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Estimating Health Tax Capacity, Effort, and Potential

EVIDENCE FROM A GLOBAL PANEL

Sanjeev Gupta, João Tovar Jalles, and Ainhoa Petri-Hidalgo

Abstract

Noncommunicable diseases—driven by tobacco use, harmful alcohol consumption, and high-sugar diets—account for over 70 percent of global deaths and impose annual economic losses exceeding US $514 billion. Excise taxes on these health-harming products offer a dual benefit of reducing consumption and raising public revenue, yet performance varies widely across countries. This paper applies stochastic frontier analysis to a global panel of 97 IMF member states to estimate maximal feasible excise tax performance for tobacco, beer, spirits, and sugar-sweetened beverages (SSBs), conditioning on GDP per capita, consumption patterns, demographics, and governance indicators. Given data availability, we estimate a revenue-based frontier for tobacco and rate-based frontiers (expressed as a share of retail price) for alcohol and SSBs. Tax-effort scores reveal that countries collect on average just 0.4 percent of GDP in tobacco excise revenue—despite a feasible capacity of 1.5 percent—indicating an untapped fiscal gap of 1.1 percent of GDP. For beer, spirits, and SSBs, countries apply only 35 percent, 25 percent, and 15 percent, respectively, of their feasible excise rates. We introduce a four-quadrant diagnostic framework to classify countries by tax collection and effort and identify tailored policy responses. These findings have major implications for health financing, fiscal reform, and technical assistance, particularly in low- and middle-income countries.

KEYWORDS
sin taxes, stochastic frontier analysis, tax capacity, excise revenue, health-tax efficiency

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1. Introduction

Noncommunicable diseases such as cardiovascular conditions, diabetes, cancers, and chronic respiratory illnesses now account for more than 70 percent of global deaths, imposing annual economic losses exceeding US $514 billion and straining health systems worldwide (WHO, 2025). A large share of this burden is attributable to modifiable risk factors—tobacco use, harmful alcohol consumption, and diets high in added sugars—making excise taxes on these "sin" goods a central policy lever both to reduce consumption and to raise public revenues (Pigou, 1920). Global institutions including the World Health Organization, World Bank, and International Monetary Fund have consistently endorsed health taxes as "win-win" instruments that improve population health outcomes while strengthening fiscal positions, and they form a core component of domestic resource mobilization under Sustainable Development Goal 17.1 (Benitez et al., 2023).

The past five years have been marked by a series of overlapping crises—COVID-19, global recession, rising debt service, and climate-related shocks—that have significantly tightened fiscal space in many developing countries, while simultaneously underscoring the importance of preventive health measures. In this context of polycrisis, health taxes have been identified as a compelling policy tool to simultaneously improve health outcomes and raise domestic revenues (Task Force on Fiscal Policy for Health, 2024). The Task Force on Fiscal Policy for Health (2024) estimate that a one-off 50 percent increase in excise rates on tobacco, alcohol, and sugar-sweetened beverages could mobilize approximately US $2.1 trillion in low- and middle-income countries over five years—equivalent to nearly 40 percent of their public health spending—while averting millions of premature deaths. Complementing this, Summan and Laxminarayan (2024) estimate own-price elasticities of −0.4 for cigarettes, −0.5 for alcohol, and up to −1.6 for sugary drinks, implying that modest tax hikes can deliver both meaningful consumption declines and substantial net revenue gains.

From an economic standpoint, sin taxes correct for negative externalities—such as higher healthcare costs, lost productivity, and environmental damage—by internalizing the social costs associated with harmful consumption (Summan and Laxminarayan, 2024). They also address "internalities," where lack of self-control in consumption of tobacco, alcohol, and sugary drinks provides an additional rationale for taxing these products (Gruber and Koszegi, 2001; Petit and Nagy, 2016). The revenue generated by these excise taxes also create critical fiscal space for universal health coverage and social protection. However, the design of tax systems matters: Complex, multi-tiered excise structures are prone to arbitrage and can increase administrative burdens, while inadequate monitoring may encourage illicit trade that undermines both health and fiscal objectives (Drope and Powell 2024).[1] In many low-income countries, revenue authorities' weak capacity further complicates effective enforcement.

1 See Petit and Nagy (2016) for a discussion on the use of specific versus ad valorem taxes.

Political-economy dynamics add another layer of challenges. Industry stakeholders routinely deploy strategies of denial, delay, and diversion to undermine policy proposals, drawing on extensive lobbying networks and front groups (Task Force on Fiscal Policy for Health, 2024). Public support for such taxes can be tenuous unless they are framed as part of broader health or social agendas. Successful examples include Mexico's 2014 sugar-drink tax, Ethiopia's 2020 tobacco reform, and Colombia's cross-party coalitions that maintained excise increases across tobacco, alcohol and ultra-processed products. At the global level, WHO Framework Convention on Tobacco Control Conferences of the Parties and IMF Fiscal Affairs Department workshops provide vital forums for sharing best practices on tax design, track-and-trace systems, and complementary measures such as advertising bans and cessation support (Mansour, Petit, and Sawadogo, 2023).

Despite broad consensus and growing adoption, the actual performance of health taxes remains highly uneven. Many countries—particularly in Sub-Saharan Africa, the Middle East, and parts of Asia—collect significantly less in excise revenues compared to peers with similar economic and demographic profiles, and excise rates often fall well below WHO's recommended minimum thresholds. To date, there is no systematic benchmarking of how much each country could feasibly raise under its own structural conditions, nor is there an assessment of the efficiency with which they currently perform.

This paper addresses that gap by asking: To what extent are IMF member countries realizing their health-tax revenue potential, and where does significant untapped capacity lie? We apply a stochastic frontier analysis separately to tobacco, alcohol, and sugar-sweetened-beverage excises, conditioning on GDP per capita, consumption patterns, demographic profiles, and governance indicators. Due to differences in global data coverage, we estimate a revenue-based frontier for tobacco and rate-based frontiers (excise as a share of retail price) for beer, spirits, and sugary drinks. To enhance comparability across products, we also include a supplementary rate-based tobacco frontier in the appendix. By estimating each country's maximum feasible excise revenue frontier and comparing observed collections to that benchmark, we derive quantitative tax-effort scores that reveal both realized capacity and untapped potential. Our analysis shows that, on average, countries achieve less than half of their estimated capacity—approximately 48 percent for tobacco, 35 percent for beer, 25 percent for spirits, and just 15 percent for sugar-sweetened beverages. High performers such as Argentina and China in tobacco, Norway and Finland in beer, Turkmenistan in spirits, and Rwanda and Bangladesh in SSBs operate near their structural frontiers, while many low- and middle-income jurisdictions collect under 20 percent of feasible revenues. Structural determinants including GDP per capita, demographic age profiles, and governance quality account for up to 70 percent of cross-country variation in capacity, highlighting the need to tailor excise rates to local conditions.

These findings underscore three key messages: Substantial fiscal and health gains remain attainable, even in countries with established excise regimes; harmonizing rate structures, simplifying bands, and strengthening enforcement can yield large returns; and targeted technical

assistance and peer learning—particularly for emerging markets and developing economies (EMDEs)—can help bridge capacity gaps and accelerate progress toward public health and revenue-mobilization objectives. While our analysis is focused on fiscal capacity, it is important to note that stronger health taxes also yield substantial non-pecuniary benefits. Prior country-specific simulations show that excise increases avert millions of premature deaths and reduce the long-term burden of noncommunicable diseases.[2]

The remainder of this paper is organized as follows. Section 2 reviews the theoretical and empirical literature on health taxes, covering externalities, behavioral foundations, revenue effects and political-economy determinants. Section 3 details our stochastic frontier methodology, data sources and model specifications. Section 4 presents the main findings on tax capacity, effort and untapped potential, along with robustness checks and subgroup analyses. Finally, Section 5 concludes and discusses policy implications for strengthening health-tax regimes through improved design, administration, and stakeholder engagement, while outlining avenues for future research.

2. Literature review

2.1 Economic rationale and empirical effects

The core rationale for health taxes is grounded in Pigouvian theory: Excise duties on tobacco, alcohol, and SSBs help internalize the social costs associated with their consumption—such as higher public health expenditures, lost productivity, and premature mortality—thereby aligning private behavior with broader social welfare (Pigou, 1920). Tobacco-related health costs alone have been estimated at over 1.8 percent of global GDP (Goodchild et al., 2018). Beyond correcting externalities, such taxes also serve as behavioral commitment devices under time-inconsistent preferences, encouraging consumers—who tend to discount long-term health risks—to reduce harmful consumption when faced with higher prices (Gruber and Kőszegi, 2001). Importantly, even if excises are regressive in incidence, they can still enhance welfare if lower-income, price sensitive groups respond with greater reductions in consumption.

Empirical evidence documents health and revenue benefits of health-related excise taxes. Chaloupka et al. (2012) show significant declines in smoking prevalence—particularly among youth and low-income cohorts—following excise increases, while Sassi et al. (2018) find analogous effects for alcohol and SSBs. Meta-analyses estimate own-price elasticities of –0.4 for cigarettes, –0.5 for alcohol, and up to –1.6 for sugary drinks, implying that modest tax hikes can both curb consumption and generate net revenue gains (Summan and Laxminarayan, 2024). Case studies from the Philippines, South Africa, and Thailand suggest that earmarking sin-tax proceeds can help generate

2 For example, Summan and Laxminarayan (2024) and Ahmed and Shafik (2025) provide estimates of health benefits from excise reforms in Mexico, South Africa, and other contexts. A promising direction for future work would be to link our four-quadrant framework to projected health gains for representative countries in each category.

political support for reforms and have coincided with increases in health spending, although the overall fiscal impact may be limited due to the fungibility of public funds (WHO, 2020).[3] However, cross-country comparisons reveal wide variation in revenues at similar statutory rates, reflecting differences in enforcement capacity, market structures, and informal trade—factors that simulation models often fail to capture.

