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# Measuring Tax Burden Efficiency in OECD countries: an International Comparison[a]

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**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.

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

**JEL Codes:** C14; C23; H20; H21; H30.

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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 revenues[1] 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 index[2] and the Bird index[3].

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 x POP)/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 at 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 Frank[5] (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 orientation[6] 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.

DEA[7] 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 peers[8]. For each DMU, in our case each country, we consider the following function:

$$Y_i = f\ (X_i),\ \ i\ =\ 1, \ldots, \mathrm{n} \qquad (1)$$

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):

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[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.

$$\text{Max}_{\phi_i,\lambda_i}\ \phi_i$$

s. to:

$$\sum_{j=1}^{n} \lambda_j y_j \geq \phi_i \text{y}_\text{i} \qquad (2)$$

$$\sum_{j=1}^{n} \lambda_j x_{kj} \leq x_{ki}$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0$$

where, k= 1, … m inputs; j = 1, … n DMUs; $\lambda_j$is the weight of the j$^{th}$ DMU which provides information on the peers of the i$^{th}$ unit, and $\phi_i$ provides information on the technical efficiency score of the i$^{th}$ unit. $\phi_i$ 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 efficiency[9] (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 x 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*= $\sum_{j=1}^{n} \lambda_j = \phi_i \text{y}_{i.}$ The output-oriented measure of technical efficiency of the ith DMU, denoted by TE$_i$, can be calculated as: TE$_i$ = ${\text{y}_i}/{y_i^*} = 1/\phi_i$, 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:

$$T_{it} = f\left(X_{it;}\ \beta\right) \cdot \xi_{it} \cdot e^{v_{it}}\ ,\ i = 1, \ldots, n \qquad (3)$$

where $T_{it}$ is the tax burden obtainable for country $i$ at time t, $f\left(X_{it;}\ \beta\right)$ 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 $\beta$ is the vector of parameters to be estimated.

This equation shows that any deviations from potential revenue are due to technical inefficiencies, $\xi_{it}$, 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:

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

where $v_{it} - u_{it}$ is the composite error term, $v_{it} \sim \mathrm{N}[0, \sigma_v^2]$ represents the random error and $u_{it} \sim \mathrm{N}^+[0, \sigma_u^2]$ 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:

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

where $\xi_{it}$ 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 - Gini) x 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) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *GDPpc* | 6.781*** | | | | | | | | 1.095*** | 0.977*** | 1.090*** |
| | (0.028) | | | | | | | | (0.100) | (0.103) | (0.100) |
| *Trade* | | 0.053*** | | | | | | | -0.000 | 0.001 | -0.000 |
| | | (0.000) | | | | | | | (0.001) | (0.001) | (0.001) |
| *Gini* | | | 0.910*** | | | | | | 0.873*** | 0.836*** | 0.845*** |
| | | | (0.003) | | | | | | (0.008) | (0.011) | (0.010) |
| *Unemp* | | | | -3.218*** | | | | | -21.717*** | -20.846*** | -21.001*** |
| | | | | (0.087) | | | | | (0.555) | (0.587) | (0.578) |
| *Exp_educ* | | | | | 3.380*** | | | | 1.149*** | 1.232*** | 1.232*** |
| | | | | | (0.029) | | | | (0.043) | (0.046) | (0.046) |
| *Corruption* | | | | | | 0.167*** | | | 0.001 | 0.001 | 0.000 |
| | | | | | | (0.002) | | | (0.004) | (0.004) | (0.004) |
| *Old* | | | | | | | 1.089*** | | | 0.058*** | |
| | | | | | | | (0.004) | | | (0.013) | |
| *Young* | | | | | | | | -0.464*** | | | -0.033*** |
| | | | | | | | | (0.002) | | | (0.007) |
| Constant | -36.456*** | 27.611*** | -30.629*** | 33.004*** | 15.759*** | 21.754*** | 9.220*** | 46.549*** | -39.795*** | -38.143*** | -37.429*** |
| | (0.278) | (0.039) | (0.223) | (0.028) | (0.150) | (0.132) | (0.088) | (0.061) | (0.761) | (0.845) | (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 default[14], 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.

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[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 value[15] 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) x 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:

$$\ln T_{it} = \beta_0 + \beta_1 \ln Corrup_{it} + \beta_2 \ln Unemp_{it} + \beta_3 \ln GDPpc_{it} + v_{it} - u_{it} \quad (6)$$

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 $\beta_s$, 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 (γ =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.

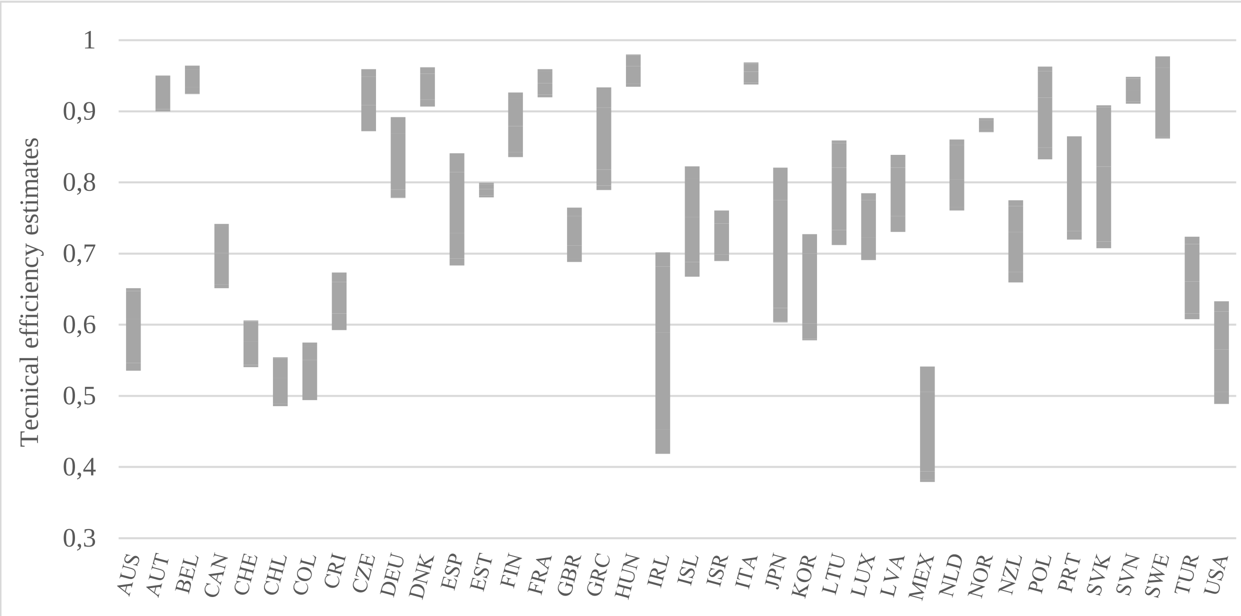
Moreover, the patterns for countries such as Austria, Belgium, the Czech Republic, Denmark, Finland, France, Greece, Hungary, Italy, Norway, Poland, Slovenia, and Sweden (towards the frontier) and Australia, Canada, Switzerland, Chile, Costa Rica, the United Kingdom, Ireland, Iceland, Japan, and Korea (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." *Social Science Quarterly* 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 - Gini) x 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 | 0.788 | | | 0.82 | | | 0.806 | | | 0.846 | | |
| Countries on the frontier | 8 | | | 9 | | | 9 | | | 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 | 0.799 | | | 0.808 | | | 0.809 | | | 0.839 | | |
| Countries on the frontier | 9 | | | 7 | | | 6 | | | 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 | | |