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Countries' Tax Effort: Disentangling the Frontier Tax Gap

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ABSTRACT

Using Stochastic Frontier Analysis, this paper updates, for 123 countries, the estimates of tax capacity—defined as the maximum level of revenue a country can feasibly achieve—and tax effort—measured as the ratio of actual tax revenue to tax capacity.

It also introduces two novel models that decompose the frontier tax gap—the difference between actual tax revenues and tax capacity—into tax policy and tax administration components. Assessing tax effort is essential before introducing new taxes or raising existing ones, as it helps determine the scope for additional revenue mobilization within the current system. The frontier tax gap decomposition thus provides a rigorous diagnostic framework for identifying where reform efforts should be initiated and where they should be most effectively targeted.

JEL Classification Numbers: C23; C51; H11; H21
Key words: Tax Capacity; Tax Effort; Tax Revenue; Revenue Mobilization; Taxation and growth.

Contents

Glossary

AETR	Average effective tax rate
BCHN	Battese and Coelli's half-normal original formulation
BTS	Benchmark tax system
CEP	Council on Economic Policies
COR	Corruption perception index of Transparency International
CPI	Consumer Price Index
DEA	Data Envelopment Analysis
EU	European Union
FTG	Frontier tax gap
FIML	Full Information Maximum Likelihood
GDP	Gross Domestic Product per capita
GTED	Global Tax Expenditures Database
IDOS	German Institute of Development and Sustainability
METR	Marginal effective tax rate (METR)
ML	Maximum likelihood
MREM	Mundlak REM
OLS	Ordinary Least Squares
PE	Public Expenditure on Education
PIT	Personal income tax
Pseudo-IV	Pseudo–instrumental Variable method
REM	Random Effects Model
SEM	Structural model equation
SFA	Stochastic Frontier Analysis
SSCs	Social Security contributions
TEs	Tax expenditures (TEs)
TFE	True Fixed Effects Model
VAT	Value-added tax
WDI	World Bank World Development Indicators
WoRLD	World Revenue Longitudinal Database

Executive Summary

1. **Employing a stochastic tax frontier model, this study estimates tax capacity, the maximum level of tax revenues that countries could potentially mobilize** (based on determinants such as per capita income, income distribution, public expenditure on education, the sectoral composition of the economy, and institutional characteristics). By comparing actual revenues with tax capacity, this paper computes the so-called tax effort, measured as the ratio of actual revenue to tax capacity.

2. **The capacity of countries to generate sustainable revenue has long been a central objective of public finance**. Our study of tax efforts is a valuable instrument for revenue mobilization, as it indicates the extent to which countries have scope to enhance their tax revenues. Before introducing new taxes or raising existing rates, countries should first assess their tax efforts to determine whether there is room for increasing revenues. The breakdown of the 'frontier tax gap' (FTG)- defined as the difference between tax capacity and actual revenues- presented in this paper provides a useful guide for identifying where reforms should begin and where efforts should be prioritized.

3. **A low level of tax effort does not imply that a country should increase its revenues**. Rather, it implies that the country's tax effort is relatively low and, that there exists, at least from a technical standpoint, potential space to mobilize additional resources. Likewise, a low level of tax effort does not indicate inefficiency in tax collection. Some countries exhibit high efficiency in revenue administration yet maintain comparatively low levels of tax collection (and tax effort) because they choose to have a low level of revenue and provide fewer public goods—that is, they opt for a smaller government.

4. **This paper updates the estimates of tax capacity and tax effort of Fenochietto and Pessino (2013) and presents two novel models to explain the FTG**. It runs four different stochastic frontier specifications[1] for 123 countries pooled from 1991 to 2023. Consistent with the existing literature, the estimations indicate that GDP per capita, trade openness, and government expenditure on education are significant and positive determinants of tax capacity, while inequality (Gini) reduces it. The inefficiency equation shows that higher inflation reduces tax effort, while better control of corruption reduces it. Under the MREM, which controls for fixed-effects, for instance, a 1.0 percent increase in GDP per capita increases potential revenue by about 1.46 percent, ceteris paribus

[1] The Battese and Coelli's half-normal (BCHN); the Mundlak version of the Random Effects Model (MREM); and a pseudo–instrumental variable (pseudo-IV) approach, which estimates the exogenous model, EX (where coefficients may absorb some inefficiency effects) and then, if necessary, the endogenous model, EN).

(significant negative quadratic term for GDP per capita also indicates diminishing returns at higher income levels).

5. **While the BCNH and the pseudo-IV models yield broadly comparable countries' tax efforts, the differences exist when contrasted with the MREM**. The MREM enhances the estimation of tax effort for certain countries. For instance, for some low-income countries (e.g., Togo, Tanzania, Myanmar, and Guinea-Bissau) or for some resource-dependent economies (e.g., Azerbaijan, Angola, the United Arab Emirates, Nigeria, Ecuador, and Papua New Guinea), it produces lower estimates of tax capacity. The MREM captures more effectively the short-term determinants of tax efforts in these cases.

6. **Consistently, the MREM mean tax effort is 0.74**, **indicating that, on average, countries operate about 26 percent below their revenue potential**. For the remaining three models, the mean is around 0.60, suggesting potential revenue gains of roughly 40 percent if inefficiencies were reduced and policies adjusted accordingly. Efficiency values range from 0.11 (Qatar) to 0.99 (Denmark) under the EN specification, reflecting considerable cross-country heterogeneity.

7. **As expected, the empirical analysis shows that tax capacity and tax effort increase with the level of development**. Exceptions include countries with high GDP per capita but low level of tax capacity, such as the United Arab Emirates, Qatar, South Korea, and Singapore, where low statutory tax rates (a policy choice) largely explain the low level of tax effort. Conversely, countries with relatively low per capita GDP but operating close to tax capacity include, among others, Mali, Namibia, Senegal, and Zambia.

8. **An important distinction between stochastic production frontier analysis and stochastic tax frontier analysis lies in their results.** In production frontier analysis, the gap between current production and the frontier represents the level of inefficiency—that is, the shortfall from the maximum attainable output. In stochastic tax frontier analysis, the difference between actual revenue and tax capacity (the FTG) captures (i) technical inefficiencies (such as high levels of non-compliance) and (ii) policy choices (citizens' preferences for lower tax burdens and a correspondingly smaller provision of public goods). Low tax rates and narrow tax bases (high level of tax expenditures, TEs) are the key policy factors that contribute to a low tax effort.

9. **To breakdown the FTG, this paper presents two complementary models**: (i) a two-stage econometric regression model and (ii) a country-by-country analytical approach. While data limitations prevented the application of these models in earlier studies (Fenochietto and Pessino, 2010, 2013), the availability of data have improved substantially over the past decade. Although current data remain insufficient to draw robust results, they now allow for preliminary findings and provide a foundation for more robust analysis as data coverage continues to expand.

10. **In the econometric regression model, the FTG is regressed on two groups of explanatory variables according the available data.** The first one, policy-related variables, includes: (i) statutory tax rates for the main taxes—corporate income tax (CIT), personal income tax (PIT), and value-added tax (VAT)—and the effective CIT rate; and (ii) TEs. The second group includes efficiency-related variables: the VAT non-compliance, and given its limited availability, the size of the informal economy. Non-compliance emerges as the most influential determinant. For instance, under the Full Information Maximum Likelihood (FIML) model, a one-unit increase in the non-compliance raises the FTG by about 1.22 percentage points, holding other factors constant, showing the importance of enhancing the efficiency of tax collections. In contrast, and as expected, higher statutory and effective tax rates are significantly associated with a lower FTG.

11. **Data presented two problems.** First, although VAT non-compliance accurately captures the inefficiency component of the FTG, it is available for 52 countries (mainly from the European Union and Latin American), among those with higher income in our sample. To deal with missing not at random data we use the Heckman Sample Selection Model and, the results were much better. The VAT rate is also significant and contributes to explain the FTG (lower rates imply high gaps and vice versa) and to a lesser extent the PIT and CIT rates.

12. **A second problem is the absence of a suitable measure of tax expenditures.** Available data is an inadequate proxy for explaining the FTG: (i) there is no internationally agreed framework for measuring TEs and, as a result, they are identified according to varying national criteria; (ii) the scope of TE estimation also varies across countries (some countries omit subnational tax expenditures from their estimates, even where tax decentralization is substantial); (iii) eliminating tax expenditures would not necessarily generate the total revenue estimated under the 'revenue forgone' methodology (applied for almost all countries), which assumes taxpayer behavior and all other conditions remain unchanged following the removal of a preferential treatment; (iv) because TEs are typically calculated as the product of the exempted tax base times the relevant tax rate, countries with higher rates shows higher TEs; and (v) differences also arise from data limitations.

13. **Country-by-country analysis is useful not only for validating econometric results but also to include certain country-specific characteristics**. We present the estimates for 26 countries with the aim at illustrating how the methodology operates. When interpreted with due caution, the results offer valuable insights for policymakers. The FTG breakdown provides a useful guide for identifying where reforms should begin or where efforts should be concentrated. Bulgaria (where approximately 98.0 percent of the gap is attributable to policy factors) and Panama (where 63.8 percent of the gap is explained by policy factors) are clear examples of that.

I. Introduction

14. **This paper estimates tax capacity, the maximum level of tax revenues that countries can collect** (based on indicators such as per capita income, income distribution, education expenditure, the sectoral composition of the economy, and institutional factors including governance quality). By comparing actual revenues with tax capacity, this paper computes the so-called tax effort, measured as the ratio of actual revenue to tax capacity.[2]

15. **While a higher level of tax capacity is desirable, the same does not necessarily hold for tax effort** (Fenochietto and Pessino, 2013; Langford and Ohlenburg, 2016). A low tax effort does not imply that a country must raise additional revenues; it merely signals potential fiscal space, with any decision to increase taxation depending on public preferences. Nor does a low tax effort imply inefficiency in tax collection: some countries maintain low tax ratios because they deliberately prefer lower taxation and smaller governments. Ultimately, tax effort reflects both policy preferences and administrative capacity.

16. **While tax capacity represents the upper bound determined by a country's economic and institutional characteristics, tax effort measures the extent to which actual revenue collection approaches that upper limit**. The starting point of any revenue-mobilization strategy—before introducing new taxes or raising rates—is to assess the gap between current revenues and tax capacity, that is, to determine the fiscal space available for potential revenue enhancement.

17. **This paper updates the tax-effort estimates originally presented in Fenochietto and Pessino (2010, 2013), employing a Stochastic Frontier Analysis (SFA)**. It further (i) addresses endogeneity more rigorously by controlling for potential correlations between explanatory variables and the error term (rather than only for omitted variable bias), and (ii) introduces two models to disentangle the 'frontier tax gap' [3] into its policy and efficiency components.

18. **This paper is structured as follows**. The remainder of this introductory Chapter provides a concise review of the relevant literature and clarifies the distinctions between the SFA approach to estimating tax effort and other methodologies used in the literature. Chapter II outlines the estimation strategy—including the specific treatment of natural resource–dependent economies—and presents the results for 123 countries. Chapter III introduces the two models developed to disentangle the FTG, and Section IV concludes with directions for future research.

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[2] Hence, a tax effort of 0.60 means that a country collects 60 percent of what it could potentially collect.

[3] The difference between tax capacity and tax effort.

A. Stochastic Frontier Analysis

19. **The SFA is an extension of the conventional regression model**. It rests on the theoretical premise that a production function represents the maximum output (in this case, the maximum level of tax revenue) that a country can achieve given a set of inputs (in this case, e.g., GDP per capita, inflation, and education level). The stochastic frontier model developed by Aigner et al. (1977) provides the standard econometric framework for this type of analysis (see Fenochietto and Pessino, (2013), Box 1).[4]

20. **Numerous studies have applied or adapted the stochastic frontier model proposed by Aigner et al**. (1977). Greene (2008) and Fenochietto and Pessino (2010, 2013) provide reviews of this literature. Early contributions include Lotz and Mors (1967), one of the first cross-country analyses of tax ratios, followed by studies such as Davoodi and Grigorian (2007), Alfirman (2003), Keen and Simone (2004), and Baunsgaard and Keen (2010). More recent applications of SFA include Langford and Ohlenburg (2016), who reached conclusions consistent with Fenochietto and Pessino (2013), and Brun and Diakité (2016), who examined the VAT frontier. Other methodologies—such as Ordinary Least Squares (OLS)–based assessments[5] and Data Envelopment Analysis (DEA)—have also been used to estimate countries' tax capacity. The next section analysis the key differences between these approaches and the SFA framework.

B. SFA, OLS, and DEA to Explain Countries Tax Collection

21. **Fenochietto and Pessino (2010, 2013) applied the SFA framework to estimate tax capacity using different panel data specifications**, including the Battese–Coelli half-normal[6] and truncated-normal models (the latter allowing for heterogeneity),[7] as well as the Mundlak version of the Random Effects Model (MREM) to account for unobserved heterogeneity. The main conceptual distinction between the OLS and the SFA is that the OLS assumes all countries are fully efficient,

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[4] Fenochietto and Pessino (2013) corroborated previous findings by identifying a positive and significant relationship between tax revenue and key structural variables such as per capita income, trade openness, and public spending on education. Conversely, they found a negative association between tax revenue and inflation, income inequality, the share of agriculture in GDP, and corruption.

[5] See, for instance, Bayraktar, N., Tuan Minh Le, T., and Moreno-Dodson, B. (2012).

[6] Battese and Coelli (1992) estimated their models in a random effects framework using the method of maximum likelihood. This often allows us to disentangle the effects of inefficiency and technological changes. The prediction of the technical efficiencies is computed by the residual using the formula provided by Jondrow and others (1982).

[7] Battese and Coelli (1992, 1995) proposed a series of models that capture heterogeneity; we estimated the mean of the truncated normal depending on observable covariates $\mu_i = \mu_0 + \mu_1' w_i$ (notice that z variables influence time-varying inefficiency and w_i variables mean time-invariant inefficiency).

whereas SFA explicitly models inefficiency through a one-sided error term—represented in Pessino and Fenochietto (2013) by the positive component u_{it}in Equation (1).[8]

22. **In contrast, DEA is a nonparametric methodology, whereas SFA is a parametric approach**. The main advantage of DEA is that it requires only information on input and output quantities. However, DEA is highly sensitive to measurement errors or random noise, as it attributes all deviations from the frontier to inefficiency. This characteristic makes DEA suitable for analyzing production frontiers but less appropriate for tax frontier estimation, where the observed gap reflects not only inefficiencies (such as noncompliance) but also deliberate policy choices, including tax expenditures and statutory tax rates. Moreover, DEA does not allow for direct statistical inference, and its estimates of production and inefficiency may be biased when deviations from the frontier arise from both inefficiency and statistical noise. Although some recent extensions have sought to address these limitations, their effectiveness remains subject to further evaluation.