Despite numerous simulation-based revenue projections (Amaglobeli, Crispolti, and Sheng, 2022; Task Force on Fiscal Policy for Health, 2024), there is still no unified econometric framework to benchmark a country's maximum feasible health-tax revenue ("capacity") or to assess actual collections ("effort") relative to that benchmark. Existing tax-effort models, typically applied to aggregate tax-to-GDP ratios (e.g., Gupta and Jalles, 2023; Fenochietto and Pessino, 2013; Mawejje and Sebudde, 2019; Benitez et al., 2023) lack sectoral detail and cannot separate inefficiency from time-varying shocks. This paper addresses that gap by extending stochastic frontier analysis (SFA) to sin taxes, disaggregated by product and incorporating product-specific inputs (excise per pack; excise as a percentage of retail price). In doing so, this paper provides the first sector-specific benchmarking of health-tax capacity, effort, and untapped potential.

2.2 Institutional and political-economy determinants

Even well-designed excise schedules can falter in the absence of strong institutions. Complex, multi-tiered tax structures—common in alcohol regimes—often invite administrative gaming and increase compliance costs, while weak monitoring enables illicit trade that undermines both health and fiscal outcomes (Drope and Powell, 2024). Studies of overall tax effort consistently find that countries with stronger government effectiveness, rule of law, and lower corruption operate closer to their revenue potential (Mawejje and Sebudde, 2019). By analogy, these governance factors likely play a similarly crucial role in health-tax performance, though they remain unexplored in this specific context.

Political-economy dynamics further shape outcomes. Industry actors deploy "deny, delay, and divert" tactics—including lobbying, litigation, and front-group campaigns—to stall or dilute tax initiatives (Task Force on Fiscal Policy for Health, 2024). Public legitimacy often hinges on transparent and credible revenue use. For example, Mexico's 2014 SSB tax paired rate hikes with earmarking for nutrition programs, securing broad support and enabling subsequent rate increases (Colchero et al., 2016). Ethiopia's 2020 tobacco reform countered industry pushback through televised parliamentary hearings and civil-society mobilization (Erku et al., 2023), while Colombia maintained cross-party coalitions across administrations to raise excises on tobacco, alcohol, and ultra-processed foods (Task Force on Fiscal Policy for Health, 2024). At the global level, WHO Framework Convention on Tobacco Control conferences and IMF "How-To" workshops foster peer learning on tax design,

3 The Philippines has designated a portion of tobacco tax revenue to health care through "soft earmarking", where allocations are not rigidly fixed and can be adjusted during the budget process. This contrasts with "hard earmarking" which involves more rigid, predetermined funding allocations.

track-and-trace technologies, and complementary measures such as advertising bans and cessation support (Mansour, Petit, and Sawadogo, 2023).

2.3 Extensions from general tax-effort literature

The broader tax-effort literature offers a strong foundation for this analysis. Early applications of stochastic frontier analysis (SFA) estimated total tax potential across panels of up to 150 countries and found average revenue-to-GDP potential of around 46 percent. These studies identified key structural drivers of tax capacity, including GDP per capita, the share of non-agricultural value-added, trade openness, human-capital investment, and institutional quality (Mawejje and Sebudde, 2019; Fenochietto and Pessino, 2013; Langford and Ohlenburg, 2016). SFA outperforms ordinary least squares by generating time-varying inefficiency estimates and quantifying untapped revenue potential. However, these models remain limited to aggregate tax collections and do not disaggregate by sector, leaving the frontier for health-specific excises unexplored.

This paper addresses that gap by adapting SFA methods to tobacco, alcohol, and SSB taxes, using product-specific inputs such as excise per pack or excise as a percentage of retail price. We employ the Battese and Coelli (1992, 1995) panel SFA framework, which allows environmental variables—such as governance indicators—to influence both the frontier and the inefficiency term. This enables us not only to benchmark health-tax capacity based on structural determinants but also assess country-level effort and identify untapped potential. The result is a set of actionable diagnostics for policymakers aiming to strengthen the design, administration, and enforcement of health taxes.

3. Methodology

3.1 Empirical strategy

As noted earlier, to assess countries' performance in mobilizing revenues from health-related taxes, we employ a stochastic frontier analysis (SFA) framework to a cross-country panel dataset, disaggregated by three key product categories: tobacco, alcohol, and SSBs. SFA is particularly well-suited for this exercise because it goes beyond standard regression approaches by explicitly modelling inefficiency—that is, the gap between observed tax performance and the maximum attainable outcome, given a country's structural and institutional characteristics. This feature is especially relevant for analyzing tax policy performance, where underperformance may stem from policy design flaws, enforcement weaknesses, or political constraints, rather than economic fundamentals alone.

Unlike traditional fixed-effects or pooled OLS models that estimate average relationships, SFA estimates a frontier function representing the maximum feasible level of health tax revenue or tax burden that a country could achieve given factors such as income level, governance quality, informality, and demographic profile. Deviations from this frontier are then interpreted

as inefficiency—or in this context, tax effort gaps—potentially reflecting suboptimal excise structures, weak administration, or political economy obstacles to reform. While this method has been widely used in the public finance literature to estimate tax capacity and effort across countries (e.g., Fenochietto and Pessino, 2013; Gupta and Jalles, 2023; Mawejje and Sebudde, 2019; Benitez et al., 2023). To our knowledge, this is the first application of the SFA framework to the health tax domain. The novelty of our approach lies in both the product-level disaggregation and the ability to estimate both revenue-based and rate-based frontiers, depending on data availability. This allows for nuanced comparisons across countries and policy instruments and offers policymakers tailored benchmarks to guided reform.

Formally, we adopt the stochastic frontier model originally developed by Aigner, Lovell, and Schmidt (1977), and later extended to panel data settings by Kumbhakar and Lovell (2000). This model distinguishes between random statistical noise and inefficiency in observed outcomes through a composite error structure. The empirical specification is given by:

$$log(Y_{it}) = \alpha + \beta' X_{it} + v_{it} - u_{it} \quad (1)$$

where:

Y_{it} is the observed value of the health tax outcome for country i in year t,
X_{it} is a vector of explanatory variables representing economic, demographic, and institutional factors,
$v_{it} \sim N(0, \sigma^2)$ is a symmetric random error term capturing noise,
$u_{it} \sim N^{+}(0, \sigma^2)$ is a non-negative inefficiency term representing shortfalls from the frontier. The term u_{it} captures the extent to which each observation falls short of the maximum attainable outcome (the frontier), conditional on structural characteristics.

By estimating this model separately for tobacco, alcohol, and SSBs, we derive a set of country- and product-specific tax effort scores, which reflect the degree to which countries are utilizing their health tax potential. These scores, bounded between 0 and 1, allow for an intuitive interpretation: values close to 1 indicate that a country is taxing near its structural maximum, while lower values suggest significant room for improvement. Such an approach is not only methodologically rigorous but also directly relevant to ongoing debates on domestic resource mobilization, fiscal space, and the design of health-oriented tax systems. We rely on the parametric stochastic frontier approach, which allows for hypothesis testing and accommodates statistical noise in cross-country fiscal data.[4]

4 The main alternative is data envelopment analysis (DEA), a non-parametric method that produces different efficiency rankings. DEA is less suited to our context because it attributes all deviations from the frontier to inefficiency and does not account for random noise (see Kumbhakar and Lovell, 2000). Applying DEA to health taxes is an important extension we leave for future work.

The tax effort is computed as:

$$Effort_{it} = exp(-u_{it}) \quad (2)$$

which lies between 0 and 1. Higher values indicate that a country is close to its estimated tax frontier, while lower values signal underperformance relative to its structural capacity. We estimate both half-normal and truncated-normal specifications for robustness and test their fit via likelihood ratio tests.

3.2 Dependent variables and frontier interpretation

The dependent variable Y_{it} is constructed differently across tax types to reflect the availability and nature of the data. Accordingly, the interpretation of the stochastic frontier—and the corresponding tax effort—differs across the three tax categories.

Tobacco (revenue-based frontier)

For tobacco, we use: Total government revenues from all tobacco taxes (including excise, VAT, and other levies), expressed in nominal local currency units and deflated to real terms using the appropriate country-level GDP deflator. These data are sourced from the IMF Government Finance Statistics (GFS) (International Monetary Fund, n.d.), with country-specific deflators taken from the IMF World Economic Outlook (WEO) April 2025 database. This enables a revenue-based stochastic frontier, where the model estimates the maximum tobacco tax revenue a country could collect, given its structural and institutional characteristics. This is the most direct and policy-relevant measure for assessing fiscal mobilization potential from health taxes.

By contrast, for alcohol and sugary drinks, consistent revenue data are largely unavailable across countries, so we rely on excise tax rates as a share of reference retail prices—resulting in a rate-based frontier approach for those products. This distinction reflects underlying data availability and is highlighted throughout the paper. While the stochastic frontier framework is applied consistently across products, the meaning of the resulting tax-effort scores differs. For tobacco, the revenue-based frontier captures both (i) policy choices on statutory rates and structure, and (ii) the efficiency of tax administration and compliance. In this context, a low effort score can reflect either under-taxation, weak enforcement, or both. For beer, spirits, and sugar-sweetened beverages (SSBs), the rate-based frontiers measure how intensively a product is taxed relative to structural peers, without observing revenue realization directly. Here, "effort" reflects policy effort in rate-setting, which may be influenced as much by political economy constraints as by structural fundamentals. As a result, the numerical values of effort are not directly comparable between tobacco and alcohol/SSBs, and the drivers of variation should be interpreted considering these conceptual differences.

Alcohol (rate-based frontier)

For alcohol, consistent revenue data in local currency are not available across countries, and where data do exist, coverage and definitions vary significantly—for example, some countries report only beer or only spirits, and others combine excise with VAT or other levies. To avoid selection bias and ensure comparability across a broad sample, we rely instead on standardized tax burden measures, expressed as a share of the retail price: (i) total beer excise (% of reference beer price); and (ii) total spirits excise (% of reference spirit price). This rate-based approach allows us to construct a unified frontier for each product and income group, while acknowledging that it does not capture revenue realization directly. These data are sourced from the WHO Global Status Report on Alcohol and Health (2011, 2014, 2018).[5] These are modelled in two separate frontier regressions, each estimating a rate-based tax frontier. In this case, the frontier represents the maximum feasible tax intensity (i.e., excise as a share of price) that a country could apply, conditional on structural and institutional characteristics. The resulting tax effort metric reflects how close a country is to its potential in rate-setting—not in revenue-generating potential. Countries with low effort are applying alcohol excise rates that fall significantly short of what comparable peers can achieve.

