834	17	ITA DNK HUN	0.872	18	GRC FRA
Germany	0.784	20	SWE BEL HUN	0.824	16	DNK BEL HUN	0.825	19	ITA DNK HUN	0.859	19	FRA DNK
Denmark	0.937	11	SWE	1.000	1	DNK	1.000	1	DNK	1.000	1	DNK
Spain	0.745	24	SWE BEL HUN	0.762	23	BEL ITA HUN	0.763	25	ITA DNK HUN	0.897	16	FRA GRC
Estonia	0.791	18	HUN SWE	0.771	20	DNK HUN	0.870	15	HUN DNK	0.828	22	GRC FRA
Finland	0.926	13	SWE HUN	0.928	12	DNK HUN	0.924	13	DNK HUN	0.935	10	DNK FRA
France	0.971	10	BEL SWE HUN	0.982	9	BEL ITA HUN	0.988	8	ITA DNK HUN	1.000	1	FRA
United Kingdom	0.671	29	SWE BEL HUN	0.734	28	DNK BEL	0.735	26	ITA DNK HUN	0.746	31	DNK FRA
Greece	0.841	16	BEL ITA HUN	0.819	17	ITA COL POL	1.000	1	GRC	1.000	1	GRC
Hungary	1.000	1	HUN	1.000	1	HUN	1.000	1	HUN	1.000	1	HUN
Ireland	0.670	30	SWE BEL	0.664	32	DNK BEL	0.630	32	ITA DNK	0.454	38	FRA DNK
Iceland	0.725	25	SWE BEL	0.769	22	BEL DNK	0.727	27	DNK ITA	0.771	26	DNK FRA
Israel	0.772	21	SWE BEL HUN	0.743	25	BEL ITA HUN	0.717	28	ITA DNK HUN	0.751	30	FRA ITA
Italy	1.000	1	ITA	1.000	1	ITA	1.000	1	ITA	1.000	1	ITA
Japan	0.575	34	BEL SWE HUN	0.629	33	DNK BEL HUN	0.619	33	ITA DNK HUN	0.764	27	FRA GRC
Korea	0.569	35	ITA SVK	0.571	37	BEL ITA HUN	0.548	36	ITA DNK HUN	0.687	33	GRC FRA ITA
Lithuania	1.000	1	LTU	0.875	14	ITA POL COL	0.777	22	HUN COL	0.827	23	GRC POL
Luxembourg	0.763	22	BEL SWE	0.793	19	DNK BEL	0.805	21	DNK ITA	0.826	24	FRA DNK
Latvia	1.000	1	LVA	0.716	29	HUN ITA POL	0.862	16	ITA COL HUN	0.819	25	POL GRC
Mexico	0.512	37	COL LVA	1.000	1	MEX	1.000	1	MEX	1.000	1	MEX
Netherlands	0.752	23	BEL SWE	0.813	18	DNK HUN	0.810	20	ITA DNK HUN	0.844	21	FRA DNK
Norway	0.841	16	BEL SWE	0.934	11	BEL DNK	0.937	11	DNK ITA	0.903	15	FRA DNK
New Zealand	0.680	28	SWE HUN	0.760	24	DNK HUN	0.708	30	DNK HUN	0.758	29	DNK FRA
Poland	1.000	1	POL	1.000	1	POL	0.887	14	HUN COL	1.000	1	POL
Portugal	0.725	25	SWE BEL HUN	0.771	20	DNK BEL HUN	0.765	24	ITA DNK HUN	0.880	17	GRC FRA
Slovak Republic	1.000	1	SVK	0.738	27	HUN POL ITA	0.768	23	ITA HUN COL	0.907	13	GRC POL
Slovenia	0.928	12	BEL ITA HUN	0.897	13	DNK BEL HUN	0.946	10	ITA DNK HUN	0.914	12	FRA ITA GRC
Sweden	1.000	1	SWE	0.990	8	HUN DNK	0.964	9	HUN DNK	0.907	13	DNK FRA
Turkey	0.791	18	LTU COL LVA	0.741	26	HUN COL	0.832	18	HUN COL	0.850	20	HUN MEX
United States	0.602	33	BEL SWE	0.588	35	BEL	0.537	37	ITA DNK	0.597	37	FRA ITA
Average Countries on the frontier	0.799	9		0.808	7		0.809	6		0.839	8	
Max	1.000			1.000			1.000			1.000		
Min	0.500			0.557			0.532			0.454		

Table B3: Output-oriented DEA VRS technical efficiency scores: 2000 - 2021 (output: tax burden; inputs: corruption, unemployment, and GDP pc)