23. **The strength of SFA lies in its ability to account for stochastic noise and to enable hypothesis testing regarding the production structure and inefficiency**. Its main limitation is the need to impose a specific parametric functional form to represent the underlying technology, along with explicit distributional assumptions for the inefficiency term. However, this weakness can be mitigated by testing alternative functional specifications, as SFA allows researchers to identify which production function best fits the data—thereby reducing the problem of relying on a single predefined functional form.

24. **Measuring productivity is essential to understanding the factors underlying observed outcomes.** In DEA, this typically involves a two-stage procedure: first, efficiency scores are calculated; second, these scores are regressed on explanatory variables using OLS. This approach, however, has important limitations, as the second-stage OLS estimation is consistent only under restrictive and uncommon assumptions about the data-generating process, which constrains its general applicability. In contrast, SFA estimates both efficiency scores and regression parameters jointly within a single framework, producing unbiased estimates. Another advantage of SFA is its capacity to control for endogeneity and fixed effects—particularly relevant in countries where political, social, or institutional characteristics are key determinants of low revenue levels. Unlike DEA, SFA enables causal analysis. Moreover, SFA can accommodate considerably more complex specifications, including panel data models, multilevel structures, and latent class frameworks.

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[8] The SFA includes two 'error terms': *uit*, represents the inefficiency, the 'failure' to produce the relative maximum level of tax collection and *vit,* the statistical noise (the disturbance or error term**,** which represents the independent variables that explain the dependent variable but are not explicitly taken into account as well as measurement errors and incorrect functional form).

C. Tax Effort, Tax Capacity, and Tax Structure

25. **Tax effort, tax capacity, and tax structure are distinct concepts**. A country's tax capacity—the level of revenue it can potentially collect—differs from the types of taxes it chooses to levy. Within the SFA framework, tax capacity represents the potential amount of tax revenue a country can generate given its economic and institutional characteristics, whereas the tax structure refers to the composition of taxes actually implemented. While both tax effort and tax structure are influenced by public policy decisions, tax capacity is not; it is determined by a country's underlying economic and social fundamentals. Tax effort is defined as the ratio of actual tax revenue to tax capacity, while tax structure describes the distribution of revenue across different tax bases, typically measured by the share of each tax source in total tax revenue.

26. **While tax collection and tax effort reflect the overall size of government activity**, **tax structure captures the way in which that activity is financed.** A useful way to illustrate this distinction is by comparing Denmark with other European Countries (EU). Like many EU members, Denmark has opted to maintain a large public sector that provides extensive health, education, and pension systems. However, it finances this expenditure largely without significant reliance on social security contributions (SSCs), instead depending on high statutory rates and broad bases for the personal income tax (PIT) and the value-added tax (VAT). In contrast, many other EU countries rely heavily on SSCs. For example, Denmark collects approximately 26 percent of GDP from PIT at both the national and subnational levels—roughly three times the EU average.[9]

27. **Any analysis of tax capacity or tax effort that excludes SSCs may incorrectly classify most EU countries as having low tax effort**—even those, such as the Netherlands, France, Belgium, and Italy, whose combined tax and SSC revenues exceed 40 percent of GDP. Similarly, an analysis limited to the PIT could misleadingly suggest low PIT effort in countries such as Belgium, Finland, and Iceland, despite these economies collecting over 11 percent of GDP from this source (with Denmark collecting more than twice that amount). These countries do not exhibit low tax effort; rather, they have adopted different tax structures to finance their public expenditures. Consequently, evaluating

[9] In addition, Denmark's VAT rate—25 percent—is among the highest in the world and applies with relatively few exemptions. As a result, VAT revenue in Denmark amounts to approximately 9.2 percent of GDP, about 50 percent above the EU average. Over the past decade, Denmark's total tax revenue has averaged around 47 percent of GDP, while SSCs have accounted for only about 0.7 percent of GDP. In contrast, Germany's total tax revenue is not only lower—approximately 40 percent of GDP—but its composition differs substantially, with SSCs representing about 15 percent of that total.

tax capacity on the basis of a single tax—such as the VAT or excise taxes—can yield biased or incomplete conclusions.[10]

28. **In this paper—as in Fenochietto and Pessino (2010, 2013) SSCs collected by the government are included in the analysis**.[11] Data on private funds, however, are excluded for several reasons. First, by definition, tax effort analysis should not encompass voluntary systems, which are common in private pension schemes. Second, in recent years, several countries have partially shifted components of their public pension systems into quasi-mandatory private schemes, which fall outside the institutional scope of our panel (covering data up to 2023). Third, in other cases, mandatory-private individual schemes have been either abolished or made optional, and therefore can no longer be considered fully compulsory or part of citizen effort paying taxes.

Natural Resource-Dependent Economies

29. **Similarly, natural resource–dependent economies should be explicitly included and identified in the analysis.** Many of these countries, which finance a large share of government spending through resource-based revenues, have not fully developed their tax structures—particularly during the period of our analysis 1991-2023).[12] Revenues derived from the sale of natural resources represent a government income source fundamentally different from tax revenues, which are generated through compulsory payments. This distinction is especially relevant for economies such as those of the Gulf Cooperation Council, where natural resource revenues often exceed 40 percent of GDP. Can this 40 percent be interpreted as the effort citizens make to pay taxes? Can it be compared to an equivalent 40 percent of GDP collected through PIT, VAT, and SSCs? Clearly not. The revenue capacity of resource-dependent economies depends primarily on the volume and quality of their natural resources (e.g., petroleum reserves), whereas tax capacity depends on economic and institutional factors such as per capita GDP, income inequality (Gini coefficient), and governance

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[10] Nevertheless, it is advisable that any study focusing on a specific tax incorporates the most appropriate proxy for its underlying tax base as an explanatory variable—for example, private or total consumption in the case of VAT, or gasoline consumption for fuel excise taxes.

[11] From different sources: mainly WEO and WorLD.

[12] Several natural-resource-dependent economies have recently undertaken reforms to strengthen the fundamental pillars of their tax systems. Notably, a number of Middle Eastern countries (including Bahrain, Saudi Arabia, and Qatar) and African countries (such as Angola and São Tomé and Príncipe) introduced a value-added tax in the post-pandemic period. The pronounced collapse in oil prices—at times even turning negative—highlighted the vulnerabilities associated with heavy reliance on hydrocarbon revenues and reinforced the urgency of diversifying fiscal sources.

indicators (as discussed below).[13] Following the methodology of Fenochietto and Pessino (2013), this paper excludes the natural resource sector from the analysis of resource-dependent economies by using as the dependent variable only non–natural resource revenue as a percent of non–natural resource GDP (see below).

II. Estimates of Tax Effort and Tax Capacity

D. Variables and Data

30. **This paper computes tax capacity by using stochastic panel data for 123 countries covering the period 1991–2023**.[14] It explores the relationship in a reduced form written as follows (Table 1 shows descriptive statistics):

$$ltot = f(lgd_t, tr_t,\ ava_t,\ pe_t,\ gini_t;\ cpi_t;\ lcor_t;\ oil_t;\ gov_t)$$

where,

- $ltot$ is the logarithm of the sum of tax revenue and social security contributions (as a percent of GDP) collected by central and subnational governments.[15] Sources: *World Economic Outlook (WEO); OECD Statistics; IMF Article IV Consultation Reports; and the World Revenue Longitudinal Database (WoRLD).*[16]

We identified a group of 14 countries where revenue from natural resources accounted for, on average, more than 25 percent of total taxes plus resource revenue during 2016–2023 (excluding non-tax revenue and grants). A dummy variable (*Oil*) was created for these economies, for which tax revenues and social security contributions exclude receipts from hydrocarbon and mining sectors and are expressed as a percent of non–natural resource GDP. When general revenue was not available, we use central government revenue distinguished the country with a dummy variable. (source WEO, WorLD, IMF Art. IV Consultations).

- lgd is the logarithm of GDP per capita (purchasing power parity, constant 2021 international dollars).[17] The level of economic development is the most commonly used explanatory variable,

[13] See also Langford and Ohlenburg (2016), who note that 'the determination of tax effort is qualitatively different in resource-dependent economies.'

[14] For some countries data was not available for all these years.

[15] A caveat is worth mentioning: we did not include social security revenue collected by private institutions. Therefore, countries such as the United States—with a significant share of private social security contributions—may appear to be further from their maximum tax capacity than they actually are.

[16] IMF-Fiscal Affairs Department, Tax Policy Division.

[17] This indicator compares the standard cost of living and the ability to pay taxes across different countries better than the per capita nominal GDP.

based on the hypothesis that higher development levels are associated with greater tax capacity. The expected coefficient sign is positive. Source: *World Bank, World Development Indicators (WDI)*.

- lgd^2 is the square of lgd (in logarithmic form), included to capture potential non-linearities in the relationship between tax revenue and per capita GDP. The expected coefficient sign is negative.

- tr represents trade openness (the sum of imports and exports as a percentage of GDP). In the medium term, greater openness is associated with higher revenues due to increased economic activity (Baunsgaard and Keen, 2010). The expected coefficient sign is positive. Source: World Bank, WDI.

- ava is the value added from agriculture, forestry, and fishing as a percentage of GDP. Tax collection from these sectors is generally more difficult, especially when dominated by small producers. Moreover, many countries exempt agricultural products from VAT or apply reduced rates. The expected coefficient sign is negative. Source: World Bank, WDI.

- pe is total public expenditure on education as a percent of GDP. A more educated population tends to exhibit higher tax compliance, as individuals better understand the role and necessity of taxation. The expected coefficient sign is positive. Source: World Bank, WDI.

- $gini$ measures income inequality, with higher values indicating a greater deviation from an equal distribution. A more equalitarian income distribution can facilitate tax collection and foster voluntary compliance; therefore, the expected coefficient is negative. Source: World Bank, WDI.

- cpi represents the annual percentage change in the consumer price index (average period). Economies that rely heavily on seigniorage (money creation) tend to exhibit weaker tax collection performance. Accordingly, the expected sign of the coefficient is negative. Source: World Bank, WDI.

- $lcor$ is the logarithm of the corruption perception index, used to capture inefficiencies in tax administration. Higher corruption is expected to reduce revenue performance; hence, the expected coefficient sign is negative. Source: The PRS Group.

- $lleb$ is the logarithm of life expectancy at birth. In the pseudo–instrumental variable estimation, this variable serves as an instrument for GDP per capita. Source: United Nations, Department of Economic and Social Affairs, Population Division (2023), (https://population.un.org/DataPortal).

Table 1. Descriptive Statistics

Variable /1	Mean	Std.Dev.	Minimum	Maximum	Observations
tot	22.9	11.5	0.7	59.1	3,210
gdp	26,348.2	25,088.3	510.8	145,591.0	3,210
gini	37.9	8.2	23.0	67.0	3,210
cor	2.9	1.3	0.5	6.0	3,210
tr	82.1	50.3	11.9	437.3	3,210
ava	10.4	10.4	0.0	63.8	3,210
cpi	6.5	13.2	-8.5	411.8	3,210
pe	4.4	1.5	0.4	10.6	3,210
gov	0.6	0.5	0.0	1.0	3,210
oil	0.1	0.3	0.0	1.0	3,210
leb	71.4	8.9	44.7	85.0	3,210

1/ All variables are presented in levels. Their transformed counterparts used in the estimation (e.g, log specifications) are defined in Section II.

E. Estimation Methodology

31. **This paper estimates tax effort and tax capacity for a group of 123 countries by using four different formulations**:

- First, the Battese and Coelli half-normal (BCHN) original formulation (Battese and Coelli, 1992 and Battese et al, 1995) without heterogeneity with the base specification g(zit) = exp[-η(t – T), for more details see Fenochietto and Pessino (2010).

- Second and third, to address potential endogeneity bias more rigorously, this paper also applies a pseudo-IV approach (pseudo-IV), following Karakaplan and Kutlu (2017), Karakaplan (2018), and Karakaplan (2022). This method estimates the exogenous model, EX (where coefficients may absorb some inefficiency effects) and then, if necessary, the endogenous coefficients, EN model, which involves identifying an instrumental variable that is correlated with the potentially endogenous regressor (e.g., GDP per capita) but uncorrelated with the model's error term. We use the life expectancy at birth and the lagged values of the independent variable trade as instruments, after verifying that they are not correlated with the error terms.

- Fourth, to deal with unobserved heterogeneity, this paper uses the Mundlak version of the Random Effects Model (REM) (originally proposed by Pitt and Lee, 1981). Fenochietto and Pessino, 2013, Section VI, describes other alternatives (including also the 'True Fixed Effects' (TFE) and the REM Models developed by Greene, 2005), to separate time-invariant inefficiency from unit specific time-invariant 'unobserved heterogeneity'. In a nutshell, we use now the MREM because the TFE model presents the incidental parameter problem (see Belotti and others, 2012), which modifies the post-estimation of inefficiencies since it leads to inconsistent variance parameter estimates. As discussed in Farsi, Filippini, and Kuenzle (2005), the TFE and REM approaches can also suffer from the 'unobserved variables bias', because the unobserved characteristics may not be distributed independently of the explanatory variables (more analysis in Fenochietto and Pessino, 2013).

The standard Mundlak model was developed for linear panel data and addresses the possible endogeneity[18] that arises from a correlation between the time-invariant unobserved heterogeneity (the fixed effect) and the time-varying explanatory variables by including the mean of the time-varying regressors as an additional set of covariates. This effectively controls for the unobserved fixed effects, providing consistent estimates for the time-varying covariates and provides a more robust way to analyze the impact of both time-varying and time-invariant factors on the frontier.

F. Findings

32. **We ran the four different specifications for 123 countries pooled from 1991 to 2023**. Table 2 shows the maximum likelihood estimation of the parameters of the stochastic frontier tax function for these four models. Estimations indicate that the models converged satisfactorily. Results are highly consistent across models, with main coefficients showing the expected signs and strong statistical significance. Inefficiency tests indicate that the vast majority of the unexplained variance in tax collection is due to the inefficiency term.[19] In Battese and Coelli half-normal, for instance, the value of *mu*[20] is high and the value of *eta*[21] is very low.