Sugar-sweetened beverages (rate-based frontier)

For SSBs, the only harmonized cross-country data available is total excise on sugar-sweetened beverages expressed as a percentage of the reference product price. Data on SSB tax burdens are compiled from the WHO Noncommunicable Disease (NCD) Progress Monitors (2017, 2020) and country survey responses. As with alcohol, this variable reflects the tax burden relative to price and is used to estimate a rate-based frontier. The model captures how intensively SSBs are taxed compared to what would be expected, given country characteristics.

Since these variables are expressed as percentages of product price, they are already normalized across time and countries and therefore do not require deflation.

3.3 Explanatory variables

The selection of explanatory variables in the stochastic frontier models is guided by a rich theoretical and empirical literature on tax capacity, institutional development, and the political economy of health taxation. Each variable aims to capture a specific structural, economic, demographic, or institutional determinant that influences a country's ability to design, implement, and enforce effective excise taxes on harmful products such as tobacco. All covariates are included in the model based on a priori expectations of their relevance and statistical significance.

Log GDP per capita (constant 2015 USD) is a core determinant of fiscal capacity. Data are sourced from the World Bank's World Development Indicators (WDI) database (World Bank, n.d.). Higher-income

5 Although a 2024 update of the WHO Global Status Report exists, it does not include comparable tax rate or revenue data in structured form for the variables used in this analysis.

countries tend to exhibit stronger tax administration, greater formalization of economic activity, and more comprehensive coverage of consumption taxes (Tanzi, 1992; Bird et al., 2008). In the context of health taxes, per capita income also proxies affordability of taxed goods and the government's capacity to enforce excise regimes. The observed negative coefficient in the preferred specification suggests that higher-income countries are already operating closer to their revenue frontier, consistent with the idea of diminishing marginal returns to efficiency in wealthier economies.

Trade openness, measured as the sum of exports and imports as a share of GDP, is also drawn from WDI (World Bank, n.d.) and serves as a proxy for economic integration and modernization of tax systems. Openness is often associated with customs reform, the strengthening of border tax collection, and alignment with international standards, including commitments under the WHO Framework Convention on Tobacco Control (Baunsgaard and Keen, 2010; IMF, 2011). In our models, trade openness is consistently and positively associated with tobacco tax efficiency, suggesting that globally integrated economies may benefit from institutional spillovers or greater exposure to health taxation norms.

Urban population (% of total) is taken from WDI (World Bank, n.d.) as well and reflects the spatial and economic organization of a country. Urbanization typically correlates with more formal distribution channels, lower marginal costs of tax administration, and higher visibility of tax-eligible transactions (Lotz and Morss, 1967). The negative coefficient in Model 1 may indicate that in some contexts, high urbanization does not always translate into higher tobacco tax efficiency, potentially due to informal markets or consumption displacement.

Share of population aged 15 and above is calculated using demographic data from the United Nations (United Nations, 2022) World Population Prospects and the World Bank (World Bank, n.d.) and is included to capture the size of the adult population that is eligible for tobacco and alcohol consumption. Since tobacco and alcohol use is highly age-dependent, this demographic variable directly influences the potential tax base. Higher shares of adults imply greater consumption potential, and the positive coefficients in Models 2 and 3 confirm its relevance as a structural determinant of tax capacity.

Adult literacy rate (included in Model 3) is drawn from the UNESCO Institute for Statistics (UNESCO Institute for Statistics, n.d.) and WDI (World Bank, n.d.), depending on data availability, and serves as a proxy for human capital and informational awareness. More literate populations may be better able to understand the health risks of tobacco use, support taxation as a deterrent, and comply with formal tax systems (Gupta and Tareq, 2008). Literacy also enhances institutional trust, which may facilitate smoother implementation of health tax reforms.

Governance indicators—drawn from the Worldwide Governance Indicators (World Bank, n.d.)—capture key dimensions of institutional quality that influence tax policy outcomes. We include three distinct measures in Model 2:

- **Government effectiveness** reflects the quality of public services and the competence of civil servants. Effective governments are better equipped to administer excise taxes and monitor compliance (IMF, 2011).
- **Rule of law** measures societal adherence to legal norms, which underpins the enforceability of tax policy and reduces incentives for evasion.
- **Control of corruption** indicates the extent to which public power is exercised for private gain. High corruption impairs revenue mobilization by weakening enforcement and distorting policy implementation (Bird et al., 2008; Kaufmann et al., 2009).

Taken together, this set of variables allows us to account for a comprehensive range of country-specific characteristics—economic, demographic, and institutional—that jointly determine health tax performance.

Although the dependent variable differs between revenue-based (tobacco) and rate-based (alcohol and SSB) models, the same structural controls are used. In revenue models, these capture potential tax base and enforcement capacity; in rate-based models, they proxy political-economy and institutional constraints that influence feasible statutory rates.

4. Results[6]

4.1 Baseline

Table 1 reports results from three stochastic frontier models estimating the efficiency of tobacco tax revenue collection across countries. All models assume a half-normal distribution for the inefficiency term and are estimated using collapsed (country-level) data[7]; thus, the number of observations corresponds to the number of countries included in each specification. Model 1 includes structural and demographic variables. Model 2 adds institutional quality indicators—government effectiveness, rule of law, and control of corruption—while Model 3 replaces governance variables with literacy as a proxy for human capital. All estimated coefficients are statistically significant at the 1 percent level. In Model 2, the sign of each covariate aligns with theoretical expectations. The coefficient on GDP per capita is negative, suggesting that higher-income countries are closer to their revenue potential, consistent with the idea of diminishing marginal gains in revenue efficiency at higher income levels. Trade openness is positively associated with tobacco tax revenue, likely reflecting the broader tax base associated with global trade integration. The share of the population aged 15 and above is positively signed, indicating that a larger tax-relevant population is associated with higher tobacco revenues. Institutional quality indicators—government effectiveness, rule of law,

6 Replication code and cleaned datasets are available from the authors upon request to facilitate reproducibility.

7 Although a panel-SFA framework was implemented, for comparability across products and to maximize country coverage we collapse to country-level averages. This avoids issues of missing values in unbalanced panels and ensures that efficiency scores are not biased by short-run fluctuations.

and control of corruption—are all positively signed, reinforcing the idea that better governance supports more effective revenue mobilization. Variance parameters confirm that inefficiency dominates over random noise in explaining deviations from the frontier: lnsig2u is statistically significant in all models, while lnsig2v is not. The estimated lambda values are very large due to the near-zero variance of the noise term (sigma$_v$), indicating that inefficiency is the primary source of variation in observed revenue outcomes.

Model 2 provides the best overall fit among the three, with a higher log-likelihood and lower AIC and BIC than Model 1. Compared to Model 3, it offers greater explanatory relevance by incorporating core institutional factors rather than proxy measures. For these reasons, Model 2 is selected as the preferred specification for the analysis that follows.

TABLE 1. Stochastic frontier models—tobacco revenue efficiency

Variable	Model 1	Model 2	Model 3
Log GDP per capita	0.411 (0.000)***	−0.422 (0.000)***	−0.606 (0.000)***
Trade openness	0.015 (0.000)***	0.007 (0.000)***	−0.002 (0.000)***
Urban population	−0.012 (0.000)***		
Aged 15+ population	−0.004 (0.000)***	0.034 (0.000)***	0.024 (0.000)***
Government effectiveness		0.127 (0.000)***	
Rule of law		1.522 (0.000)***	
Corruption control		0.231 (0.000)***	
Literacy			0.037 (0.000)***
Constant	−3.179 (0.000)***	1.207 (0.000)***	0.956 (0.000)***
lnsig2v	−29.789 (186.443)	−31.571 (365.153)	−30.054 (222.352)
lnsig2u	2.448 (0.186)***	2.181 (0.191)***	2.440 (0.196)***
Log Likelihood	−113.076	−99.890	−101.171
AIC	234.152	217.781	212.342
BIC	244.726	235.847	226.467
Sigma$_u$	3.400	2.975	3.387
Sigma$_v$	3.40e−07	1.39e−07	2.98e−07
Lambda	1.00e+07	2.13e+07	1.14e+07
Observations	58	55	52

Notes: This table reports results from stochastic frontier models of tobacco revenue efficiency. All models assume a half-normal distribution for the inefficiency term. Coefficients are reported with standard errors in parentheses. lnsig2v and lnsig2u denote the logarithms of the variance parameters for the noise term (v) and the inefficiency term (u), respectively. Sigma$_v$ and Sigma$_u$ are the standard deviations of these components, and Lambda is the ratio Sigma$_u$/Sigma$_v$. The log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) measure model fit. Statistical significance is indicated by *p < 0.10, **p < 0.05, and ***p < 0.01. *How to Read the Coefficients:* In the stochastic frontier regressions, a positive coefficient means that, all else equal, higher values of that variable are associated with a higher structurally attainable tax rate or revenue share. For example, a positive coefficient on "rule of law" in the beer excise model means that stronger legal institutions are linked to a higher feasible excise rate for beer. A negative coefficient means the opposite: higher values of that variable are associated with a lower feasible frontier. These coefficients do not measure actual changes in revenue or rates directly; rather, they indicate how each factor shifts the maximum attainable value given a country's structural conditions.