Country	2000-2010	Rank	Peers	2011-2021	Rank	Peers
Australia	0.629	33	SWE BEL DNK	0.608	33	FRA DNK
Austria	0.935	14	DNK BEL HUN	0.933	11	FRA DNK
Belgium	1.000	1	BEL	0.961	8	DNK FRA
Canada	0.729	29	POL SWE FRA HUN	0.716	28	FRA DNK
Switzerland	0.570	36	ITA DNK	0.589	35	FRA DNK
Chile	0.559	38	POL HUN SWE	0.578	36	GRC HUN COL
Colombia	1.000	1	COL	1.000	1	COL
Costa Rica	0.667	31	HUN COL	0.737	27	HUN COL GRC
Czech Republic	0.868	18	HUN ITA POL	0.857	18	ITA FRA HUN
Germany	0.824	23	SWE FRA	0.828	20	DNK FRA
Denmark	1.000	1	DNK	1.000	1	DNK
Spain	0.930	15	FRA SVK	0.891	14	FRA GRC
Estonia	0.839	22	HUN POL SWE	0.827	21	GRC FRA HUN
Finland	0.980	12	SWE FRA	0.943	9	FRA DNK
France	1.000	1	FRA	1.000	1	FRA
United Kingdom	0.716	30	BEL SWE DNK HUN	0.715	29	DNK FRA
Greece	0.923	16	POL ITA	1.000	1	GRC
Hungary	1.000	1	HUN	1.000	1	HUN
Ireland	0.665	32	ITA DNK	0.536	38	DNK FRA
Iceland	0.775	26	DNK SWE	0.807	24	FRA DNK
Israel	0.858	20	FRA SVK	0.699	31	FRA ITA
Italy	1.000	1	ITA	1.000	1	ITA
Japan	0.598	34	DNK BEL HUN	0.682	32	HUN FRA
Korea	0.568	37	HUN ITA POL	0.592	34	FRA HUN ITA
Lithuania	0.862	19	POL HUN COL	0.794	26	GRC COL HUN
Luxembourg	0.801	24	DNK ITA	0.810	23	FRA DNK
Latvia	0.847	21	POL ITA	0.857	18	GRC COL HUN
Mexico	1.000	1	MEX	1.000	1	MEX
Netherlands	0.785	25	SWE DNK HUN	0.827	21	FRA DNK
Norway	0.915	17	DNK ITA	0.863	15	FRA DNK
New Zealand	0.750	28	SWE HUN	0.702	30	FRA DNK
Poland	1.000	1	POL	0.908	12	HUN COL
Portugal	0.761	27	FRA SWE BEL HUN	0.863	15	FRA HUN GRC
Slovak Republic	1.000	1	SVK	0.858	17	FRA HUN GRC
Slovenia	0.942	13	BEL DNK HUN	0.907	13	FRA HUN
Sweden	1.000	1	SWE	0.941	10	FRA DNK
Turkey	1.000	1	TUR	0.799	25	COL GRC HUN
United States	0.583	35	DNK ITA	0.563	37	FRA DNK
Average	0.839			0.821		
Countries on the frontier	11			7		
Max	1.000			1.000		
Min	0.559			0.536		

Table B4: Input-oriented DEA VRS technical efficiency scores: 2000 - 2021 (output: tax burden; inputs: corruption, unemployment, and GDP pc)

Country	2000-2010	Rank	Peers	2011-2021	Rank	Peers
Australia	0.820	35	HUN COL	0.828	34	HUN COL
Austria	0.941	20	SWE HUN	0.947	21	FRA HUN
Belgium	1.000	1	BEL	0.971	10	FRA HUN
Canada	0.855	30	POL HUN COL	0.877	27	HUN COL GRC
Switzerland	0.780	38	COL HUN	0.797	38	COL HUN
Chile	0.922	21	HUN COL	0.923	23	HUN COL
Colombia	1.000	1	COL	1.000	1	COL
Costa Rica	0.947	17	COL HUN	0.953	18	GRC COL HUN
Czech Republic	0.947	17	POL HUN COL	0.952	19	HUN COL
Germany	0.881	25	HUN SWE POL	0.896	24	FRA HUN
Denmark	1.000	1	DNK	1.000	1	DNK
Spain	0.900	23	SWE POL HUN	0.960	14	COL GRC
Estonia	0.946	19	POL HUN COL	0.952	19	HUN COL GRC
Finland	0.975	13	FRA POL SWE	0.957	17	GRC FRA HUN
France	1.000	1	FRA	1.000	1	FRA
United Kingdom	0.849	32	HUN COL	0.867	33	HUN COL
Greece	0.955	15	TUR POL	1.000	1	GRC
Hungary	1.000	1	HUN	1.000	1	HUN
Ireland	0.828	34	COL HUN	0.813	37	HUN COL GRC
Iceland	0.853	31	HUN COL	0.869	32	HUN COL
Israel	0.878	26	POL HUN COL	0.875	28	HUN COL
Italy	1.000	1	ITA	1.000	1	ITA
Japan	0.843	33	HUN COL	0.879	26	HUN COL
Korea	0.863	28	COL HUN	0.872	30	HUN COL
Lithuania	0.977	12	HUN COL POL	0.958	16	HUN COL GRC
Luxembourg	0.800	37	COL HUN	0.828	34	GRC HUN COL
Latvia	0.964	14	HUN COL POL	0.972	9	HUN GRC COL
Mexico	1.000	1	MEX	1.000	1	MEX
Netherlands	0.861	29	HUN COL	0.895	25	HUN FRA GRC
Norway	0.896	24	HUN SWE	0.872	30	FRA HUN
New Zealand	0.870	27	HUN COL	0.875	28	HUN COL
Poland	1.000	1	POL	0.984	8	COL HUN
Portugal	0.910	22	HUN COL	0.961	13	GRC HUN COL
Slovak Republic	1.000	1	SVK	0.968	11	HUN COL GRC
Slovenia	0.948	16	SWE HUN	0.959	15	GRC HUN COL
Sweden	1.000	1	SWE	0.943	22	GRC FRA HUN
Turkey	1.000	1	TUR	0.965	12	GRC COL HUN
United States	0.806	36	HUN COL	0.819	36	COL HUN
Average	0.921			0.926		
Countries on the frontier	11			7		
Max	1.000			1.000		
Min	0.780			0.797		