33. **In the EN model, which corrects for endogeneity in GDP per capita and trade openness, both variables are significant determinants of tax frontier**. GDP per capita (*lgd*) and trade (*tr*) positively affect potential revenue, while inequality (Gini) reduces it. The negative quadratic term for GDP per capita (lgd^2) suggests diminishing returns at higher income levels. Government expenditure on education is also associated with higher tax frontier. The inefficiency equation shows that higher inflation increases inefficiency, while better control of corruption reduces it. The endogeneity test ($\chi^2(2) = 34.34$, $p<0.001$) confirms that correction for endogeneity is statistically required.

[18] Endogeneity would exist if the determinants of the frontier are correlated to the two-sided error term.

[19] *As explained, in frontier tax analysis, the inefficiency term includes both policy and inefficiencies in collection*.

[20] *Mu* is the average inefficiency across countries at the reference time; the higher the value more inefficiency.

[21] *Eta* indicates how fast inefficiency decays over time. Small positive value (0.009) implies a very slow decline in inefficiency per year.

Table 2. Parameters of the Battese and Coelli Half-Normal and Pseudo-Instrumental-Variable Models

Parameters of the Stochastic Frontier Tax Function

Variable	Battese and Coelli Half-nomal			Endogenous Model			Exogenous Model			Mundlack		
	Coeff.		P>|z|	Coeff.		P>|z|	Coeff.		P>|z|	Coeff.		P>|z|
	Frontier Model											
_cons	-0.813		0.210	-8.323	***	0.000	-3.362	***	0.000	0.495		0.681
lgd	0.913	***	0.000	2.392	***	0.000	1.357	***	0.000	1.461	***	0.000
tr	0.001	***	0.000	0.002	***	0.000	0.001	***	0.000	0.001	***	0.000
gini	-0.006	***	0.000	-0.009	***	0.000	-0.009	***	0.000	-0.010	***	0.000
lgd2	-0.048	***	0.000	-0.119	***	0.000	-0.065	***	0.000	-0.071	***	0.000
ava	-0.004	***	0.000	0.001		0.392	-0.006	***	0.000	-0.006	***	0.000
oil	0.056		0.157	0.120		0.002	0.121		0.001			
gov	0.301	***	0.000	0.157	***	0.000	0.175	***	0.000			
pe	0.031	***	0.000	0.022	***	0.000	0.021	***	0.000	0.023	***	0.000
meanava										-0.015	***	0.007
meanlgd										-0.815		0.003
meanlgd2										0.042		0.004
meantr										-0.002		0.003
meangini										-0.005		0.244
meanpe										0.044	***	0.001
										Wald chi2		1,832.5
	Inefficiency determinants											
_cons				-0.490	***	0.001	-0.49	***	0.001			
lcor				-0.359	***	0.000	0.01	***	0.000			
cpi				0.008	***	0.000	-0.36	***	0.000			
mu	0.458	***	0.000									
eta	0.009	***	0.000									
Lambda 1/	4.051	***	0.000							4.051	***	0.000
/sigmau_2	0.332	***	0.000							0.332	***	0.000
/sigmav_2	0.020	***	0.000							0.020	***	0.000

***, **, * = significance 1%, 5%, 10% level.

34. **In the EX-model, where regressors are treated as exogenous, results remain qualitatively similar to the EN model**—though the magnitudes of key elasticities (particularly GDP per capita and trade) are smaller, confirming that ignoring endogeneity slightly biases estimate. The inefficiency determinants are robust across models: higher inflation and corruption worsen efficiency (stronger governance improves tax effort).

35. **The MREM converges properly** (Log-likelihood = 1,416.4 is reasonably high) **and is highly significant overall.** Wald χ^2 (12) = 1,832.47 ($p < 0.001$) implies that the regressors jointly explain a substantial portion of the variation of potential revenue. The estimated inefficiency parameter

(λ=4.05) is also high and indicates that the vast majority of the unexplained variance in tax collection is due to inefficiency rather than random noise.[22]

36. **Coefficients of variables within-country[23] (time-varying) effects are significant at 1 percent and with expected signs** (Table 2). For instance, a 1 percent increase in GDP per capita increases potential revenue by about 1.46 percent, ceteris paribus, showing, as expected, an income elasticity >1; the significant negative quadratic term for GDP per capita indicates diminishing returns at higher income levels (which is rational and the reason why this variable was introduced); and trade is positive but has a small effect. GDP per capita, trade openness, and public expenditure are also the main positive determinants of potential revenue, while inequality and agricultural dependence reduce it.

37. **The 'mean' variables (Mundlak terms) capture the long-run or structural effects** (among-country differences) **rather than within-country** (over time) **effects.** For instance, a -0.815 coefficient for *meanlgd* implies that countries with persistently higher income levels have lower efficiency-adjusted potential.[24] In other words, when a country grows richer, its tax capacity increases (*lgd* coefficient is positive = 1.46), but across countries, richer countries tend to have relatively lower frontier positions (or diminishing tax capacity returns).

38. **Our findings on the determinants of tax capacity are consistent with the existing literature**. Early evidence by Lotz and Mors (1967) identified a significant and positive relationship between revenue and economic development. Similarly, Keen and Simone (2004) showed that revenue performance tends to improve when trade liberalization is accompanied by enhancements in customs administration. Gupta (2007) also found that per capita GDP, the share of agriculture in GDP, and trade openness positive and significantly influence tax revenues. In the same vein, Davoodi and Grigorian (2007) extended the traditional framework of potential tax revenue determinants and demonstrated that improvements in institutional quality reduce the size of the informal economy. Consistent with these findings, Fenochietto and Pessino (2010, 2013) found that tax capacity increases with higher levels of development, trade, education, and efforts to reduce corruption.

[22] λ Is equal to σ_u / σ_v, where: σ_u is the standard deviation of the *inefficiency* term (u_i), and σ_v is the standard deviation of the *random noise* term (v_i); therefore it indicates the importance of inefficiency in explaining deviations from the potential (frontier) performance. A higher λ means inefficiency is a much larger component than random noise in the data; if λ were equal to zero, there were no difference with an OLS regression (no *v* error component). The level of σ_u^2 = 0.332 and σ_v^2 = 0.020 confirms that most of the residual variance comes from inefficiency.

[23] Those that are not mean variables.

[24] Possibly because of saturation or diminishing returns at higher development levels.

G. Countries Tax Capacity and Tax Effort

39. **Using the estimates of Table 1 we predict counties' tax capacity and tax effort given the observable value of v_{it}-u_{it}** (Table 3). While the BCNH and the pseudo-IV models yield broadly comparable countries' tax effort results, differences exist when contrasted with the MREM. Consistent with previous estimates (Fenochietto and Pessino, 2013), the MREM enhances the estimation of tax effort in certain instances. For instance, for some low-income countries (e.g., Togo, Tanzania, Myanmar, and Guinea-Bissau); for some resource-dependent economies (e.g., Trinidad and Tobago, Azerbaijan, Angola, the United Arab Emirates, Nigeria, Ecuador, and Papua New Guinea); and for some developed countries (e.g., Singapore and Ireland) with persistent comparable low levels of tax revenues, it produces lower estimates of tax capacity. This outcome suggests that the MREM captures more effectively the short-term determinants of tax capacity in these cases. Accordingly, such countries are likely to converge toward the benchmark levels estimated by the other models only over the long term.

40. **This interpretation appears particularly plausible**. For instance, for resource-dependent and least-developed economies, limited revenue generation and weak institutional capacity—especially in tax administration and customs—constrain, at least in the medium and short run, the realization of potential tax capacity.

41. **Consistently, the mean tax effort estimated under the MREM is approximately 0.74** (Table 3, below lines), **implying that countries operate, on average, 26 percent below their revenue potential**. For the remaining three models, the mean is around 0.60, suggesting potential revenue gains of roughly 40 percent if inefficiencies were reduced and policies adjusted accordingly. Values rangers of tax 0.11 (Qatar) and 0.99 (Denmark) under the EN, indicating considerable cross-country heterogeneity.

42. **The EN model (pseudo-IV) generally provides accurate estimations of tax capacity and effort**. However, as explained, for certain countries, the MREM model yields more reliable estimates because it accounts for fixed effects. This advantage arises not only from its ability to address potential endogeneity, but also because fixed effects often play a crucial role in shaping public choices regarding the size of government and the level of taxation required to sustain it.

Table 3. Countries' Tax Capacity and Tax Effort

	Country	Year	Tax Revenue	Total Revenue: Tax and SSC 1/	Percapita GDP, PPP const 2021	Tax Effort				Tax Capacity % of GDP/2			
						CBHN	MREM	EN	Ex HN	CB HN	MREM	EN	EX
						CI	CII	CIII	CIV	CV	CVI	CVII	CVIII
1	Albania	2023	19.2	25.3	17,976	0.58	0.91	0.59	0.64	44.0	27.8	43.2	39.3
2	Algeria	2023	15.9	15.9	15,159	0.52	0.67	0.41	0.45	30.8	23.9	39.2	35.5
3	Angola	2023	13.0	9.7	7,245	0.45	0.66	0.43	0.43	21.7	14.6	22.8	22.6
4	Argentina	2023	22.4	29.2	27,105	0.66	0.82	0.56	0.63	44.2	35.4	52.2	46.2
5	Armenia	2023	22.9	23.8	19,230	0.65	0.81	0.61	0.65	36.9	29.5	38.8	36.7
6	Australia	2023	30.4	30.4	60,409	0.70	0.66	0.68	0.68	43.7	46.3	44.8	44.5
7	Austria	2023	27.8	43.0	64,336	0.92	0.90	0.94	0.93	46.6	47.9	45.9	46.4
8	Azerbaijan	2023	28.6	34.6	21,262	0.61	0.86	0.58	0.63	56.8	40.2	59.3	55.3
9	Bahamas, The	2023	18.8	18.8	33,106	0.42	0.34	0.38	0.36	44.6	54.8	49.6	51.7
10	Bangladesh	2023	8.8	8.8	8,242	0.28	0.41	0.26	0.28	31.8	21.6	34.3	31.3
11	Belarus	2021	24.0	32.3	27,611	0.68	0.87	0.69	0.72	47.7	37.0	46.9	45.1
12	Belgium	2023	29.0	44.1	62,876	0.92	0.96	0.92	0.91	47.8	45.9	47.8	48.4
13	Benin	2023	12.2	12.2	3,721	0.44	0.60	0.50	0.52	27.8	20.3	24.5	23.4
14	Bolivia	2023	21.6	27.4	9,844	0.70	0.97	0.83	0.89	38.9	28.3	32.9	30.9
15	Botswana	2023	21.1	21.1	18,846	0.65	0.82	0.64	0.62	32.5	25.9	33.0	34.1
16	Brazil	2023	23.9	29.1	19,018	0.71	0.92	0.77	0.83	40.9	31.8	37.6	35.2
17	Bulgaria	2023	20.0	26.7	33,112	0.61	0.81	0.62	0.63	43.5	32.8	43.1	42.2
18	BurkinaFaso	2023	18.0	19.6	2,482	0.60	0.80	0.77	0.81	32.7	24.5	25.3	24.1
19	Cameroon	2023	11.8	12.0	4,871	0.47	0.60	0.49	0.50	25.4	19.9	24.5	23.9
20	Canada	2023	29.1	33.8	56,687	0.77	0.79	0.76	0.76	44.1	42.5	44.6	44.6
21	Chile	2023	20.5	21.5	29,491	0.71	0.77	0.64	0.65	30.4	27.8	33.5	32.8
22	China,P.R.M.	2023	17.7	26.6	22,138	0.65	0.94	0.67	0.73	40.9	28.4	39.6	36.4
23	Colombia	2023	21.7	23.7	17,352	0.54	0.81	0.60	0.65	43.5	29.2	39.5	36.7
24	Congo,Repof	2023	12.2	12.2	6,172	0.64	0.86	0.58	0.63	19.2	14.2	21.2	19.4
25	CostaRica	2023	15.4	23.2	25,990	0.49	0.75	0.50	0.54	47.7	31.0	46.2	42.8
26	Cote d'Ivoire	2023	13.6	15.2	6,485	0.47	0.60	0.53	0.52	32.3	25.4	28.4	29.2
27	Croatia	2023	27.1	38.4	41,100	0.80	0.92	0.80	0.82	48.3	41.6	48.2	46.9
28	Cyprus	2023	24.6	37.8	52,148	0.64	0.69	0.62	0.62	59.5	54.6	61.3	60.6
29	Czech Republi	2023	18.6	33.9	47,452	0.71	0.78	0.67	0.68	47.7	43.5	50.5	50.0
30	Denmark	2023	48.7	49.5	71,390	0.95	0.83	0.99	0.96	52.3	59.8	50.2	51.5
31	DominicanRep	2023	13.6	13.8	23,088	0.47	0.46	0.41	0.44	29.0	29.9	33.6	31.3
32	Ecuador	2023	13.8	19.6	14,472	0.49	0.83	0.48	0.53	39.6	23.7	41.1	36.8
33	Egypt	2023	12.4	14.5	16,691	0.38	0.63	0.35	0.37	37.8	23.1	41.0	38.9
34	ElSalvador	2023	19.0	21.2	72,660	0.67	0.65	0.58	0.58	31.7	32.8	36.5	36.3
35	Estonia	2023	21.7	34.2	41,669	0.66	0.82	0.66	0.66	51.8	42.0	51.6	52.2
36	Ethiopia	2023	7.5	7.5	2,755	0.53	0.86	0.64	0.73	14.2	8.7	11.6	10.3
37	Finland	2023	30.2	42.2	56,455	0.91	0.84	0.94	0.91	46.6	50.4	44.8	46.2
38	France	2023	29.0	45.4	53,969	0.96	0.94	0.98	0.98	47.1	48.4	46.4	46.1
39	Gambia,The	2023	9.4	9.4	2,932	0.40	0.67	0.46	0.49	23.3	14.1	20.4	19.1
40	Germany	2023	23.2	40.4	63,098	0.84	0.79	0.84	0.83	48.3	51.0	47.8	48.6
41	Ghana	2023	13.3	13.4	6,796	0.35	0.47	0.37	0.37	38.7	28.4	36.7	36.2
42	Greece	2023	27.7	40.9	36,821	0.80	0.90	0.77	0.82	51.1	45.3	52.8	49.9
43	Guatemala	2023	11.7	12.1	12,389	0.45	0.58	0.40	0.44	26.9	21.0	30.3	27.8
44	Guinea	2023	11.9	11.9	3,949	0.46	0.75	0.52	0.55	26.1	15.8	22.9	21.7
45	Guinea-Bissau	2023	10.9	10.9	2,579	0.35	0.73	0.43	0.45	31.5	15.0	25.5	24.3
46	Guyana	2023	16.1	18.3	49,315	0.43	0.85	0.49	0.50	42.1	21.4	37.1	36.5
47	Honduras	2023	18.0	21.1	6,468	0.49	0.81	0.54	0.61	42.7	26.0	39.3	34.6
48	Hungary	2023	27.1	37.1	40,168	0.75	0.88	0.73	0.73	49.6	42.1	50.8	50.9
49	Iceland	2023	32.2	35.3	66,880	0.75	0.70	0.75	0.74	47.4	50.1	47.2	47.7
50	India	2023	18.3	18.3	9,160	0.46	0.67	0.52	0.56	39.6	27.2	35.0	32.9
51	Indonesia	2023	10.3	10.7	13,890	0.43	0.58	0.40	0.42	25.0	18.5	26.6	25.6
52	Iran, I.R. of	2021	5.3	5.3	14,952	0.24	0.28	0.15	0.17	22.1	19.0	36.6	31.9
53	Ireland	2023	17.8	21.8	115,401	0.58	0.71	0.52	0.52	37.6	30.8	41.6	42.2
54	Israel	2023	25.9	31.4	48,356	0.69	0.80	0.68	0.71	45.7	39.5	46.2	43.9
55	Italy	2023	29.7	43.3	52,589	0.97	0.99	0.95	0.98	44.8	44.0	45.5	44.1
56	Jamaica	2023	26.4	27.7	10,291	0.75	0.77	0.76	0.80	36.8	35.9	36.3	34.5
57	Japan	2023	20.4	34.2	45,949	0.75	0.72	0.72	0.74	45.7	47.5	47.5	46.3
58	Jordan	2023	17.1	17.5	9,363	0.53	0.60	0.49	0.51	33.1	29.3	35.5	34.0
59	Kenya	2023	15.0	15.0	5,683	0.52	0.65	0.60	0.61	29.0	23.1	24.9	24.4
60	Korea	2023	14.3	18.0	49,995	0.54	0.41	0.46	0.47	33.1	43.4	39.0	38.7

1/ Tax and social contributions as percent of GDP.