Table 2 reports results from three stochastic frontier models estimating the rate-setting efficiency of beer excise taxation across countries. Unlike the tobacco models, which focus on excise revenue relative to GDP, these regressions model beer excises as a share of the retail price, capturing the intensity of taxation from a rate-based (rather than revenue-based) perspective. Model 1 includes structural, demographic, and institutional variables. Model 2 retains structural and demographic controls but omits governance indicators. Model 3 introduces a dummy for advanced economies (AE) in place of institutional variables. This specification captures variation in tax-setting behavior that may reflect broader policy frameworks or tax administrative capacity. The dependent variable in all models is the log of beer excise tax as a percent of the retail price. Several results stand out. In Model 1, the estimated coefficients are all statistically significant and align with theoretical expectations. The coefficient on log GDP per capita is positive and significant, suggesting that wealthier countries have higher feasible beer tax rates—likely reflecting greater institutional capacity, health policy commitment, and tolerance for "sin taxes" in affluent settings. Trade openness is negatively associated with excise rates, consistent with the idea that more open economies may face constraints in raising alcohol taxes due to cross-border trade, competition concerns, or WTO-related commitments. Urban population share and the share of population aged 15 and over also show significant associations: More urbanized countries tend to apply lower excise rates, possibly due to greater industry lobbying or enforcement difficulties, while a larger adult population is positively linked to higher tax intensity. Alcohol consumption prevalence is positively and significantly associated with beer excise rates, particularly in Models 1 and 3, suggesting that governments in high-consumption settings may be more inclined—or politically able—to impose higher taxes. Institutional quality matters as well: Rule of law and control of corruption are both strongly and positively signed in Model 1. This reinforces the view that stronger institutions are associated with greater capacity or willingness to tax alcohol at higher rates. In Model 3, the inclusion of an AE dummy captures a similar structural dimension; advanced economies are estimated to have significantly higher feasible beer excise burdens, conditional on other controls. From a technical perspective, the inefficiency variance (lnsig2u) is statistically significant in all models, while the random noise variance (lnsig2v) is not, consistent with the notion that inefficiency rather than noise drives deviations from the frontier. This is confirmed by very low values of lambda and gamma and the near-zero $sigma_v$ values, indicating that almost all observed variation in beer excise rates across countries reflects inefficiency rather than stochastic error.

Among the three specifications, Model 3 offers the best statistical fit, with the lowest AIC and BIC values. While Model 1 provides rich institutional insights, and Model 2 offers a simpler structure, Model 3 is preferred for policy discussion due to its combination of explanatory power and parsimony, incorporating a key structural dummy for advanced economies in lieu of institution-specific metrics. The corresponding tax effort scores—derived from this preferred model—inform the comparative analysis in the next section.

TABLE 2. Stochastic frontier models—beer excise efficiency

Variable	Model 1	Model 2	Model 3
Log GDP per capita	0.550 (0.000)***	0.919 (0.547)	0.110 (0.287)
Trade openness	−0.007 (0.000)***	−0.005 (0.006)	−0.004 (0.004)
Urban population	−0.042 (0.000)***	−0.030 (0.015)*	−0.022 (0.012)
Aged 15+ population	0.108 (0.000)***	0.047 (0.034)	0.061 (0.028)*
Alcohol consumption (%)	0.033 (0.000)***	0.159 (0.100)	0.120 (0.046)**
Rule of law	−0.434 (0.000)***		
Corruption control	1.527 (0.000)***		
AE dummy			2.913 (0.490)***
Constant	−8.197 (0.000)***	−8.968 (2.337)***	−4.727 (1.438)**
lnsig2v	−31.478 (191.628)	−0.090 (1.616)	0.133 (0.295)
lnsig2u	2.088 (0.148)***	1.682 (0.972)	0.857 (0.439)
Log Likelihood	−161.045	−180.266	−165.076
AIC	338.089	372.532	344.153
BIC	358.176	387.792	361.956
$Sigma_u$	0.017	0.011	0.094
$Sigma_v$	2.146	1.083	4.291
Lambda	0.008	0.010	0.022
Gamma	0.000	0.000	0.000
Observations	91	94	94

Notes: This table reports results from stochastic frontier models of beer excise efficiency. All models assume a half-normal distribution for the inefficiency term. Coefficients are reported with standard errors in parentheses. lnsig2v and lnsig2u denote the logarithms of the variance parameters for the noise term (v) and the inefficiency term (u), respectively. $Sigma_v$ and $Sigma_u$ are the standard deviations of these components, and Lambda is the ratio $Sigma_u/Sigma_v$. The log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) measure model fit. Statistical significance is indicated by *p < 0.10, **p < 0.05, and ***p < 0.01.

Table 3 reports three stochastic-frontier estimates of spirits-excise rate-setting efficiency, with the dependent variable defined as the log of the excise share of the retail price. In Model 1, which includes structural, demographic and institutional controls, only the demographic and consumption variables achieve statistical significance: The share of the population aged 15 and over (0.151; p = 0.004) and alcohol consumption prevalence (0.219; p = 0.011) both carry positive, highly significant coefficients, while GDP per capita, trade openness, urbanization, rule of law, and corruption control all enter with the expected positive signs but fail to reach conventional significance levels. Dropping the institutional measures in Model 2 leaves a virtually unchanged demographic-consumption profile—age 15+ (0.141; p = 0.005) and consumption (0.241; p = 0.005) remain the only robust predictors—underscoring their primacy in explaining cross-country variation in excise rates. Model 3 replaces governance indicators with a dummy for advanced economies, revealing that membership in the advanced-economy group exerts a powerful independent effect (3.584; p < 0.001) on spirits-excise intensity. Even after accounting for this structural classification, the age 15+ share (0.152; p = 0.001) and consumption prevalence (0.183; p = 0.010) remain positive and significant, while trade openness

acquires a marginal positive coefficient (0.010; p = 0.096). Across all specifications the inefficiency variance ($\ln \sigma_u^2$) is statistically significant whereas the noise variance ($\ln \sigma_v^2$) is not, and values of λ near zero confirm that deviations from the frontier are driven by inefficiency rather than random shocks.

Taken together, these results suggest that larger adult populations and higher baseline consumption provide the strongest justification for higher spirits-excise rates, but that institutional capacity per se is less informative than a country's overall "advanced-economy" status. With the lowest AIC and BIC and a clear, interpretable structural effect, Model 3 strikes the best balance of parsimony and explanatory power and is therefore preferred for deriving the policy-relevant efficiency scores that follow.[8]

TABLE 3. Stochastic frontier models—spirits excise efficiency

Variable	Model 1	Model 2	Model 3
Log GDP per capita	0.268 (0.614)	0.856 (0.042)**	−0.125 (0.773)
Trade openness	0.009 (0.134)	0.009 (0.134)	0.010 (0.096)*
Urban population	−0.030 (0.173)	−0.039 (0.063)*	−0.027 (0.134)
Aged 15+ population	0.151 (0.004)**	0.141 (0.005)**	0.152 (0.001)***
Alcohol consumption (%)	0.219 (0.011)**	0.241 (0.005)**	0.183 (0.010)**
Rule of law	0.417 (0.706)		
Corruption control	0.426 (0.679)		
AE dummy			3.584 (0.000)***
Constant	−10.686 (0.001)***	−14.671 (<0.001)***	−8.981 (0.000)***
lnsig2v	1.070 (0.036)**	1.130 (0.062)*	1.195 (0.002)**
lnsig2u	1.994 (0.002)***	1.929 (0.020)**	1.196 (0.261)
Log Likelihood	−213.423	−220.493	−210.507
AIC	442.847	452.986	435.015
BIC	463.193	468.434	453.038
$Sigma_u$	0.005	0.001	0.011
$Sigma_v$	1.238	1.128	6.001
Lambda	0.004	0.001	0.002
Gamma	0.000	0.000	0.000
Observations	94	97	97

Notes: This table reports results from stochastic frontier models of spirits excise efficiency. All models assume a half-normal distribution for the inefficiency term. Coefficients are reported with standard errors in parentheses. lnsig2v and lnsig2u denote the logarithms of the variance parameters for the noise term (*v*) and the inefficiency term (*u*), respectively. $Sigma_v$ and $Sigma_u$ are the standard deviations of these components, and Lambda is the ratio $Sigma_u/Sigma_v$. The log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) measure model fit. Statistical significance is indicated by *p < 0.10, **p < 0.05, and ***p < 0.01.

8 While Model 3 is preferred for policy application due to its coverage, parsimony, and statistical fit, we acknowledge that Model 1 yields richer institutional insights. For readers interested in the specific role of governance quality, enforcement capacity, or rule of law, the Model 1 results offer valuable complementary interpretation alongside the main benchmarking analysis.

Table 4 presents three stochastic-frontier estimates of sugar-sweetened-beverage (SSB) excise rate-setting efficiency, where the dependent variable is the log of the excise share of the retail price.[9] In Model 1, which includes structural (GDP per capita, trade openness), demographic (urbanization, population aged 15+), and institutional (rule of law, corruption control) controls, only trade openness (coefficient –0.003; p = 0.004), urban population share (–0.015; p = 0.008), and the share of adults age 15+ (0.003; p = 0.019) reach conventional significance. GDP per capita enters positively but not significantly (0.378; p = 0.210), while the rule-of-law and corruption-control indices carry expected signs yet remain far from significant. Model 2 omits the institutional measures, focusing solely on structural and demographic drivers; it reproduces the same demographic-consumption profile as Model 1. Trade openness (–0.003; p = 0.004), urbanization (–0.013; p = 0.008) and the 15+ population share (–0.001 vs. 0.003 in Model 1, p = 0.019) continue to be the only robust predictors of excise-rate variation, underscoring their primacy in explaining cross-country differences in SSB excise shares. Model 3 introduces a dummy for advanced-economy status in place of detailed institutional indices. This advanced-economy indicator exerts a powerful, negative effect on SSB excise intensity (–1.487; p < 0.001), implying that, all else equal, advanced economies set lower relative SSB excise rates. Interestingly, advanced economies perform worse on SSB excise effort relative to middle-income peers, particularly in Latin America. This likely reflects the early adoption of SSB taxes in response to acute public health pressures in the latter group, whereas many advanced economies have yet to implement dedicated SSB excises despite greater fiscal capacity. Even with this group classification in the mix, the demographic effects persist: log GDP per capita (0.474; p < 0.001), trade openness (–0.009; p < 0.001), urbanization (–0.016; p < 0.001), and the share of adults 15+ (0.011; p < 0.001) all remain highly significant.

Across all three specifications, the inefficiency variance term ($\ln \sigma_u^2$)is statistically significant, whereas the noise variance ($\ln \sigma_v^2$) is not, and the estimated λ (σ_u/σ_v) hovers near zero—confirming that deviations from the frontier are driven primarily by inefficiency rather than random shocks. With the lowest AIC and BIC values, and a clear structural interpretation afforded by the advanced-economy dummy, Model 3 strikes the best balance of parsimony and explanatory power and is therefore preferred for deriving the policy-relevant efficiency scores that follow.

9 For a discussion on the complexity of setting excise taxes on high-caloric food and beverages, see Petit, Mansour, and Wingender (2021).

TABLE 4. Stochastic frontier models—SSBs excise efficiency

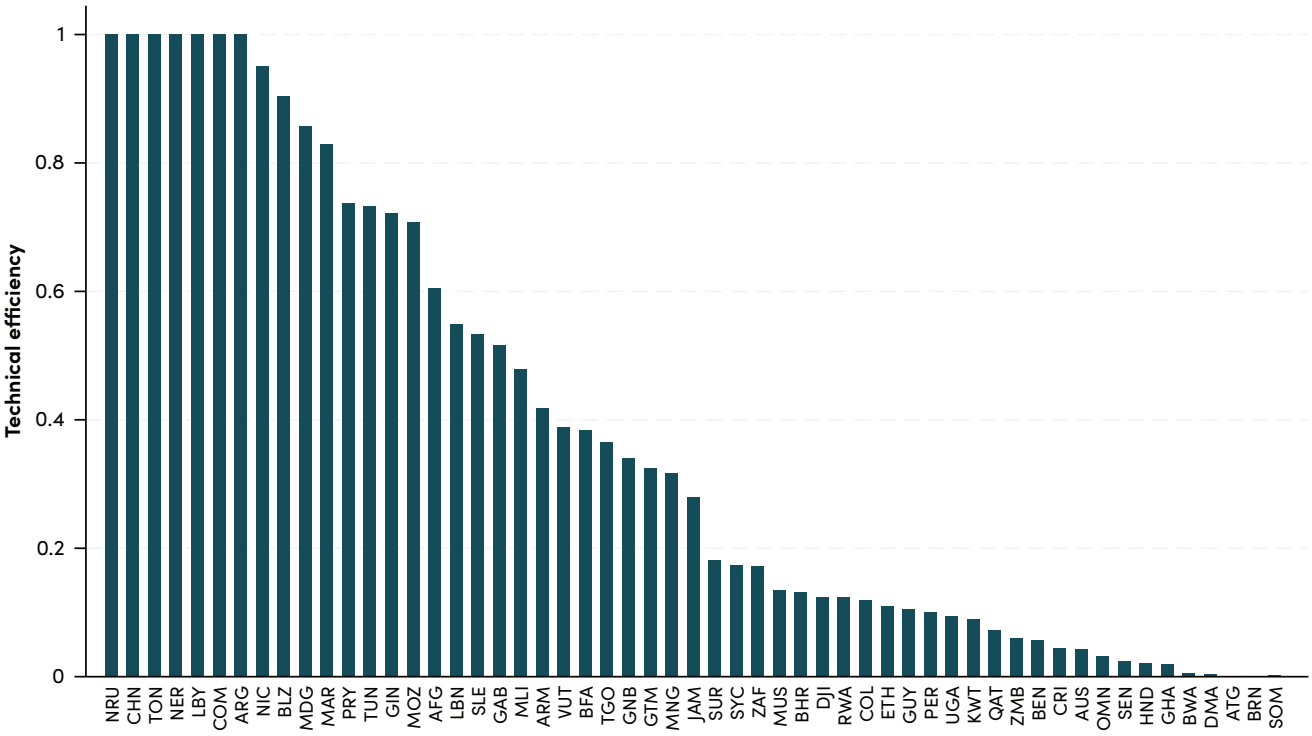
Variable	Model 1	Model 2	Model 3
Log GDP per capita	0.378 (0.210)	0.321 (0.194)	0.474*** (0.000)
Trade openness	−0.003 (0.004)	−0.003 (0.004)	−0.009*** (0.000)
Urban population	−0.015 (0.008)	−0.013 (0.008)	−0.016*** (0.000)
Population 15+ share	0.003 (0.019)	−0.001 (0.019)	0.011*** (0.000)
Rule of law	−0.324 (0.389)		
Corruption control	0.149 (0.355)		
AE dummy			−1.487*** (0.000)
Constant	−4.257*** (1.218)	−3.566*** (0.839)	−4.623*** (0.000)
lnsig2v (constant)	−1.264* (0.534)	−1.215* (0.573)	−34.315 (434.311)
lnsig2u (constant)	0.019 (0.513)	0.077 (0.540)	0.718*** (0.175)
Log Likelihood	−76.066	−79.037	−70.506
AIC	168.132	170.075	155.012
BIC	185.403	183.121	170.233
$Sigma_u$	0.532	0.545	0.000
$Sigma_v$	0.119	0.168	0.099
Lambda (σ_u/σ_v)	4.467	3.240	0.000
Gamma ($\sigma_u^2/(\sigma_u^2+\sigma_v^2)$)	0.952	0.913	0.000
Observations	64	65	65

Notes: This table reports results from stochastic frontier models of SSBs excise efficiency. All models assume a half-normal distribution for the inefficiency term. Coefficients are reported with standard errors in parentheses. lnsig2v and lnsig2u denote the logarithms of the variance parameters for the noise term (v) and the inefficiency term (u), respectively. $Sigma_v$ and $Sigma_u$ are the standard deviations of these components, and Lambda is the ratio $Sigma_u/Sigma_v$. The log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) measure model fit. Statistical significance is indicated by *p < 0.10, **p < 0.05, and ***p < 0.01.

Figure 1a presents technical efficiency scores in tobacco revenue collection across countries, estimated using the preferred specification (Model 2). A score of 1 indicates full efficiency—meaning a country collects as much tobacco tax revenue as expected given its economic and institutional characteristics. The distribution of scores is highly skewed, with a small group of countries achieving near-perfect efficiency while most fall well below 0.5. The top five performers—Argentina (ARG), Comoros (COM), China (CHN), Libya (LBY), and Niger (NER)—register scores close to 1, suggesting these countries are effectively capturing their estimated tobacco revenue potential. This may reflect appropriate policy calibration, enforcement capability, or other favorable structural factors. In contrast, the bottom five performers—Somalia (SOM), Brunei (BRN), Antigua and Barbuda (ATG), Dominica (DMA), and Botswana (BWA)—show extremely low scores, in some cases near zero. These low efficiency levels suggest substantial gaps between actual and potential revenue, possibly due to weak tax administration, policy exemptions, enforcement challenges, or unmeasured informal activity. The stark disparities across countries underscore the uneven capacity to mobilize tobacco taxes effectively. While top performers demonstrate that it is feasible to operate close to potential, most countries lag significantly, indicating considerable room for improvement. These findings point

to the value of targeted technical assistance and policy reform in low-efficiency settings, while high-efficiency cases may provide relevant lessons for enhancing tax performance elsewhere.[10]

FIGURE 1a. Country efficiency in tobacco revenue collection



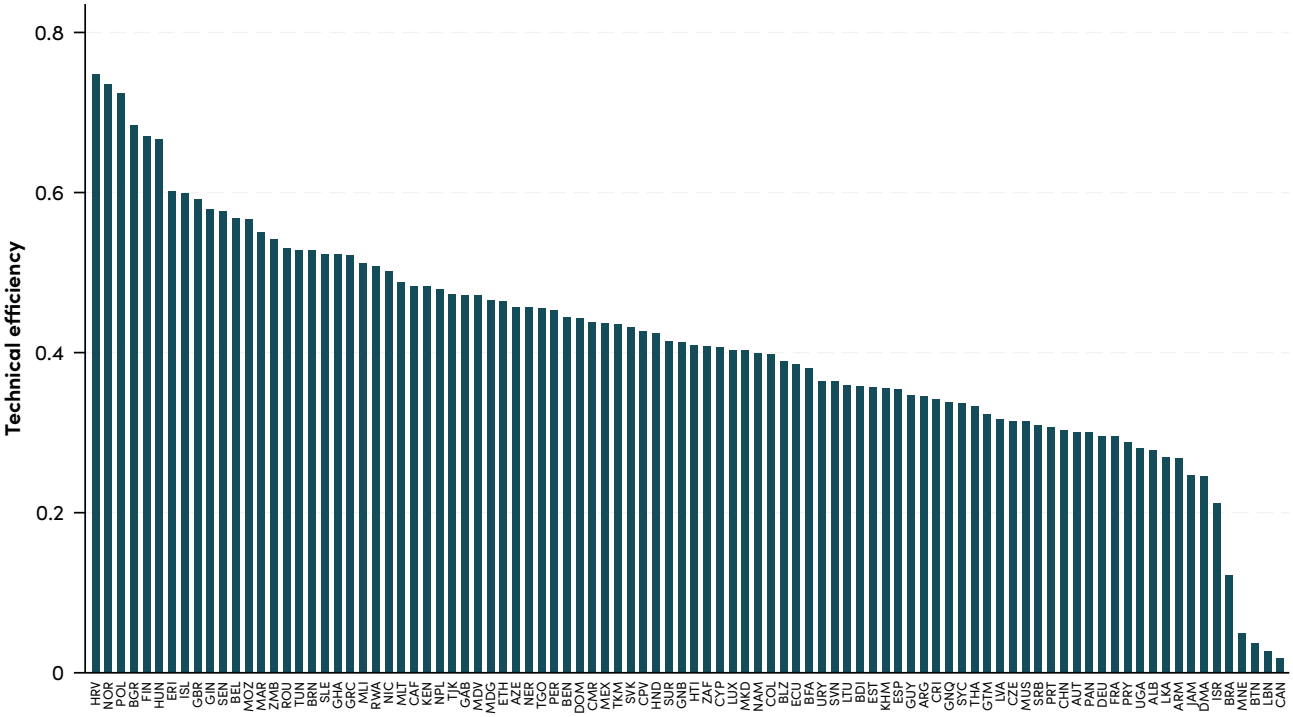
Notes: This figure displays estimated technical efficiency scores from the preferred stochastic frontier model (Model 2). A score of 1 indicates full efficiency, where a country collects as much tobacco tax revenue as predicted given its structural and institutional characteristics. Scores below 1 reflect varying degrees of inefficiency. The distribution is highly skewed: a few countries achieve near-perfect efficiency, while most fall significantly below the frontier, highlighting substantial gaps in revenue performance. Estimates are based on collapsed (country-level) data.