2/ Tax capacity (percent of GDP): tax and social contributions divided tax effort.

	Countrq	Year	Tax Revenue	Total Revenue: Tax and SSC	Percapita GDP, PPP const 2021	Tax Effort				Tax Capacity % of GDP/3			
						CB HN	MREM	EN	Ex HN	CB HN	MREM	EN	EX
						CI	CII	CIII	CIV	CV	CVI	CVII	CVIII
61	Kuwait	2023	9.3	11.7	46,458	0.34	0.39	0.26	0.26	34.4	30.2	45.9	44.8
62	KyrgyzRepublic	2023	25.5	30.2	6,403	0.49	0.81	0.57	0.61	61.1	37.1	53.3	49.2
63	Latvia	2023	20.1	29.5	38,333	0.61	0.74	0.61	0.62	48.7	39.7	48.7	47.8
64	Lebanon	2023	6.5	6.8	11,417	0.45	0.49	0.14	0.16	15.1	13.7	49.7	41.3
65	Lithuania	2023	22.0	32.8	46,118	0.63	0.78	0.64	0.64	52.1	41.8	51.4	51.0
66	Luxembourg	2023	29.3	42.2	130,373	0.77	0.91	0.70	0.67	54.8	46.2	60.6	63.0
67	Madagascar	2023	11.5	11.5	1,643	0.44	0.68	0.48	0.56	26.1	16.8	23.8	20.5
68	Malawi	2023	12.7	14.2	1,648	0.56	0.86	0.72	0.82	25.3	16.5	19.7	17.4
69	Mali	2023	13.7	14.8	2,395	0.62	0.98	0.78	0.82	24.0	15.1	19.1	18.1
70	Malta	2023	21.8	27.0	59,548	0.73	0.76	0.61	0.62	36.8	35.4	44.5	43.7
71	Mexico	2023	13.9	16.1	21,874	0.33	0.47	0.31	0.34	48.2	33.9	52.0	47.5
72	Moldova	2023	19.5	28.8	15,855	0.60	0.84	0.65	0.68	47.8	34.1	44.2	42.1
73	Mongolia	2023	25.2	25.8	16,223	0.55	0.89	0.57	0.59	46.6	29.2	45.4	43.4
74	Montenegro	2023	27.2	37.0	27,343	0.72	0.97	0.77	0.78	51.6	38.3	48.1	47.2
75	Morocco	2023	20.5	22.5	8,869	0.73	0.78	0.78	0.82	30.7	29.0	28.8	27.6
76	Mozambique	2023	21.7	21.7	1,512	0.63	0.95	0.89	0.98	34.3	22.8	24.4	22.2
77	Myanmar	2023	7.2	7.3	5,364	0.24	0.63	0.25	0.27	30.3	11.7	29.4	27.0
78	Namibia	2023	30.0	30.0	10,106	0.88	0.97	0.99	0.98	34.2	31.0	30.3	30.6
79	Netherlands	2023	25.4	38.7	70,610	0.79	0.80	0.77	0.75	49.0	48.5	50.4	51.7
80	New Zealand	2023	32.4	32.4	48,580	0.73	0.83	0.76	0.76	44.1	39.2	42.5	42.6
81	Nicaragua	2023	19.5	26.7	7,487	0.70	0.94	0.71	0.80	38.3	28.3	37.7	33.5
82	Niger	2023	10.3	10.8	1,703	0.46	0.74	0.58	0.65	23.7	14.6	18.8	16.5
83	Nigeria	2023	6.4	6.9	5,593	0.28	0.62	0.27	0.28	24.4	11.1	25.4	25.2
84	Norway	2023	37.2	49.5	90,160	0.99	0.95	0.98	0.98	49.9	51.8	50.7	50.6
85	Oman	2023	7.9	12.4	38,311	0.24	0.32	0.19	0.19	50.8	39.0	64.9	64.5
86	Pakistan	2023	10.1	12.1	5,439	0.35	0.63	0.36	0.39	34.4	19.2	33.5	30.9
87	Panama	2023	7.7	12.5	35,864	0.49	0.57	0.42	0.45	25.4	22.1	29.6	27.8
88	PapuaNewGui	2023	16.7	16.7	4,174	0.62	0.98	0.60	0.65	26.8	17.0	27.7	25.5
89	Paraguay	2023	10.1	11.3	15,783	0.37	0.52	0.33	0.36	30.3	21.6	33.9	31.3
90	Peru	2023	15.1	17.2	15,294	0.61	0.69	0.57	0.61	28.1	24.9	30.3	28.3
91	Philippines	2023	15.1	17.9	9,901	0.46	0.70	0.50	0.54	38.6	25.5	36.1	33.4
92	Poland	2023	21.6	35.9	43,585	0.74	0.81	0.73	0.75	48.5	44.3	49.0	47.6
93	Portugal	2023	25.2	35.6	41,498	0.74	0.79	0.74	0.75	48.3	45.3	47.9	47.5
94	Qatar	2023	8.3	8.3	116,159	0.12	0.18	0.11	0.11	68.0	44.7	74.4	74.8
95	Romania	2023	16.4	26.4	40,267	0.65	0.86	0.64	0.66	40.4	30.8	41.2	40.0
96	Russia	2023	24.6	31.4	39,753	0.77	0.91	0.78	0.82	40.6	34.5	40.1	38.4
97	Saudi Arabia	2023	12.7	12.7	55,055	0.22	0.24	0.18	0.17	56.9	52.2	72.0	72.9
98	Senegal	2022	17.6	18.7	4,228	0.57	0.70	0.63	0.67	32.6	26.8	29.6	27.8
99	Serbia	2023	23.7	37.1	25,718	0.99	0.99	0.96	0.98	37.6	37.6	38.6	37.9
100	Singapore	2023	13.8	13.8	127,544	0.32	0.46	0.28	0.27	43.8	29.7	48.7	50.6
101	Sierra Leone	2023	8.9	8.9	3,034	0.38	0.46	0.28	0.27	23.3	19.2	31.4	33.0
102	SlovakRepublic	2023	19.8	35.2	39,172	0.64	0.76	0.60	0.60	54.8	46.1	58.9	58.3
103	Slovenia	2023	21.0	37.1	47,825	0.73	0.81	0.72	0.72	50.5	45.9	51.6	51.3
104	South Africa	2023	23.9	26.1	13,690	0.60	0.88	0.72	0.72	43.2	29.7	36.2	36.4
105	Spain	2023	24.3	35.7	47,298	0.80	0.83	0.79	0.81	44.7	43.0	45.4	44.3
106	SriLanka	2023	9.8	10.0	13,030	0.51	0.55	0.41	0.45	19.7	18.3	24.1	22.2
107	Suriname	2023	17.3	17.9	19,044	0.56	0.78	0.46	0.48	31.7	22.9	38.8	37.5
108	Sweden	2023	37.7	41.0	62,665	0.92	0.82	0.95	0.93	44.5	49.8	43.3	44.1
109	Switzerland	2023	20.7	27.2	81,684	0.63	0.59	0.59	0.59	43.3	46.1	46.0	46.4
110	Tanzania	2023	12.1	12.1	3,621	0.44	0.65	0.51	0.55	27.3	18.7	23.6	22.0
111	Thailand	2023	20.8	21.7	21,143	0.45	0.65	0.43	0.46	48.2	33.4	50.4	47.1
112	Togo	2023	13.9	13.9	2,768	0.48	0.79	0.58	0.63	29.2	17.6	23.9	22.1
113	TrinidadandTol	2023	27.4	31.1	31,706	0.80	0.95	0.68	0.71	38.8	32.7	45.8	43.7
114	Tunisia	2023	24.8	24.8	12,553	0.58	0.71	0.57	0.60	42.5	34.9	43.5	41.6
115	Türkiye	2023	17.0	24.2	34,252	0.60	0.83	0.55	0.60	40.2	29.4	44.1	40.6
116	UAE	2023	23.4	24.6	68,578	0.53	0.78	0.48	0.47	46.7	31.5	51.5	52.5
117	Uganda	2023	12.6	12.6	2,791	0.45	0.70	0.52	0.57	28.0	18.0	24.2	22.1
118	Ukraine	2023	25.5	33.3	15,885	0.70	0.87	0.75	0.78	47.8	38.2	44.2	42.5
119	UnitedKingdom	2023	26.2	33.1	52,589	0.77	0.73	0.76	0.76	43.1	45.3	43.4	43.7
120	UnitedStates	2023	19.2	25.2	74,578	0.69	0.64	0.68	0.68	36.4	39.6	37.1	36.9
121	Uruguay	2023	18.4	25.7	31,019	0.62	0.79	0.66	0.67	41.2	32.5	39.1	38.3
122	Vietnam	2023	12.8	12.8	13,492	0.39	0.67	0.40	0.42	33.1	19.0	32.3	30.2
123	Zambia	2023	15.8	15.8	3,673	0.66	0.82	0.80	0.81	24.1	19.2	19.8	19.6
	Average					0.59	0.74	0.60	0.62	38.9	31.8	39.7	38.4
	Standard deviation					0.18	0.17	0.20	0.20	10.5	11.7	11.5	11.9
	Median					0.61	0.78	0.60	0.63	40.2	30.8	40.1	38.4

1/ Tax and social contributions as percent of GDP.

2/ Tax capacity (percent of GDP): tax and social contributions divided tax effort.

43. **The relevance of fixed effects can be illustrated by considering two elements that strongly influence public preferences toward government size and tax revenue**: the social contract and the level of natural resource dependence. When the social contract is weakened,[25] countries may systematically exhibit low levels of tax revenue and tax effort. This may help explain why, in countries such as Argentina or Guatemala, the MREM model produces considerably higher estimates of tax effort. For example, in Guatemala, the average tax revenue during the period analyzed was approximately 11 percent, despite the frustrated attempts of successive governments to increase it, for example, by raising the VAT and income tax rates (12 percent and 7percent, respectively), among the lowest in the world.

44. **Likewise, governments that derive substantial rents from the oil sector often maintain low levels of tax revenue to avoid the political costs associated with higher tax effort** (despite the fiscal risks linked to resource dependence). The only exception identified is Saudi Arabia, which increased its tax revenue by approximately 370 percent (from 4.8 percent to 12.7 percent of GDP) between 2017 and 2023, following a decline in oil prices that was further exacerbated during the COVID-19 pandemic. During this period, the country not only introduced the VAT (a measure adopted by few of its peers) but also raised its rate from 5 percent to 16 percent.

45. **As expected, and also consistent with previous estimates,[26] the empirical analysis shows that tax capacity and tax effort increase with the level of development** (Figure 1). Exceptions include countries with high per capita GDP but low tax capacity, such as the oil-dependent economies of the United Arab Emirates and Qatar, as well as South Korea and Singapore, where low statutory tax rates (a policy choice) largely explain the low level of tax effort. Conversely, countries with relatively low per capita GDP but operating close to tax capacity include, among others, Mali, Namibia, Senegal, and Zambia. Several factors could explain these outcomes, including the presence of mining activities—though revenues from this sector rarely exceed 25 percent of total collections—conducted mainly by large companies that are easier to monitor than small producers (in addition, outdated GDP base years often lead to underestimation of GDP, which can distort measures of tax revenues and, therefore, of effort).

46. **The group of 14 natural resource countries included in this analysis is very heterogeneous**. While some countries (such as Bolivia and Mexico) have developed, at least somewhat, their non-natural resource GDP tax revenue, others (such as Kuwait) have not. Therefore, while some natural resource dependent countries have a very low tax effort (reaching only 0.11 for Qatar and 0.15 for Iran under the EN model, Table 3, column III), others, such as Papua New Guinea,

[25] For instance, when taxpayers perceive persistent government waste or widespread corruption.

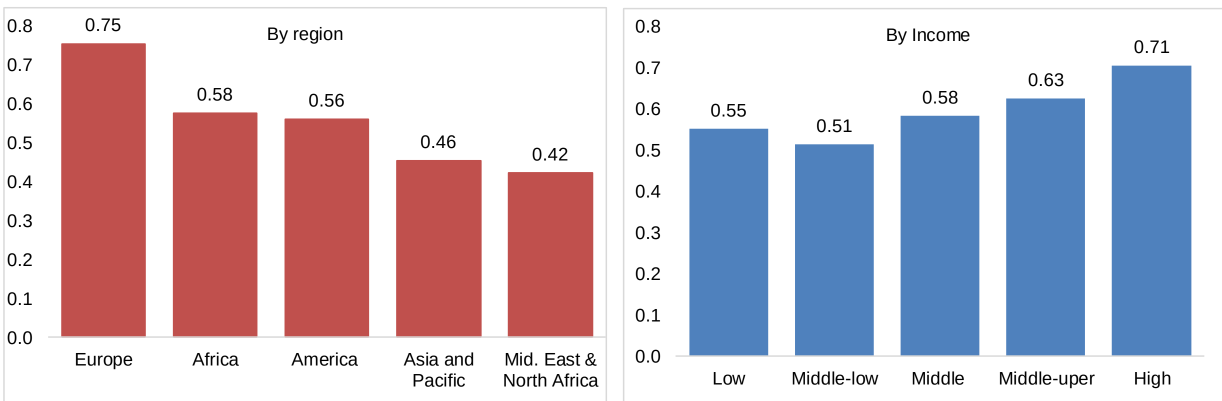
[26] Fenochietto and Pessino (2013).