Figure 1b presents technical efficiency scores in beer excise taxation across countries, estimated using the preferred specification (Model 3). A score of 1 indicates full efficiency, meaning a country is taxing beer at a rate as high as structurally feasible given its income level, demographics, alcohol consumption patterns, and broader policy environment. These scores reflect the efficiency of rate-setting, not revenue collection, and measure how close countries are to their potential in taxing beer as a share of the retail price. The distribution is skewed, with most countries falling well below the halfway mark. The top five performers—Croatia (HRV), Norway (NOR), Poland (POL), Bulgaria (BGR), and Finland (FIN)—register efficiency scores between 0.67 and 0.75, indicating that they apply excise

10 The findings in Figure 1 are further complemented by the additional descriptive analyses provided in Appendix Figure A1, which includes both a boxplot and a histogram of technical efficiency scores for tobacco revenue collection. The boxplot highlights substantial dispersion in efficiency across countries, with a pronounced concentration of countries below the median efficiency score. Similarly, the histogram emphasizes the skewed distribution and reveals distinct clusters of countries at both low and high ends of efficiency. Together, these additional visuals underscore the significant heterogeneity and reinforce the conclusion that while some countries approach full efficiency, most have considerable room for improvement.

rates on beer that are close to the estimated frontier. These countries likely benefit from stronger institutional frameworks, robust public health commitments, and relatively high policy effort in alcohol taxation. At the other end of the spectrum, the bottom five performers—Canada (CAN), Lebanon (LBN), Bhutan (BTN), Montenegro (MNE), and Brazil (BRA)—score below 0.13, with Canada's efficiency just above 0.01.[11] These low scores suggest that actual beer excise rates in these countries fall far short of their structural potential. Possible reasons include weak political commitment to alcohol taxation, pressure from industry groups, administrative limitations, or competing fiscal priorities. The stark disparities between high and low performers underscore the uneven global application of beer excise taxation. Countries with low efficiency have considerable scope to raise excise rates without exceeding what is structurally and institutionally feasible. High-efficiency countries, in turn, offer useful policy benchmarks. These findings support the case for targeted technical assistance, fiscal policy reform, and greater alignment between health and tax objectives in alcohol taxation.

FIGURE 1b. Country efficiency in beer excise rate-setting (% of retail price)

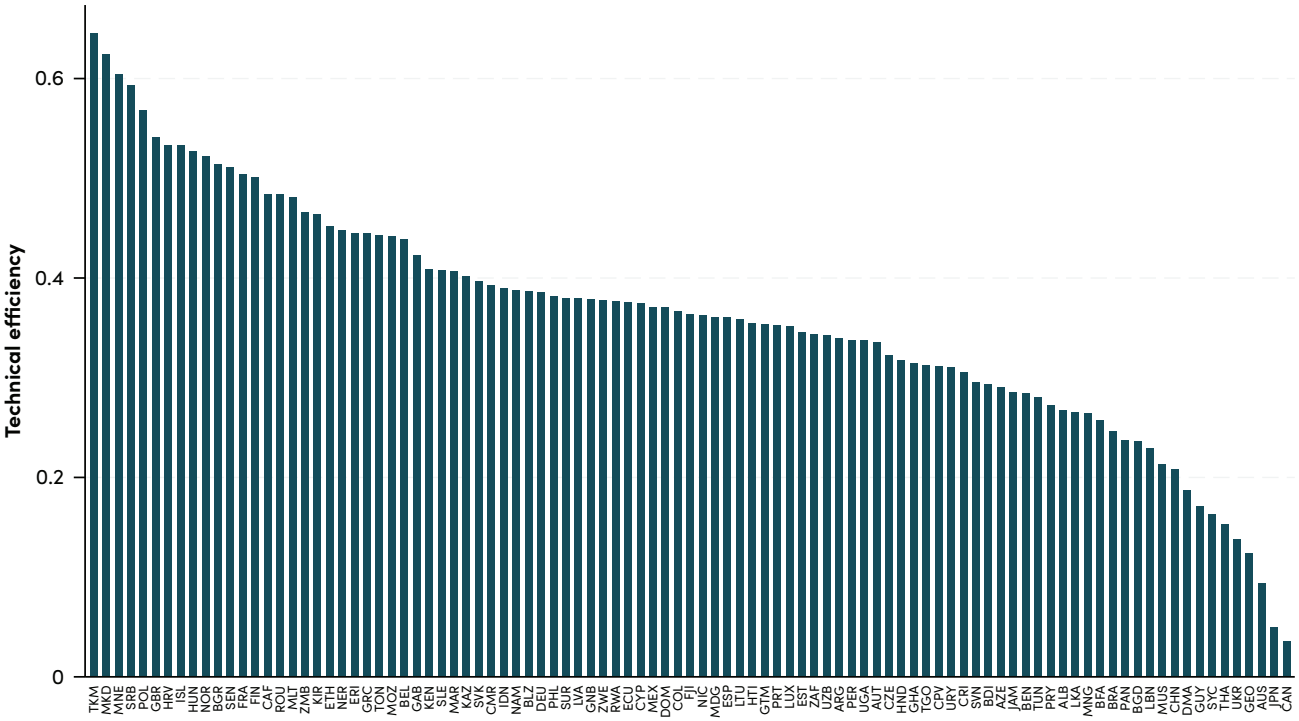


Notes: This figure displays estimated technical efficiency scores from the preferred stochastic frontier model (Model 3). A score of 1 indicates full efficiency, where a country applies a beer excise rate as high as predicted given its structural characteristics, demographic profile, and policy environment. Scores below 1 reflect varying degrees of inefficiency in rate-setting. The distribution is highly skewed: a few countries approach the policy frontier, while most fall significantly below it, highlighting substantial gaps between actual and feasible excise intensity. Estimates are based on collapsed (country-level) data.

11 In countries with decentralized alcohol taxation, such as Canada, our dataset reflects federal excise rates only. This may understate total statutory burdens and result in lower apparent efficiency scores.

Figure 1c plots country-level technical efficiency scores in spirits excise taxation, estimated from our preferred frontier (Model 3). A score of 1 denotes full efficiency while lower values signal unexploited potential. The distribution is heavily skewed: Only five countries exceed 0.56, led by Turkmenistan (0.65), North Macedonia (0.62), Montenegro (0.60), Serbia (0.59), and Poland (0.57), suggesting these governments levy spirits duties close to their estimated frontier. At the opposite extreme, Canada (0.04), Japan (0.05), Australia (0.09), Georgia (0.12) and Ukraine (0.14) rank lowest, indicating that their actual excise rates fall well below what institutional and structural conditions would allow. Such wide disparities highlight significant room for low-efficiency countries to raise spirits taxes without overstepping political or economic constraints, while high-efficiency peers offer clear policy benchmarks for aligning tax and public health objectives.

FIGURE 1c. Country efficiency in spirits excise rate-setting (% of retail price)

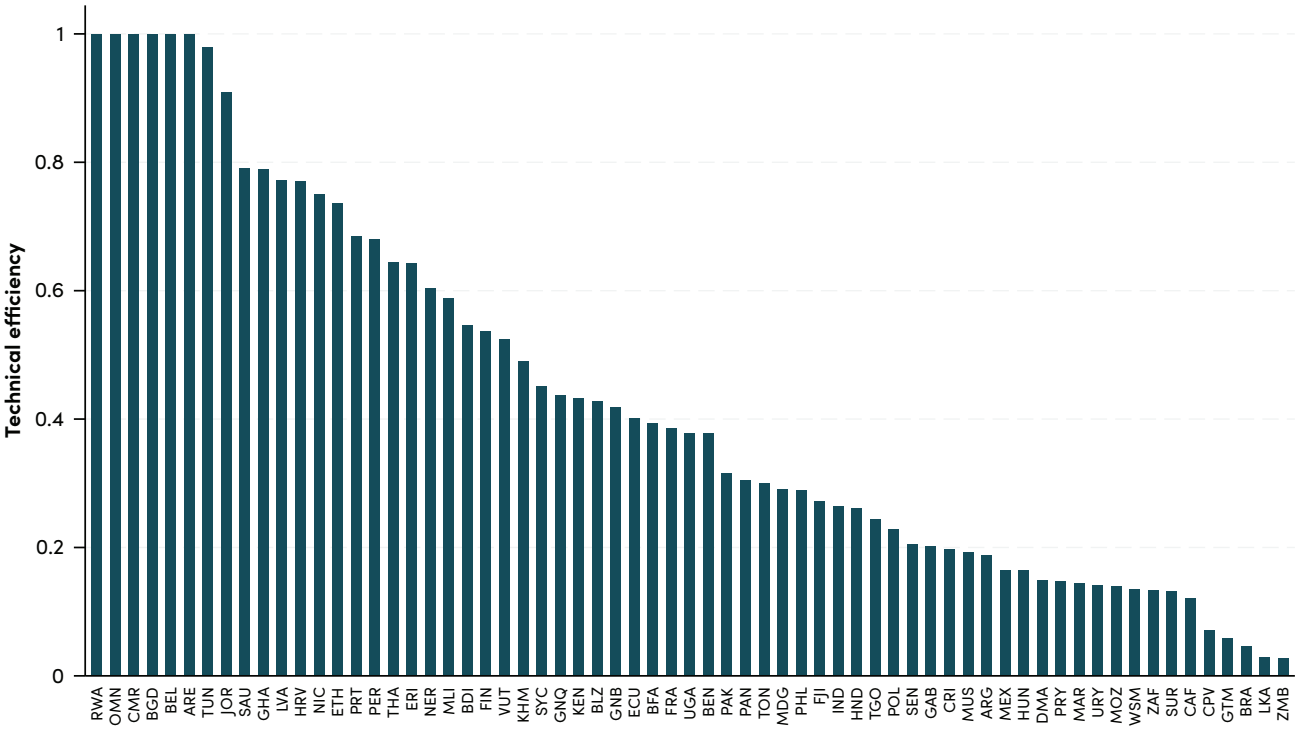


Notes: This figure displays estimated technical efficiency scores from the preferred stochastic frontier model (Model 3). A score of 1 indicates full efficiency, where a country applies a spirits excise rate as high as predicted given its structural characteristics, demographic profile, and policy environment. Scores below 1 reflect varying degrees of inefficiency in rate-setting. The distribution is highly skewed: a few countries approach the policy frontier, while most fall significantly below it, highlighting substantial gaps between actual and feasible excise intensity. Estimates are based on collapsed (country-level) data.