Bolivia, and Norway, are much closer to their maximum levels of tax capacity. This is explained in part, because the latter countries had developed their tax systems before exploiting their natural resources.

47. **Most European countries with a high level of development are near their tax capacity have a higher tax effort** (Figure 1). This is particularly the case of Austria, Belgium, Denmark, Finland, France, Italy, and Sweden (with tax efforts higher than 90 percent). Both the demand for public expenditure and the efficiency in collecting taxes are a crucial determinant of the higher level of tax effort.

Figure 1. Countries' Tax Effort – EN

by Level of Development and Region



48. **It is worth emphasizing that, as in many economic analyses, our approach is not a perfect estimation and is subject to various caveats**. This includes potential difficulties in data comparability (the quality of data usually improves with development); some reverse causality from the level of development and tax revenue to specific explanatory variables, such as the level of corruption. However, with sufficient caution in the interpretation, the results provide important guide to tax potential (considering country-specific conditions, see analysis in next section) and suggest scope for tax policy and administration reform, especially for many low-income countries.

H. Sensitivity Analysis

49. **We examined the robustness of our results under alternative weighting schemes and tested several scenarios:**

- First, we run the MREM model after increasing GDP per capita by 15 percent for the 25 countries with the lowest income levels. The model parameters do not change significantly (for example, the GDP-per-capita coefficient shifts only from 1.461 to 1.511, and the trade coefficient from 0.0015 to 0.0014; see Appendix 1, CI and CII). Overall tax effort remains essentially unchanged as well—the mean is identical, and the highest change is that of India, which tax effort increases only marginally, from 0.67 to 0.68 (Appendix 2).

- Second, to further stress-test the possibility that low-income countries underestimate GDP, we run the EN model after increasing GDP per capita by 15 percent for the 25 lowest-income countries and simultaneously reducing their revenue (taxes and social security contributions) by the same proportion. The results are similar: the significance of the estimated parameters does not change in any meaningful way (Appendix 1, CI and CIII), nor does the distribution of tax effort (Appendix 2).
- Finally, we run the MREM model under three additional robustness checks: (1) excluding the three countries with the highest GDP per capita (Luxembourg, Norway, and Singapore); (2) excluding the four countries with the lowest GDP per capita (Malawi, Mozambique, Niger, and Madagascar); and (3) excluding the three countries with the lowest Gini coefficients. These adjustments also have no meaningful effect on the results. For example, when excluding the countries with the lowest GDP per capita, changes in tax effort are minimal: in almost all countries the difference is below 0.04, with the only exceptions being Ethiopia (0.076) and Burkina Faso (0.086)—both of which are among the countries with the lowest GDP per capita.

III. Disentangling the Frontier Tax Gap

50. **An important distinction between stochastic production frontier analysis and stochastic tax frontier analysis lies in their results.** In production frontier analysis, the difference between current production and the frontier represents the level of inefficiency, what firms fail to achieve. In stochastic tax frontier models, the difference between actual revenue and tax capacity (the 'frontier tax gap', TFG) reflects both technical inefficiencies and policy-related issues.

51. **Consequently, the FTG can be explained by two groups of variables**: (i) those that represent inefficiencies in government tax collection, mainly high levels of non-compliance (primarily an administrative issue), and (ii) those related to the preferences of citizens, who may opt for lower tax revenues and a reduced provision of public goods and services (a policy issue). Low tax rates and narrow tax bases (high level of tax expenditures: exemptions, exclusions, and deductions) are the key policy factors that contribute to a low tax effort.[27] Disentangling the components of the FTG helps identify strategies for revenue mobilization by pinpointing where each country has space to raise tax revenue.

[27] Other factors include turnover taxes, which are becoming increasingly uncommon in modern tax systems; missing taxes (taxes that have been not introduced in a country); and high-income thresholds—particularly in the PIT—below which individuals are exempt from taxation.

52. **The SFA estimates countries' tax effort and the potential additional revenue that could be mobilized**. However, it does not disentangle the extent to which this additional revenue could be achieved by reducing inefficiencies (e.g., non-compliance) as opposed to implementing policy measures (e.g., increasing tax rates, narrowing personal income tax brackets, or eliminating tax expenditures). Previous studies (see Fenochietto and Pessino 2010 and 2013) did not deal with the determinants of the frontier tax gap owing to the unavailability of suitable data.

53. **This section presents two complementary models to assess the relative contributions of inefficiency and policy factors to the frontier tax gap**: (i) a two-stage econometric regression model and (ii) a country-by-country analytical approach. The availability and quality of data have improved substantially over the past decade. Although current data remain insufficient to draw robust empirical conclusions, they now allow for preliminary findings and provide a foundation for more robust analysis as data coverage continues to expand. The country-by-country approach can already be applied separately to most developed economies.

54. **The regression equation that examines the relationship between the FTG and its explanatory variables is specified as follows** (the next subsections describe each variable and its source in detail):

$$ftg = f(\text{tax policy, non-compliance})$$

where:

- ftg is the FTG, defined as one minus the percentage of tax effort.
- tax policy includes variables for statutory rates; for the CIT effective tax rate; and for tax expenditures (such as exemptions, incentives, and deductions).
- non-compliance represents inefficiencies in tax collection.

55. **To establish an appropriate econometric framework for disentangling the ftg, the following explanatory variables were identified** (their definitions and data sources are detailed in the next sections):

- Policy-related variables: (i) statutory tax rates for the main taxes—CIT, PIT, VAT—and the effective CIT rate; and (ii) tax expenditures, including exemptions, deductions, and reduced rates.
- Efficiency-related variables: (i) VAT non-compliance, and given its limited availability (for 52 countries), (ii) the size of the informal economy, which serves as a proxy for overall tax collection inefficiency.

I. Non-compliance and Informality

56. **Systematic estimation and analysis of tax avoidance began in many developed countries around sixty years ago and gained prominence in emerging markets and developing economies roughly two decades later**.[28] Today, many countries estimate the VAT non-compliance using a top-down analytical approach and the IMF has implemented a program to assist countries with the estimation (IMF, 2017). Estimates of PIT and CIT non-compliance are less common, particularly in developing economies, as the bottom-up methods typically used for PIT estimation are resource-intensive and require specialized audit teams.

57. **Given this limitation, the study employs country-level VAT non-compliance estimates as a proxy for overall tax collection inefficiency**, **based on the assumption that non-compliance levels are broadly similar across major taxes**. This assumption rests on the nature of taxpayer behavior: firms or individuals that evade VAT—by underreporting sales or overstating purchases—typically underreport profits too, thereby lowering their CIT or PIT liabilities. Furthermore, because value added reflects both labor and capital income, underreporting transactions or inflating input costs not only reduces the value added declared to tax authorities but also diminishes PIT and SSCs or CIT liabilities.[29]

58. **As VAT non-compliance data are available for only 52 countries, this study applies the Heckman Sample Selection Model[30] to address potential selection bias** (considering that the missing observations are unlikely to be random).[31] To improve model identification, we incorporate an additional variable *inf—the size of the informal economy*—which is assumed to influence tax non-

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[28] Two main methodological approaches are commonly used to estimate tax non-compliance: the top-down and bottom-up approaches. The top-down approach relies on aggregated data—typically from national accounts—to estimate the potential revenue from a given tax and then calculates the size of the compliance gap by subtracting actual revenue from potential revenue (IMF, 2017). This approach is most frequently applied to estimate the VAT non-compliance gap. In contrast, the bottom-up approach estimates non-compliance by extrapolating the results of detailed audits conducted on a stratified random sample of tax returns, which are thoroughly reviewed by experienced auditors. This method is generally used in developed countries to estimate the PIT non-compliance gap.

[29] There could be some exemptions, which should not be significant. For instance, some operations could be exempted from the VAT but not from the CIT and vice versa.

[30] The Heckman model is a two-stage method that addresses endogenous sample selection. A first-stage probit model is run to estimate the probability of being selected or observed in the data (selection equation). Second, the main panel model is run with a control function derived from the selection equation (the inverse Mills ratio) to correct for the selection bias.

[31] VAT non-compliance estimates are available for almost all EU countries (European Commission, 2022), among the most developed countries in our sample, and Latin America countries, among the middle-income group in our study (Source: country estimates and publications).

compliance but not directly the frontier tax gap. Although informality and tax evasion are conceptually distinct, they are often closely interrelated. Tax evaders frequently exploit the informal sector as a means to evade taxation. In the United States, a substantial share of tax evasion is associated with the informal economy and in Latin America and Asia, large or medium-sized importers sometimes bring in full containers of goods that are subsequently sold in informal markets to small taxpayers, many of whom are unregistered or, if registered, underreport their income.[32] We use the level of informal economy calculated in Medina and Schneider, 2018.

J. Tax Expenditures

59. **Tax expenditures (TEs) constitute a significant component of the FTG**. They include any kind of benefit that reduce the tax bases and, therefore, tax collection. They are usually defined as the revenue forgone due to preferential tax treatments (e.g., exemptions, deductions, or reduced rates) relative to a reference or benchmark tax system (BTS). Constructing a variable that adequately captures TEs presents several challenges:

- First, not all countries systematically estimate TEs.
- Second, there is no internationally agreed framework for measuring them—particularly with respect to defining the BTS; the magnitude of TEs, therefore, will depend on how the BTS is defined. The adoption of different definitions of the BTS and other factors may bias cross-country comparisons of TEs. As a result, TEs are identified according to varying national criteria and policy motivations. For example, while some countries include within their CIT expenditures those related to non-profit organizations, embassies, and public bodies (e.g., Ecuador), others exclude them (e.g., Argentina). Similarly, some countries incorporated customs exemptions arising from Free Trade Agreements (e.g. Pakistan in 2014-15), whereas others do not; and, in some jurisdictions, such as Germany, VAT reduced rates are treated as TEs. Different definitions produce different results, making it difficult to create a variable for countries' tax expenditures.
- Third, and related with the previous one, the scope of TE estimations also varies across countries. Many countries omit subnational tax expenditures from their estimates, even where tax decentralization is substantial, as is the case in Brazil, Argentina, and India.

[32] A similar pattern is observed among medium-sized and small enterprises that possess a basic organizational structure. Some artificially firms divide their operations into multiple entities—often using front persons—so that each entity's income remains below the minimum threshold for VAT or income tax liability. Others opt to remain within simplified tax regimes, where the overall tax burden is lower, thereby reducing their effective tax obligations.

- Fourth, Estimates usually do not include tax expenditures associated with taxes that have not been introduced; for instance, Bolivia does not include PIT-related tax expenditures, and Ecuador excludes those related to fuel taxation.
- Fifth, since the revenue forgone methodology measures amounts net of non-compliance, differences in non-compliance levels across countries affect comparability.[33]
- Sixth, one of the most critical factors affecting cross-country comparability of TEs measurements is the variation in statutory tax rates. Because TEs are typically calculated as the product of the exempted tax base and the relevant tax rate, higher tax rates implied higher TEs. To address this bias, this paper also employs an alternative indicator (*ite*): tax expenditures normalized by each percentage point of the corresponding statutory tax rate.
- Seventh, differences also stem from data limitations. A substantial bias exists in the availability of information: developed countries typically report significantly higher tax expenditures than developing countries, partly due to more extensive tax benefits and higher rates, but also because data availability is greater.[34]
- Eighth, eliminating some tax expenditures would not necessarily generate the total revenue estimated under the 'revenue forgone' methodology (applied for almost all countries), which assumes taxpayer behavior and all other conditions remain unchanged following the removal of a preferential treatment.

60. **Nonetheless, some of these limitations could be partially mitigated in the current analysis.** And, considering how the availability of data improved in the last years, they could be mitigated even more in the near future. First, the recent international agenda on tax transparency has encouraged most countries to institutionalize the measurement of tax expenditures. In line with this trend, the Council on Economic Policies (CEP) and the German Institute of Development and Sustainability (IDOS)[35] have developed a cross-country database that compiles official national TE estimates (we used data for 89 countries from these international sources). Second, although the

[33] Consider, for instance, three countries that exempt apples from VAT, where the level of production, sale prices, and VAT rate are the same—one; $100; and 10 percent, respectively—but non-compliance levels differ: 20, 40, and 50 percent. Despite the level of consumption of apples is the same in the 3 countries, the estimation of tax expenditures differs due to the different levels of noncompliance: 8 in the first country; 6 in the second; and 5 in the third.

[34] For instance, while Netherland, Czechia, and Finland report levels over 10 percent of GDP, while Bolivia, Cote d'Ivoire, and Tanzania report levels below than 1.2 percent.

[35] The Global Tax Expenditures Database (GTED), led by the CEP and IDOS, brings together the official and publicly available data on tax expenditures, as published by national governments, and makes it available online (Redonda 2024 and https://gted.taxexpenditures.org/what-is-the-gted/)

revenue forgone methodology overstates the potential fiscal impact of eliminating tax expenditures, the resulting bias is largely uniform across countries, thereby preserving cross-country comparability. Third, certain tax expenditures are widely adopted and embedded in the structure of most tax systems—such as VAT exemptions on self-consumption and financial services, and CIT exemptions for non-profit organizations—and are, therefore, not captured in the frontier estimation.[36] Fourth, to deal with missing values (which we expect are not completely at random), this paper uses a Full Information Maximum Likelihood (FIML) approach.[37]

61. **We emphasized that it is appropriate for countries to measure tax expenditures**. The lack of cross-country comparability or the disconnection between how tax expenditures are measured and revenue mobilization does not diminish the value of this effort. On the contrary, it represents an excellent initiative—the same to the GTED—whose main purpose is greater transparency. In our model, transparency is more closely related to governance and institutional quality (measured through the variable *cor*, represented by corruption) than to the portion of the tax base that could be modified to increase revenue and reduce the FTG.