Figure 1d plots country-level technical efficiency scores in SSB excise taxation, estimated from our preferred frontier (Model 3). A score of 1 denotes full efficiency—i.e., that a country's actual SSB excise rate lies on its estimated feasibility frontier—while lower values signal unexploited potential. The distribution is heavily skewed: Only five countries exceed 0.99, led by Bangladesh, Oman, United Arab Emirates, Rwanda, and Cameroon, suggesting these governments levy SSB duties at

virtually the maximum their structural and institutional contexts would support. At the opposite extreme, Zambia (0.0273), Sri Lanka (0.0290), Brazil (0.0467), Guatemala (0.0587), and Cape Verde (0.0703) rank lowest, indicating that their actual excise rates fall far below what economic and political conditions would allow. Such wide disparities highlight significant room for low-efficiency countries to tighten SSB taxes without overstepping fiscal or political constraints, while high-efficiency peers offer clear policy benchmarks for aligning tax design with public health objectives.

FIGURE 1d. Country efficiency in SSBs excise rate-setting (% of retail price)

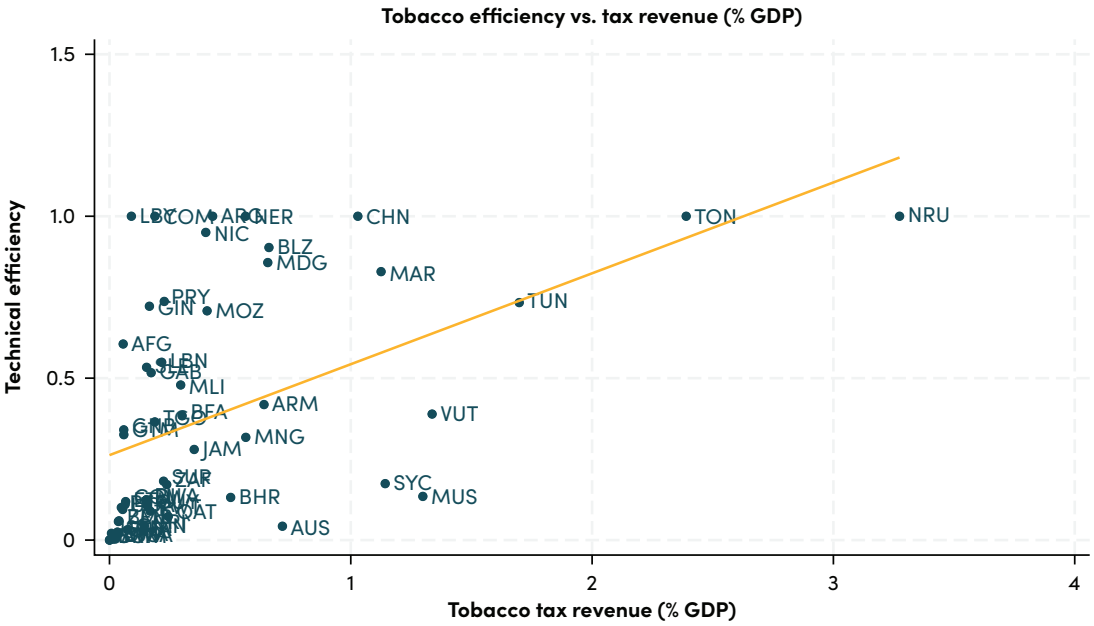


Notes: This figure displays estimated technical efficiency scores from the preferred stochastic frontier model (Model 3). A score of 1 indicates full efficiency, where a country applies a SSBs excise rate as high as predicted given its structural characteristics, demographic profile, and policy environment. Scores below 1 reflect varying degrees of inefficiency in rate-setting. The distribution is highly skewed: a few countries approach the policy frontier, while most fall significantly below it, highlighting substantial gaps between actual and feasible excise intensity. Estimates are based on collapsed (country-level) data.

Figure 2a provides a scatter plot illustrating the relationship between technical efficiency in tobacco tax collection and tobacco tax revenue as a percentage of GDP. Each observation represents a country (identified by its country code), with the plotted red regression line capturing the overall trend. The figure clearly demonstrates a positive relationship between technical efficiency and tobacco tax revenue, suggesting that higher efficiency is generally associated with greater revenue collection relative to GDP. However, significant heterogeneity is evident across countries. Some countries, such as Nauru (NRU) and Tonga (TON), exhibit particularly high revenue shares combined with

relatively high efficiency, placing them at the upper-right quadrant of the plot. Conversely, a cluster of countries is positioned at the lower-left quadrant, highlighting both low technical efficiency and minimal revenue generation from tobacco taxes. This dispersion indicates varied potential for improvement across countries. For instance, countries positioned far below the fitted line could achieve substantial gains by enhancing efficiency, thereby significantly increasing revenue mobilization from tobacco taxation.

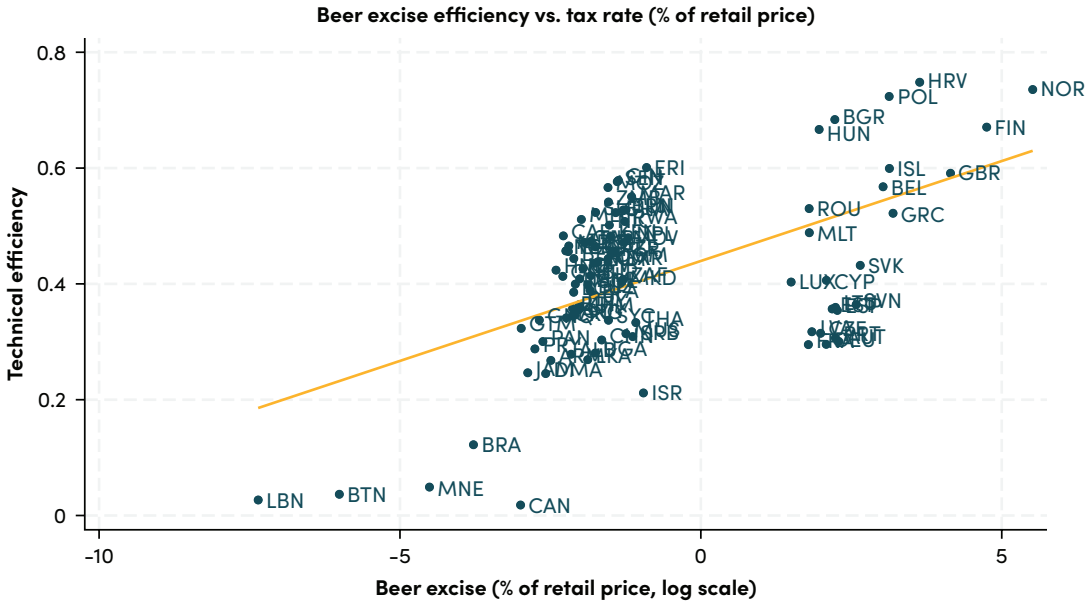
FIGURE 2a. Relationship between tobacco tax revenue and technical efficiency



Notes: This scatter plot depicts the relationship between tobacco tax revenue (as a percentage of GDP) and technical efficiency in tobacco tax collection across selected countries. Each point represents a country, labelled by its ISO country code. The yellow line represents the linear fit, highlighting the positive overall correlation between efficiency and revenue performance. Countries positioned significantly below the fitted line indicate potential opportunities for improving tax collection efficiency.

Figure 2b shows a clear positive relationship between technical efficiency and beer excise rates (log of % of retail price). Countries like Norway (NOR), Finland (FIN), and Croatia (HRV) combine high rates with high efficiency, occupying the upper-right quadrant. In contrast, Canada (CAN), Lebanon (LBN), Bhutan (BTN), and Montenegro (MNE) fall in the lower-left quadrant, indicating both low excise intensity and inefficient rate-setting. A dense cluster of countries around the mid-range suggests moderate efficiency and scope to raise rates. Countries positioned well below the fitted line—such as Brazil (BRA)—show particularly large gaps between current excise effort and their estimated potential, highlighting untapped fiscal and public health space.

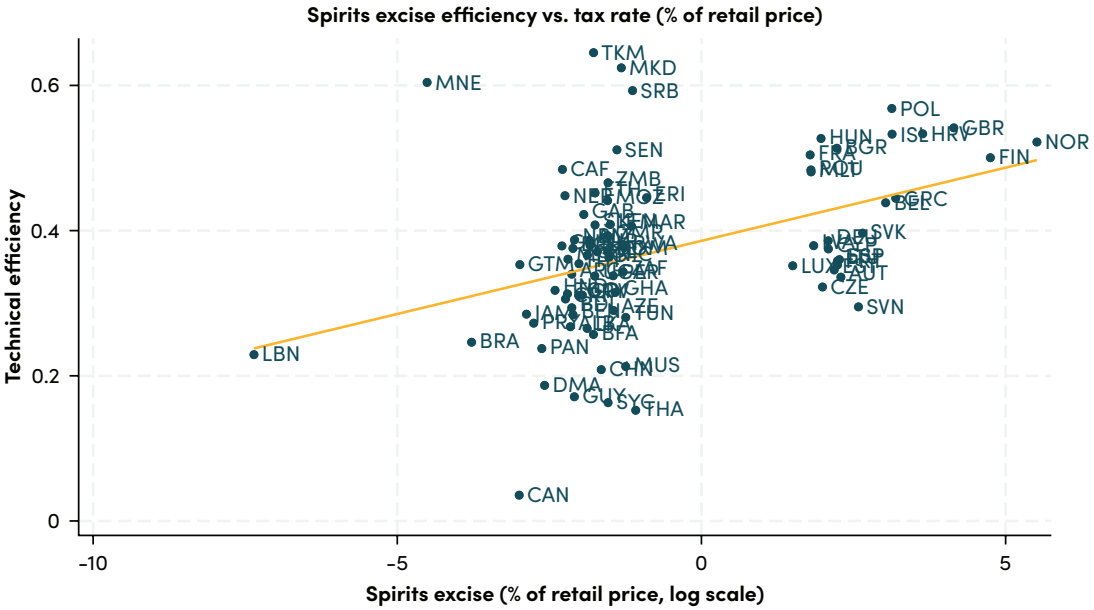
FIGURE 2b. Relationship between beer excise (% of retail price) and technical efficiency



Notes: This scatter plot depicts the relationship between beer excise rates (expressed as a percentage of the retail price, in log scale) and technical efficiency in beer excise rate-setting across selected countries. Each point represents a country, labelled by its ISO country code. The fitted line illustrates the overall relationship between applied excise intensity and estimated efficiency. Countries positioned significantly below the line may be underutilizing their rate-setting potential relative to structurally similar peers, suggesting scope for policy improvement.