K. Tax Rates

62. **Several tax rate measures are commonly employed in cross-country analyses of tax burdens**. First, the statutory tax rate, defined in tax legislation and easily observable across jurisdictions. However, statutory rates do not necessarily capture the effective burden of taxation, as the ultimate impact on revenue—and consequently on tax effort—depends on a range of factors that impact the tax base. For instance, under the CIT, the presence of investment incentives and accelerated depreciation schemes can substantially reduce effective liabilities; similarly, under the PIT, personal allowances can significantly alter the effective rate faced by taxpayers (Benedek et al, 2022). Second, the average effective tax rate (AETR), generally calculated as the ratio of total taxes paid to total (taxable) income and frequently used as a proxy for the tax burden. Finally, the marginal effective tax rate (METR) measures the proportion of an incremental of additional tax paid for every additional dollar earned, capturing the distortionary impact of taxation on investment and labor supply decisions.

[36] To address potential overstatement and ensure greater methodological consistency, the country-specific analysis applies an adjustment factor, reducing reported tax expenditures estimates by 40 percent.

[37] FIML estimates the structural model equation (SEM) using all available data by calculating the likelihood of each observation based on the variables that are observed. Instead of dropping cases with missing values, FIML uses information from the other variables to produce efficient and unbiased parameter estimates under the assumption that the data are missing at random. In other words, the regression is run as if no data were lost, while correctly accounting for the missing values.

63. **Statutory tax rates are transparent, easily comparable, and available for all countries included in this study**. However, because the actual amount of tax paid depends on both the statutory rate and the breadth of the tax base, statutory rates alone may not accurately reflect a country's revenue performance. Similarly, marginal effective tax rates are useful for analyzing investment decisions and assessing the tax burden on specific forms of income or consumption, but they are not suitable for measuring the tax burden of a country. Therefore, this study employs two complementary approaches:

- **First**, the CIT AETR, which measures the present value of taxes paid on a project relative to the present value of the pre-tax income stream it generates.[38]
- **Second**, because AETR data is only available for 74 countries and for the CTI, the analysis also uses statutory (standard) tax rates for the VAT, PIT, and CIT, complemented with estimates of tax expenditures. In the case of the PIT, most countries apply progressive rate schedules in which the thresholds for each bracket vary substantially; this analysis uses the simple average between the minimum non-zero rate and the top marginal rate.

L. Main Findings

Econometric Model

64. **The FTG is regressed on the independent variables described in the previous section for the 123 countries in the sample**. Initially, simple regressions are estimated using *ftg1* (one minus the percentage of tax capacity estimated through the endogeneity-corrected model, EN) and *ftg* (one minus the percentage of tax capacity estimated using the MREM). Table 4 reports the regression coefficients for *ftg1*:

[38] https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/corporate-taxation/explanatory-annex-corporate-effective-tax-rates.pdf and Hanappi (2018).

T4. Parameters of the Baseline Regressions

Variable	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|	Coeff.	P>|t|
Observations	**119**		**74**		**89**		**89**		**52**		**52**	
Column #	1		2		3		4		5		6	
Dep Var	*ftg1*		*ftg1*		*ftg1*		*ftg1*		*ftg1*		*ftg1*	
Ind Variables												
apit	-0.006 ***	0.001	-0.007 ***	0.001	-0.004 *	0.089	-0.004	0.102	-0.003	0.137	-0.0037	0.106
vatr	-0.020 ***	0.000	-0.020 ***	0.000	-0.020 ***	0.000	-0.019 ***	0.000	-0.014 ***	0.004	-0.0138 ***	0.004
citr	-0.001	0.685			-0.002	0.433	-0.002	0.467	-0.008 ***	0.011	-0.0083 ***	0.010
etr			-0.003	0.122								
nonc									0.636 ***	0.000	0.63709 ***	0.000
inf	0.122	0.304	0.131	0.346	0.288 **	0.043	0.286 **	0.045				
ite					-0.049	0.714			0.087	0.522		
texp							-0.003	0.671			0.0041	0.502
Constan	0.848 ***	0.000	0.919	0.000	0.775 ***	0.000	0.768 ***	0.000	0.726 ***	0.000	0.7401 ***	0.000
F test	28.00		21.31		12.56							
Prob > F	0.000		0.000		0.000							
R-squared	0.496		0.553		0.431		0.431		0.556		0.556	
Adj R-squared	0.478		0.527		0.396		0.397		0.560		0.560	

- **Columns 1** includes the standard tax rates—*apit* (the average of the minimum and maximum PIT rates), *vatr* (the standard VAT rate), and *citr* (the standard CIT rate)—as well as *inf* (the size of the informal economy as a percentage of GDP), which serves as a proxy for noncompliance. These variables are available for almost all countries in the sample (119). The results show that the model explains a considerable share of the variation in *ftg1* (adjusted $R^2 = 0.478$). The VAT and PIT rates are statistically significant at the 1 percent level, whereas the CIT rate and informality are not. This may be because statutory CIT rates are not the final rate paid by taxpayers, and because informality is an imperfect proxy for tax noncompliance. Moreover, the model does not consider tax expenditures. Despite these limitations, the F test is relatively high and the Prob > F value is very low, indicating the overall model significance.
- **Regression 2** replaces *citr* with *etr* (the corporate average effective tax rate), which partially reflects tax expenditures (CIT tax incentives). This substitution increases the adjusted R-squared to 0.527 (from 0.478), although the number of observations declines from 119 to 74 (the OECD countries and a group of emerging economies).
- **Regressions 2 to 4 include *texp*[39] and *ite*[40]**, which, as expected, are not statistically significant.
- **Regressions 5 to 6 replace informality with VAT noncompliance** (*nonc*), a variable that more accurately captures the inefficiency component of the frontier tax gap. *Nonc* is consistently significant, as are the VAT rate and the CIT *etr*. Consequently, these equations yield higher

[39] Reported tax expenditures as percent of GDP reduced by 40 percent.

[40] Reported tax expenditures normalized by each percentage point of the corresponding statutory tax rate.

adjusted R-squared values. However, the sample size decreases to 52, corresponding to the countries for which i-compliance data are available (mainly EU and Latin American countries).

65. **Regarding data, the previous analysis presents two problems**. First, although VAT non-compliance is an appropriate variable for capturing inefficiencies, it is available for only 52 countries, which significantly reduces the sample size. Moreover, these 52 countries are among those with higher level of income. Second, while the informality variable is available for nearly all countries, it is not a reliable proxy for non-compliance in many cases. Clear examples include countries that choose to maintain low levels of tax collection—such as Saudi Arabia, the United Arab Emirates, Qatar, or Singapore—and, therefore, exhibit a high frontier tax gap despite relatively low levels of informality. As noted earlier, we address non-random missing data using the Heckman sample selection model.

66. **Table 5 presents the parameters of the outcome equation, regression for *nonhat*[41]** (how explanatory variables affect the outcome after correcting for selection bias). The results are better than those of Table 4. For instance, column 1 shows that the model explains a large share of the variation in ftg1 ($R^2 = 0.836$; adjusted $R^2 = 0.830$). The overall model is statistically significant (F is 145.44, $p < 0.001$), indicating that the explanatory variables jointly have a strong effect on *ftg1*. Among them, *vatr, citr, and nonhat* are statistically significant at 1 percent level, with the first two exhibiting negative relationships and *nonhat* a positive one. In contrast, *apit* is not statistically significant ($p = 0.982$). The Root MSE of 0.080 indicates a small average prediction error, confirming a good model fit. *Nonhat* is very significant: when it is reduced by a one–percentage-point, ftg1 is also reduced by approximately 1.58 percentage points; CIT y VAT rates are also significant and when their rates increase by a one–percentage-point, the frontier tax gap is reduced by approximately 1.5 and 0.6 percent percentage points respectively.

[41] Nonhat is *nonc* with values for all countries, using the Heckman model, including those with missing data.

Table 5. Parameters of the Regressions with Heckman Model

Variable	Coefficient		P>|t|	Coefficient		P>|t|
Observations	**119**			**75**		
Rregresion #	1			2		
Dep Var	*ftg1*			*ftg1*		
Ind Variables						
apit	0.000		0.982	-0.0035	**	0.023
vatr	-0.006	***	0.001	-0.0092	***	0.004
citr	-0.015	***	0.000			
etr				-0.0062	***	0.001
nonhat	1.582	***	0.000	1.018	***	0.000
Constan	0.520	***	0.000	0.548	***	0.000
F test	145.44			54.27		
Prob > F	0.000			0.000		
R-squared	0.836			0.756		
Adj R-squared	0.830			0.742		
Root MSE	0.080			0.096		

67. **A second problem concerns the absence of a suitable measure of tax expenditures.** Models employing statutory tax rates as explanatory variables should be controlled for at least one indicator of base narrowing (or tax base breadth), which is largely determined by tax expenditures—broadly defined to include all forms of preferential treatment (e.g., incentives, reduced rates, and deductions). Not including tax expenditures in the model may introduce omitted-variable bias. However, data on tax expenditures are available for only 89 countries, and this variable is an inadequate proxy to explain the FTG.

68. **When the models in Tables 4 and 5 were estimated including *texp* or *ite* neither variable was statistically significant**. To address potential bias due to missing data on tax expenditures, we applied the FIML approach to assess whether the lack of significance resulted from missing observations or not. We also included a dummy variable for OECD countries. Table 6, columns 1 and 2, present the results for *ftg* and *ftg1*.

69. **The structural equation model (SEM) results also show that the frontier tax gap is strongly associated with several structural and policy variables**. The tests indicate that the model fits the data well: a chi2_ms(0) = 0 implies that the model perfectly reproduces the data. Overall, the specification yields a coherent set of results consistent with the underlying conceptual framework; the chi2_bs(6) value shows that it performs substantially better than the baseline model; and the p > chi2 statistic confirms that the model is significantly superior to the baseline specification. And, as expected, tax expenditures are not significant.

Table 6. Parameters of the Structural Equation Models

Variable	Coefficient	P>|t|	Coeff.	P>|t|
Observations	**123**		**123**	
Rregresion #	1		2	
Dep Var	*ftg*		*ftg1*	
Ind Variables				
ite	-0.0449	0.733	0.024	0.818
apit	-0.0051 ***	0.001	-0.005 ***	0.000
vatr	-0.0115 ***	0.000	-0.011 **	0.000
etr	-0.006 ***	0.001	-0.007 ***	0.000
oecd	0.150 ***	0.000	0.093 ***	0.001
nonhat	0.856 ***	0.000	1.225 ***	0.000
Constan	0.463 ***	0.000	0.554 ***	0.000
log likelihood	-824.30		-806.27	
LR test				
model vs saturated	chi2(0) = 0.00		chi2(0) = 0.00	
baseline vs saturated	chi2_bs(6) = 93.8		chi2_bs(6) = 166.7	
p > xhi2	0.00		0.00	

***, **, * = significance 1%, 5%, 10% level.

70. **Non-compliance emerges as the most influential determinant**: a one-unit increase in the non-compliance index raises the frontier tax gap (*ftg1* under MREM) by about 1.22 percentage points, holding other factors constant. In contrast, higher statutory rates and CIT effective tax rate are all significantly associated with a lower frontier gap. OECD membership is positively correlated with the FTG, reflecting, in some way, a higher tax capacity (typical of advanced economies). The ITE variable is not statistically significant, indicating that once the other structural factors are accounted for, it does not contribute meaningfully to explain cross-country differences in the FTG. The covariance structure among the exogenous variables displays expected patterns, such as the negative relationships between non-compliance and both APIT and the VAT rate, and the positive association between OECD membership and higher tax rates.

71. **It might be advisable that countries include tables of feasible revenue mobilization measures in their tax expenditure reports**.[42] However, even if this becomes standard practice,

[42] In many countries, policymakers, multinational organizations, and the public at large have assumed that eliminating tax expenditures would increase revenue collection by an amount equivalent to the value of those expenditures. However, this was not the case. For instance, exemptions for non-profit organizations under the CIT are extremely difficult, if not impossible, to remove; the same applies to exemptions for medicines and vaccines under the VAT, or for goods covered by free trade agreements under customs duties. Moreover, eliminating certain tax expenditures—such as the VAT exemption on intermediate goods—could actually reduce total revenue.

several comparability issues will persist, and it will be still necessary to adjust countries' estimates to construct a proper explanatory variable of the frontier tax gap. Although differences in statutory tax rates are relatively straightforward to address by recalculating the value of tax expenditures relative to each tax rate, other discrepancies are more complex. To construct a comparable variable across countries, tax expenditure estimates must be adjusted so that they reflect the same types of fiscal benefits and are based on a consistent methodology. While such harmonization is not technically difficult, it is time-consuming and requires the availability of multi-year data. Ideally, most countries would publish tax expenditure reports that include estimates for each major tax, and where relevant, for subnational taxes—especially when subnational governments play a significant fiscal role.

Country-by-Country Breakdown

72. **Country-by-country analysis is valuable not only for validating the econometric results but also for incorporating country-specific characteristics** (Box I). As an illustration, this paper examines the breakdown of the FTG for a sample of countries that meet the minimum data requirements and for which information on the structure of the tax system is available. Owing to data limitations—particularly regarding the composition of the tax base—the analysis does not include SSCs.

Box I. Country Specific Characteristics

Although many countries share similar tax structures and revenue administrations, their tax systems are shaped by country-specific features that can also explain the frontier tax gap, in addition to the two groups of variables described in previous section.[43] When such factors are identifiable, they should be incorporated into the country-by-country analysis to obtain a more accurate decomposition of the frontier tax gap. Example of these factors include:

- Turnover taxes in addition to the VAT, where they generate substantial revenue. For instance, Brazil applied several turnover taxes at the federal and subnational levels, while Argentina levies a federal tax on banking transactions (about 1percent of GDP) and a provincial cascading turnover tax (about 4percent of GDP). These taxes are not common in most countries around the world; however, caution is needed, as these taxes may substitute revenue from other instruments (e.g., lower VAT rates).
- Sales taxes (like in the USA at subnational level) and turnover taxes (like in Myanmar) instead of the VAT.
- Stamp duties and fees, which remained common between 2002 and 2023 in various natural resource–dependent and Middle Eastern economies.
- Missing or weakly implemented taxes**.** Some countries do not levy key taxes commonly found in most tax systems, or apply them at minimal rates. For example, Kuwait has not introduced a VAT; Qatar, the

[43] The policy-related variables (tax rates of the VAT, CIT, and PIT and tax expenditures) and efficiency-related variables (VAT non-compliance or the size of the informal economy).

United Arab Emirates, Saudi Arabia, and Bolivia did not levy a PIT; and some resource-dependent economies—such as Ecuador—either did not impose excise taxes on specific fuel products or apply them at very low rates. Although many countries have recently phased out fuel subsidies and introduced or increased fuel excise taxes, the effective tax burden on fuel products remained relatively low in several cases over the study period (2002–2023).

73. **Table 7 presents, for 27 countries, the decomposition of the FTG for taxes estimated with the EN-pseudo-IV model**. In the case of Albania, for example, tax expenditures, non-compliance, and PIT, CIT, and VAT rates explain 81 percent of the total gap. The overall gap amounts to 13.6 percent of GDP (CIII), of which 11.0 percent was identified (CIV); 5.9 percent stems from inefficiency in tax collection (CVI); and 5.1 percent from policy choices (CVII). For each country, the value of each variable was compared with its respective benchmark. The benchmark for VAT was set at 0.06 of potential VAT revenue, corresponding to the first quartile of the 123 countries in the sample. The benchmark for tax expenditures was 60 percent of the lower quartile, while for tax rates it corresponded to the value of the upper quartile.

Table 7. Frontier tax gap. Country-by-country Breakdown

FTG obtained with EN-pseudo-IV model

	Country	Tax Revenue	Tax Capacity - EN	FTG	FTG Explained	% Explained	Ineficiencies	Policy - Percent of GDP				
								Total Policy	Tax Rates			Tax Exp
									PIT/1	VAT	CIT	
		CI	CII	CIII	CIV	CV	CVI	CVII	CVIII	IX	X	XI
		Percent of GDP										
1	Albania	19.2	32.8	13.6	11.0	81.0	**-5.9**	**-5.1**	-1.2	0.0	-2.5	-1.4
2	Armenia	22.9	37.4	14.5	10.9	75.3	**-1.5**	**-9.4**	-4.7	0.0	-1.7	-3.0
3	Austria /2	27.8	29.6	1.8	2.5	100.0	**1.0**	**1.5**	3.2	0.0	-0.7	-1.0
4	Belgium	29.0	31.4	2.4	2.3	96.1	**-1.5**	**-0.8**	2.7	0.3	-1.5	-2.4
5	Brazil /2	23.9	30.9	7.0	9.8	100.0	**-6.5**	**-3.3**	-1.9	-0.4	0.6	-1.7
6	Bulgaria	20.0	32.3	12.3	12.0	97.6	**-0.3**	**-11.7**	-5.9	0.0	-5.4	-0.4
7	Chile	20.5	31.9	11.4	7.6	66.5	**-5.1**	**-2.5**	0.6	-0.5	-2.3	-0.3
8	Colombia	21.7	36.2	14.4	10.3	71.2	**-6.1**	**-4.2**	0.1	-0.3	0.2	-4.1
9	CostaRica	15.4	30.7	15.3	10.0	65.5	**-5.8**	**-4.2**	0.0	-2.6	0.0	-1.6
10	Czech Republic	18.6	27.7	9.1	7.8	85.9	**1.2**	**-9.0**	-1.8	0.4	-2.3	-5.4
11	Denmark /2	48.7	49.4	0.7	1.8	100.0	**-1.2**	**2.9**	2.4	1.9	-1.1	-0.3
12	Guatemala	11.7	29.3	17.6	12.3	69.9	**-3.3**	**-9.0**	-3.8	-4.2	-0.6	-0.4
13	ElSalvador	19.0	32.7	13.7	10.3	75.2	**-2.9**	**-7.3**	-1.3	-5.1	0.0	-0.9
14	France /2	29.0	29.6	0.6	1.7	100.0	**0.0**	**-1.7**	-0.2	0.0	-0.5	-1.0
15	Greece	27.7	35.7	8.0	4.6	56.8	**-2.3**	**-2.2**	1.1	0.4	-1.0	-2.8
16	Honduras	18.0	33.5	15.5	11.5	74.3	**-5.4**	**-6.1**	-0.9	-2.4	0.0	-2.8
17	Hungary /2	27.1	37.1	10.0	10.3	100.0	**1.1**	**-11.3**	-11.0	2.8	-2.8	-0.4
18	Italy	29.7	31.2	1.5	1.2	78.4	**-1.4**	**0.2**	1.5	0.6	-0.5	-1.4
19	Jamaica /2	26.4	34.6	8.2	10.2	100.0	**-5.7**	**-4.5**	-0.1	-2.6	-0.6	-1.2
20	Netherlands /2	25.4	33.1	7.7	7.9	100.0	**-0.4**	**-7.5**	0.3	0.3	-0.6	-7.5
21	Panama	7.7	18.2	10.5	8.4	80.3	**-3.1**	**-5.4**	-0.7	-3.3	-0.4	-0.9
22	Poland	21.6	29.5	7.9	3.8	48.5	**-0.5**	**-3.4**	-0.7	0.9	-1.6	-2.0
23	Romania	16.4	25.6	9.2	8.5	92.5	**-0.5**	**-8.0**	-3.9	-0.4	-2.2	-1.6
24	Sweden	37.7	39.8	2.1	1.9	89.4	**0.3**	**1.5**	2.4	1.9	-1.6	-1.1
25	UnitedKingdom	26.2	34.3	8.1	6.9	84.8	**-0.7**	**-6.2**	1.2	0.0	-3.9	-3.5
26	Uruguay	18.4	28.0	9.6	6.7	69.4	**-3.1**	**-3.5**	-0.9	0.6	-0.5	-2.7

1/ Average top and minimum rates.

2/ Identified policies and inefficiencies slightly outweigh the gap.

74. **Table 8 also presents the main indicators that explain the FTGs**. For example, in Bulgaria, approximately 98.0 percent of the gap is attributable to policy factors—an outcome that is plausible given the country's low level of VAT non-compliance (0.08 percent of potential VAT revenue, which is very close to the benchmark). Similarly, in Panama, 63.8 percent of the gap is explained by policy factors, which is also reasonable considering that Panama's VAT rate of 7.0 percent is among the lowest in the world, combined with the large number of tax incentives the country grants.

Table 8. Explanation of the Frontier Tax Gaps by Country

	Country	Percent of GDP		Percent of Total /2		Policy % of GDP				Nominal			VAT noncompliance % of Potential Revenue
						Tax Rates			Tax Exp	Tax Rates			
		Ineficiency	Policy	Ineficiency	Policy	VAT	PIT /1	CIT		PIT /1	VAT	CIT	
1	Albania	-5.9	-5.1	**54.0**	**46.0**	**0.0**	**-1.2**	**-2.5**	**-1.4**	18.0	20.0	15.0	0.29
2	Armenia	-1.5	-9.4	**13.4**	**86.6**	**0.0**	**-4.7**	**-1.7**	**-3.0**	15.5	20.0	18.0	0.12
3	Austria /2	1.0	1.5	**39.1**	**60.9**	**0.0**	**3.2**	**-0.7**	**-1.0**	37.5	20.0	25.0	0.03
4	Belgium	-1.5	-0.8	**65.0**	**35.0**	**0.3**	**2.7**	**-1.5**	**-2.4**	37.5	21.0	20.0	0.11
5	Brazil /2	-6.5	-3.3	**66.7**	**33.3**	**-0.4**	**-1.9**	**0.6**	**-1.7**	17.5	19.0	34.0	0.27
6	Bulgaria	-0.3	-11.7	**2.1**	**97.9**	**0.0**	**-5.9**	**-5.4**	**-0.4**	10.0	20.0	10.0	0.08
7	Chile	-5.1	-2.5	**66.8**	**33.2**	**-0.5**	**0.6**	**-2.3**	**-0.3**	37.5	19.0	20.0	0.25
8	Colombia	-6.1	-4.2	**59.6**	**40.4**	**-0.3**	**0.1**	**0.2**	**-4.1**	29.0	19.0	35.0	0.27
9	CostaRica	-5.8	-4.2	**58.0**	**42.0**	**-2.6**	**0.0**	**0.0**	**-1.6**	28.1	13.0	30.0	0.32
10	Czech Republic	1.2	-9.0	**12.1**	**87.9**	**0.4**	**-1.8**	**-2.3**	**-5.4**	19.0	21.0	19.0	0.04
11	Denmark /2	-1.2	2.9	**28.5**	**71.5**	**1.9**	**2.4**	**-1.1**	**-0.3**	31.8	25.0	22.0	0.09
12	Guatemala	-3.3	-9.0	**26.9**	**73.1**	**-4.2**	**-3.8**	**-0.6**	**-0.4**	6.0	12.0	25.0	0.27
13	ElSalvador	-2.9	-7.3	**28.5**	**71.5**	**-5.1**	**-1.3**	**0.0**	**-0.9**	20.0	13.0	30.0	0.19
14	France /2	0.0	-1.7	**1.1**	**98.9**	**0.0**	**-0.2**	**-0.5**	**-1.0**	28.0	20.0	25.0	0.06
15	Greece	-2.3	-2.2	**51.3**	**48.7**	**0.4**	**1.1**	**-1.0**	**-2.8**	34.5	21.0	20.0	0.14
16	Honduras	-5.4	-6.1	**46.8**	**53.2**	**-2.4**	**-0.9**	**0.0**	**-2.8**	20.0	15.0	30.0	0.28
17	Hungary /2	1.1	-11.3	**12.1**	**87.9**	**2.8**	**-11.0**	**-2.8**	**-0.4**	9.5	27.0	9.0	0.02
18	Italy	-1.4	0.2	**86.6**	**13.4**	**0.6**	**1.5**	**-0.5**	**-1.4**	33.0	22.0	24.0	0.11
19	Jamaica /2	-5.7	-4.5	**56.0**	**44.0**	**-2.6**	**-0.1**	**-0.6**	**-1.2**	27.5	15.0	25.0	0.23
20	Netherlands /2	-0.4	-7.5	**5.2**	**94.8**	**0.3**	**0.3**	**-0.6**	**-7.5**	29.5	21.0	25.8	0.08
21	Panama	-3.1	-5.4	**36.2**	**63.8**	**-3.3**	**-0.7**	**-0.4**	**-0.9**	20.0	7.0	25.0	0.33
22	Poland	-0.5	-3.4	**12.3**	**87.7**	**0.9**	**-0.7**	**-1.6**	**-2.0**	24.5	23.0	19.0	0.08
23	Romania	-0.5	-8.0	**5.9**	**94.1**	**-0.4**	**-3.9**	**-2.2**	**-1.6**	10.0	19.0	16.0	0.09
24	Sweden	0.3	1.5	**18.7**	**81.3**	**1.9**	**2.4**	**-1.6**	**-1.1**	34.5	25.0	20.6	0.06
25	UnitedKingdom	-0.7	-6.2	**10.4**	**89.6**	**0.0**	**1.2**	**-3.9**	**-3.5**	32.5	20.0	19.0	0.09
26	Uruguay	-3.1	-3.5	**47.0**	**53.0**	**0.6**	**-0.9**	**-0.5**	**-2.7**	23.0	22.0	25.0	0.20
	Benchmark of comparison								28.5	20.0	29.9	1.2	0.06

1/ Average top and minimum.
2/ Percentage of total identified.

75. **It is worth emphasizing that this approach does not provide a perfect estimation too and is subject to several caveats**. Some assumptions—such as the use of quartile benchmarks and of the reduction of the estimates of tax expenditures in 40 percent—can be debated. Its main purpose is to illustrate how the methodology operates and, when interpreted with due caution, the results offer valuable insights for policymakers and, as mentioned, results are expected to improve as data availability increases, particularly regarding estimates of tax expenditures from a revenue mobilization perspective. Estimates of tax effort represent an essential first step in understanding a country's tax system and for revenue mobilization. Before introducing new taxes or raising existing

rates, countries should first assess their tax effort to determine whether there is room for improvement. In this sense, the FTG breakdown provides a useful guide for identifying where reforms should begin or where efforts should be prioritized.

IV. Future Agenda

76. **The future research agenda includes updating the models and re-estimating the econometric and country-by-country analyses using improved and more comprehensive data**. Data quality is expected to advance as additional countries express interest in measuring VAT, PIT, and CIT noncompliance. Nevertheless, it remains unlikely that countries will systematically identify and publish lists of tax expenditures that could realistically be eliminated—excluding those that are inherently difficult or impossible to remove—or that they adopt methodologies differing from the prevailing 'revenue forgone' approach currently used to estimate revenue losses from tax expenditures. Accordingly, the agenda also includes developing this variable, potentially based on national tax expenditure reports. It is further expected that both the number of countries publishing such reports and the availability of related data will increase substantially in the future.

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Appendix 1. Parameters of the: BCHN, Pseudo-IV models, MREM, and Sensitivity Tests

							CI		CII		CIII	
	Battese and Coelli Half-nomal Original		Endogenous Model		Exogenous Model		Mundlack		Mundlack - GDP per capita + 15%		Endogenous Model withouth 4/1	
Variable	Coeff.	P>|z|	Coeff	P>|z|	Coeff.	P>|z|	Coeff.	P>|z|	Coeff.	P>|z|	Coeff.	P>|z|
_cons	-0.813	0.210	-8.323 ***	0.000	-3.362 ***	0.000	0.495	0.681	0.124	0.912	-9.352 ***	0.000
lgd	0.913 ***	0.000	2.392 ***	0.000	1.357 ***	0.000	1.461 ***	0.000	1.511 ***	0.000	2.599 ***	0.000
tr	0.001 ***	0.000	0.002 ***	0.000	0.0015 ***	0.000	0.001 ***	0.000	0.001 ***	0.000	0.002 ***	0.000
gini	-0.006 ***	0.000	-0.009 ***	0.000	-0.009 ***	0.000	-0.010 ***	0.000	-0.010 ***	0.000	-0.009 ***	0.000
lgd2	-0.048 ***	0.000	-0.119 ***	0.000	-0.065 ***	0.000	-0.071 ***	0.000	-0.074 ***	0.000	-0.128 ***	0.000
ava	-0.004 ***	0.000	0.001	0.392	-0.006 ***	0.000	-0.006 ***	0.000	-0.006 ***	0.000	0.002	0.290
oil	0.056	0.157	0.120	0.002	0.121	0.001				0.000	0.121 ***	0.001
gov	0.301 ***	0.000	0.157 ***	0.000	0.175 ***	0.000				0.000	0.160 ***	0.000
pe	0.031 ***	0.000	0.022 ***	0.000	0.021 ***	0.000	0.023 ***	0.000	0.024 ***	0.000	0.022 ***	0.000
meanava							-0.015 ***	0.007	-0.015 ***	0.004		
meanlgd							-0.815	0.003	-0.794 ***	0.002		
meanlgd2							0.042	0.004	0.041 ***	0.004		
meantr							-0.002	0.003	-0.002 ***	0.002		
meangini							-0.005	0.244	-0.005	0.244		
meanpe							0.044 ***	0.001	0.045	0.000		
							Wald chi2	1,832.5	Wald chi2	1,885.1		

1/ Withouth Malawi, Mozambique, Niger, and Magascar.

Appendix 2. Tax Effort: EN Pseudo-IV model, MREM, and Sensitivity Tests

	Country	Year	Total Revenue /1	Percapita GDP	Tax Effort					
					MREM	MREM+15% /1	Dif	EN	EN+-15/2	Dif
					CI	CII	CIII=CI-CII	CIV	CV	CVI=CI-CII
1	Albania	2023	25.3	17,976	0.91	0.91	-0.005	0.59	0.58	0.003
2	Algeria	2023	15.9	15,159	0.67	0.67	0.000	0.41	0.41	0.001
3	Angola	2023	9.7	7,245	0.66	0.67	-0.003	0.43	0.43	0.001
4	Argentina	2023	29.2	27,105	0.82	0.82	0.001	0.56	0.56	0.001
5	Armenia	2023	23.8	19,230	0.81	0.81	-0.004	0.61	0.61	0.000
6	Australia	2023	30.4	60,409	0.66	0.66	0.001	0.68	0.68	0.000
7	Austria	2023	43.0	64,336	0.90	0.90	0.000	0.94	0.94	0.000
8	Azerbaijan	2023	34.6	21,262	0.86	0.87	-0.005	0.58	0.58	0.004
9	Bahamas, The	2023	18.8	33,106	0.34	0.34	0.000	0.38	0.38	-0.001
10	Bangladesh	2023	8.8	8,242	0.41	0.41	-0.005	0.26	0.26	-0.001
11	Belarus	2021	32.3	27,611	0.87	0.87	0.000	0.69	0.68	0.003
12	Belgium	2023	44.1	62,876	0.96	0.96	0.000	0.92	0.92	0.001
13	Benin	2023	12.2	3,721	0.60	0.60	0.002	0.50	0.48	0.014
14	Bolivia	2023	27.4	9,844	0.97	0.97	0.000	0.83	0.83	0.003
15	Botswana	2023	21.1	18,846	0.82	0.81	0.002	0.64	0.64	0.001
16	Brazil	2023	29.1	19,018	0.92	0.91	0.002	0.77	0.77	0.003
17	Bulgaria	2023	26.7	33,112	0.81	0.82	-0.001	0.62	0.62	0.003
18	BurkinaFaso	2023	19.6	2,482	0.80	0.80	0.001	0.77	0.75	0.023
19	Cameroon	2023	12.0	4,871	0.60	0.60	0.003	0.49	0.48	0.012
20	Canada	2023	33.8	56,687	0.79	0.79	0.000	0.76	0.76	0.000
21	Chile	2023	21.5	29,491	0.77	0.77	0.001	0.64	0.64	-0.001
22	China,P.R.M.	2023	26.6	22,138	0.94	0.94	0.000	0.67	0.67	0.003
23	Colombia	2023	23.7	17,352	0.81	0.81	0.000	0.60	0.60	0.002
24	Congo,Repof	2023	12.2	6,172	0.86	0.85	0.005	0.58	0.56	0.013
25	CostaRica	2023	23.2	25,990	0.75	0.75	0.001	0.50	0.50	0.002
26	Cote d'Ivoire	2023	15.2	6,485	0.60	0.60	-0.006	0.53	0.54	-0.002
27	Croatia	2023	38.4	41,100	0.92	0.92	0.000	0.80	0.79	0.003
28	Cyprus	2023	37.8	52,148	0.69	0.69	0.001	0.62	0.62	0.002
29	Czech Republi	2023	33.9	47,452	0.78	0.78	-0.001	0.67	0.67	0.002
30	Denmark	2023	49.5	71,390	0.83	0.83	0.002	0.99	0.99	0.000
31	DominicanRep	2023	13.8	23,088	0.46	0.46	-0.001	0.41	0.41	0.000
32	Ecuador	2023	19.6	14,472	0.83	0.83	-0.001	0.48	0.47	0.004
33	Egypt	2023	14.5	16,691	0.63	0.63	-0.001	0.35	0.35	0.001
34	ElSalvador	2023	21.2	72,660	0.65	0.65	-0.002	0.58	0.58	-0.003
35	Estonia	2023	34.2	41,669	0.82	0.81	0.000	0.66	0.66	0.002
36	Ethiopia	2023	7.5	2,755	0.86	0.86	-0.004	0.64	0.62	0.021
37	Finland	2023	42.2	56,455	0.84	0.84	0.002	0.94	0.94	0.000
38	France	2023	45.4	53,969	0.94	0.94	0.002	0.98	0.98	0.000
39	Gambia,The	2023	9.4	2,932	0.67	0.67	0.001	0.46	0.45	0.013
40	Germany	2023	40.4	63,098	0.79	0.79	0.000	0.84	0.84	0.000
41	Ghana	2023	13.4	6,796	0.47	0.48	-0.007	0.37	0.37	-0.002
42	Greece	2023	40.9	36,821	0.90	0.90	0.000	0.77	0.77	0.003
43	Guatemala	2023	12.1	12,389	0.58	0.58	-0.003	0.40	0.40	0.000
44	Guinea	2023	11.9	3,949	0.75	0.75	0.001	0.52	0.51	0.014
45	Guinea-Bissau	2023	10.9	2,579	0.73	0.73	-0.001	0.43	0.42	0.012
46	Guyana	2023	18.3	49,315	0.85	0.86	-0.003	0.49	0.49	0.002
47	Honduras	2023	21.1	6,468	0.81	0.82	-0.008	0.54	0.54	0.002
48	Hungary	2023	37.1	40,168	0.88	0.88	0.000	0.73	0.73	0.003
49	Iceland	2023	35.3	66,880	0.70	0.70	0.002	0.75	0.75	0.000
50	India	2023	18.3	9,160	0.67	0.68	-0.010	0.52	0.52	0.000
51	Indonesia	2023	10.7	13,890	0.58	0.58	-0.003	0.40	0.40	0.000
52	Iran, I.R. of	2021	5.3	14,952	0.28	0.28	-0.001	0.15	0.15	0.000
53	Ireland	2023	21.8	115,401	0.71	0.71	-0.002	0.52	0.52	0.000
54	Israel	2023	31.4	48,356	0.80	0.79	0.002	0.68	0.68	0.002
55	Italy	2023	43.3	52,589	0.99	0.99	0.000	0.95	0.95	0.001
56	Jamaica	2023	27.7	10,291	0.77	0.77	-0.002	0.76	0.76	0.000
57	Japan	2023	34.2	45,949	0.72	0.72	0.000	0.72	0.72	0.001
58	Jordan	2023	17.5	9,363	0.60	0.60	-0.002	0.49	0.49	0.000

1/ GDP per capita increased by 15 percent for the 25 countries with the lowest income levels (percapita DGP).

2/ For the 25 lowest-income countries, GDP per capita and their revenues reduced (taxes and SSCs) by 15 percent.

	Country	Year	Total Revenue /1	Percapita GDP	Tax Effort					
					MREM	MREM+15% /1	Dif	EN	EN+-15/2	Dif
					CI	CII	CIII=CI-CII	CIV	CV	CVI=CI-CII
59	Kenya	2023	15.0	5,683	0.65	0.65	0.005	0.60	0.59	0.013
60	Korea	2023	18.0	49,995	0.41	0.41	0.000	0.46	0.46	-0.001
61	Kuwait	2023	11.7	46,458	0.39	0.39	0.000	0.26	0.26	0.000
62	KyrgyzRepublic	2023	30.2	6,403	0.81	0.81	0.005	0.57	0.55	0.015
63	Latvia	2023	29.5	38,333	0.74	0.74	0.000	0.61	0.60	0.002
64	Lebanon	2023	6.8	11,417	0.49	0.50	-0.002	0.14	0.14	-0.002
65	Lithuania	2023	32.8	46,118	0.78	0.78	0.000	0.64	0.64	0.002
66	Luxembourg	2023	42.2	130,373	0.91	0.92	-0.008	0.70	0.70	-0.002
67	Madagascar	2023	11.5	1,643	0.68	0.68	-0.001	0.48	0.47	0.016
68	Malawi	2023	14.2	1,648	0.86	0.86	-0.001	0.72	0.70	0.024
69	Mali	2023	14.8	2,395	0.98	0.98	0.000	0.78	0.75	0.022
70	Malta	2023	27.0	59,548	0.76	0.76	0.000	0.61	0.61	0.000
71	Mexico	2023	16.1	21,874	0.47	0.47	0.000	0.31	0.31	0.002
72	Moldova	2023	28.8	15,855	0.84	0.85	-0.002	0.65	0.65	0.003
73	Mongolia	2023	25.8	16,223	0.89	0.89	-0.002	0.57	0.57	0.003
74	Montenegro	2023	37.0	27,343	0.97	0.97	0.000	0.77	0.77	0.003
75	Morocco	2023	22.5	8,869	0.78	0.78	-0.005	0.78	0.78	-0.001
76	Mozambique	2023	21.7	1,512	0.95	0.96	-0.005	0.89	0.86	0.028
77	Myanmar	2023	7.3	5,364	0.63	0.63	0.001	0.25	0.24	0.005
78	Namibia	2023	30.0	10,106	0.97	0.97	0.001	0.99	0.99	0.000
79	Netherlands	2023	38.7	70,610	0.80	0.80	-0.001	0.77	0.77	0.000
80	New Zealand	2023	32.4	48,580	0.83	0.83	0.001	0.76	0.76	0.001
81	Nicaragua	2023	26.7	7,487	0.94	0.95	-0.006	0.71	0.71	0.000
82	Niger	2023	10.8	1,703	0.74	0.74	-0.002	0.58	0.56	0.018
83	Nigeria	2023	6.9	5,593	0.62	0.62	0.002	0.27	0.27	0.008
84	Norway	2023	49.5	90,160	0.95	0.95	0.001	0.98	0.98	0.000
85	Oman	2023	12.4	38,311	0.32	0.32	0.000	0.19	0.19	0.000
86	Pakistan	2023	12.1	5,439	0.63	0.63	0.002	0.36	0.35	0.010
87	Panama	2023	12.5	35,864	0.57	0.57	-0.001	0.42	0.42	0.000
88	Papua New G	2023	16.7	4,174	0.98	0.98	0.000	0.60	0.59	0.017
89	Paraguay	2023	11.3	15,783	0.52	0.52	-0.001	0.33	0.33	0.000
90	Peru	2023	17.2	15,294	0.69	0.69	-0.002	0.57	0.57	0.000
91	Philippines	2023	17.9	9,901	0.70	0.71	-0.008	0.50	0.49	0.001
92	Poland	2023	35.9	43,585	0.81	0.81	0.001	0.73	0.73	0.003
93	Portugal	2023	35.6	41,498	0.79	0.79	0.001	0.74	0.74	0.002
94	Qatar	2023	8.3	116,159	0.18	0.19	-0.001	0.11	0.11	0.000
95	Romania	2023	26.4	40,267	0.86	0.86	-0.001	0.64	0.64	0.002
96	Russia	2023	31.4	39,753	0.91	0.91	0.000	0.78	0.78	0.003
97	Saudi Arabia	2023	12.7	55,055	0.24	0.24	0.001	0.18	0.18	0.000
98	Senegal	2022	18.7	4,228	0.70	0.69	0.004	0.63	0.61	0.017
99	Serbia	2023	37.1	25,718	0.99	0.99	0.000	0.96	0.96	0.000
100	Singapore	2023	13.8	127,544	0.46	0.47	-0.004	0.28	0.28	-0.001
101	Sierra Leone	2023	8.9	3,034	0.46	0.47	-0.004	0.28	0.28	-0.001
102	SlovakRepublic	2023	35.2	39,172	0.76	0.77	-0.001	0.60	0.59	0.003
103	Slovenia	2023	37.1	47,825	0.81	0.81	0.000	0.72	0.72	0.002
104	SouthAfrica	2023	26.1	13,690	0.88	0.88	0.001	0.72	0.72	0.002
105	Spain	2023	35.7	47,298	0.83	0.83	0.001	0.79	0.78	0.001
106	SriLanka	2023	10.0	13,030	0.55	0.55	-0.005	0.41	0.42	-0.001
107	Suriname	2023	17.9	19,044	0.78	0.79	-0.002	0.46	0.46	0.000
108	Sweden	2023	41.0	62,665	0.82	0.82	0.002	0.95	0.95	0.000
109	Switzerland	2023	27.2	81,684	0.59	0.59	-0.001	0.59	0.59	0.000
110	Tanzania	2023	12.1	3,621	0.65	0.65	0.002	0.51	0.50	0.014
111	Thailand	2023	21.7	21,143	0.65	0.65	-0.002	0.43	0.43	0.002
112	Togo	2023	13.9	2,768	0.79	0.79	0.001	0.58	0.56	0.017
113	Trin. & Tobago	2023	31.1	31,706	0.95	0.95	0.000	0.68	0.68	0.002
114	Tunisia	2023	24.8	12,553	0.71	0.71	0.000	0.57	0.57	0.000
115	Türkiye	2023	24.2	34,252	0.83	0.83	-0.001	0.55	0.55	0.002
116	UAE	2023	24.6	68,578	0.78	0.78	-0.002	0.48	0.48	0.000
117	Uganda	2023	12.6	2,791	0.70	0.70	0.001	0.52	0.50	0.015
118	Ukraine	2023	33.3	15,885	0.87	0.87	-0.001	0.75	0.75	0.004
119	UnitedKingdom	2023	33.1	52,589	0.73	0.73	0.001	0.76	0.76	0.001
120	UnitedStates	2023	25.2	74,578	0.64	0.64	0.001	0.68	0.68	-0.001
121	Uruguay	2023	25.7	31,019	0.79	0.79	-0.001	0.66	0.66	0.002
122	Vietnam	2023	12.8	13,492	0.67	0.68	-0.006	0.40	0.39	0.002
123	Zambia	2023	15.8	3,673	0.82	0.82	0.004	0.80	0.78	0.020
	Average				0.737	0.738		0.596	0.592	

1/ GDP per capita increased by 15 percent for the 25 countries with the lowest income levels (percapita DGP).

2/ For the 25 lowest-income countries, GDP per capita and their revenues reduced (taxes and SSCs) by 15 percent.