Figure 2c illustrates a clear positive gradient between spirits-excise intensity (log of excise as a percentage of retail price) and technical efficiency. High-rate, high-efficiency governments—such as Norway, Finland, and Poland—cluster in the upper-right quadrant, confirming that the most aggressive taxing regimes also make the most of their structural potential. By contrast, Canada sits at the extreme lower-left: With both a low spirits duty and an efficiency score near zero, it exemplifies a country that is neither taxing heavily nor doing so efficiently. Lebanon likewise falls in the lower-left, combining a modest excise rate with sub-par efficiency. Montenegro and Serbia, despite relatively low to moderate excise rates, occupy the upper-left, indicating that they exploit much of their feasible capacity even if their headline rates remain tempered. A dense central cloud of countries—spanning excise logs between –2 and +2 and efficiency scores from roughly 0.3 to 0.5—marks nations with room to incrementally tighten spirits duties. Brazil, which plots below the fitted trend line, demonstrates one of the largest shortfalls: Its actual duty is well below both the frontier and what peers with similar structural profiles achieve. Overall, the upward sloping fit underscores that higher excises tend to go together with more efficient rate-setting, while outliers point to specific targets for policy improvement.

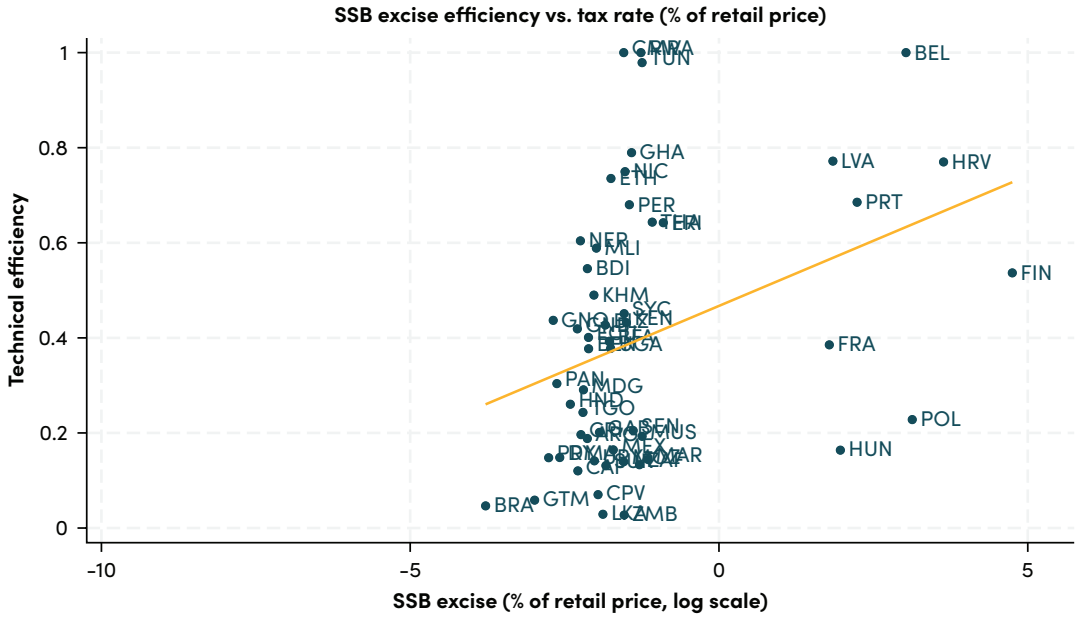
FIGURE 2c. Relationship between spirits excise (% of retail price) and technical efficiency



Notes: This scatter plot depicts the relationship between spirits excise rates (expressed as a percentage of the retail price, in log scale) and technical efficiency in spirits excise rate-setting across selected countries. Each point represents a country, labelled by its ISO country code. The fitted line illustrates the overall relationship between applied excise intensity and estimated efficiency. Countries positioned significantly below the line may be underutilizing their rate-setting potential relative to structurally similar peers, suggesting scope for policy improvement.

Figure 2d plots country-level technical efficiency scores in SSB excise taxation (Model 3) against the log of excise as a share of retail price. A score of 1 denotes full efficiency—i.e., that a country's actual SSB duty sits exactly on its estimated feasibility frontier—while lower values signal unexploited potential. The distribution is heavily skewed: Only five countries exceed 0.75 in efficiency, led by Belgium (1.00), Rwanda (0.99), Tunisia (0.99), Ghana (0.79), and Latvia (0.77), suggesting these governments levy SSB duties close to their structural and institutional limits. At the opposite extreme, Zambia (0.03), Sri Lanka (0.03), Brazil (0.05), Guatemala (0.06), and Cape Verde (0.07) rank lowest, indicating that their actual excise rates fall well below what their economic and political conditions would allow. Such wide disparities highlight significant room for low-efficiency countries to tighten SSB excises without overstepping fiscal or political constraints, while high-efficiency peers offer clear policy benchmarks for aligning tax design with public health objectives.

FIGURE 2d. Relationship between SSBs excise (% of retail price) and technical efficiency



Notes: This scatter plot depicts the relationship between SSBs excise rates (expressed as a percentage of the retail price, in log scale) and technical efficiency in SSBs its excise rate-setting across selected countries. Each point represents a country, labelled by its ISO country code. The fitted line illustrates the overall relationship between applied excise intensity and estimated efficiency. Countries positioned significantly below the line may be underutilizing their rate-setting potential relative to structurally similar peers, suggesting scope for policy improvement.

4.2 Assessing tax capacity and effort: identifying high and low performers in health taxation

In this section, we examine the tax effort and tax collection performance of countries based on their structural capacity to raise health taxes—measured using revenue-based frontiers for tobacco and rate-based frontiers for alcohol and sugary drinks. This analysis is based on the selected model from the SFA conducted earlier. Using this model, we classify countries into four distinct categories that highlight varying degrees of efficiency in mobilizing tax revenues.

First, tax capacity refers to the maximum theoretical revenue a country can generate from health taxes, given its structural characteristics, including income levels, demographics, governance, and openness. As noted earlier, this is the baseline or frontier that reflects a country's potential to collect revenue. Second, tax effort is the ratio of actual tax revenue to tax capacity, providing a measure of how efficiently a country mobilizes its revenue potential. Countries with an effort greater than 1 are performing above their estimated capacity, while those with an effort less than 1 are underperforming relative to their potential. Finally, tax potential is the difference between capacity and actual revenue, reflecting the untapped opportunities for revenue collection, which could arise

from improving tax compliance, broadening the tax base, or adjusting tax rates. Based on these definitions, we classify countries into four distinct categories[12]:

1. **Low Collection, Low Effort:** Countries that are far from their theoretical tax capacity and demonstrate low effort in mobilizing revenues. These countries may face structural or administrative challenges, including poor tax enforcement, narrow tax bases, or high levels of noncompliance.
2. **High Collection, High Effort:** Countries that are performing at or near their tax capacity, effectively mobilizing revenue from health taxes. These countries show both high tax collection and high effort, indicating efficient and effective tax systems.
3. **Low Collection, High Effort:** Countries with relatively low actual revenue but high effort—meaning they are collecting close to their structural potential. In these cases, limited revenue reflects structural constraints such as low income levels, young populations, or consumption patterns rather than policy underperformance. While immediate gains may be limited, long-term progress may depend on broader development, institutional strengthening, or external technical support.
4. **High Collection, Low Effort:** Countries that collect high levels of revenue but could significantly increase their tax revenue with relatively modest improvements in effort. These countries may have favorable tax policies or high tax rates but suffer from inefficiencies in collection or a narrow tax base.

This analysis applies a consistent four-quadrant framework to tobacco, beer, spirits, and sugar-sweetened beverage (SSB) excise taxes, classifying each country by actual yield (tobacco revenue as a share of GDP; beer, spirits, and SSB excises as shares of the retail price) and by technical efficiency, or "effort," defined as the ratio of actual collections to estimated capacity. Countries falling above the global mean for yield and above the global mean for effort appear in the High-Collection/High-Effort quadrant; those below both thresholds in the Low-Collection/Low-Effort quadrant; and the remaining two quadrants distinguish high effort with low yield from high yield with low effort.[13]

In the tobacco analysis (Table 5a), Argentina, China, and Tonga emerge as exemplars: Their high tobacco revenues, coupled with effort scores near unity, reflect well-designed and effectively administered taxes. At the opposite extreme, countries such as Somalia, Brunei, and Botswana collect little tobacco revenue and do so inefficiently, indicating substantial room for reform. Meanwhile, Guatemala, Nicaragua, and Guinea demonstrate relatively strong effort despite low

12 Note that while the quadrant framework is consistent across products, the interpretation of 'effort' and 'capacity' differs slightly. For tobacco, both axes refer to revenue-based performance; for alcohol and SSBs, they refer to excise rate levels relative to structural potential. In all cases, the taxonomy identifies underutilized fiscal space relative to feasible benchmarks.

13 To assess whether our findings are sensitive to missing data across tax types, we repeated the analysis on the restricted subset of countries with complete observations for tobacco, beer, spirits, and SSBs. The relative efficiency rankings and quadrant assignments remained broadly consistent with our main results. This suggests that our conclusions are not driven by sample selection. Full tables are available upon request.

absolute yields—suggesting external constraints on revenue mobilization—while Seychelles and Bahrain, although among the highest tobacco revenue generators, underperform in efficiency, hinting at legacy structures or indexation gaps.

Turning to beer excise taxes (Table 5b), measured here as a percentage of retail price rather than GDP, Slovakia, Greece, and the United Kingdom stand out in the High-Collection/High-Effort quadrant: Steep excise rates are matched by administrative performance close to structural potential. Canada, Bhutan, and Brazil, by contrast, occupy the Low-Collection/Low-Effort quadrant, maintaining low beer excise shares and realizing only a small fraction of their capacity. South Africa, Mozambique, and Kenya sit in the Low-Collection/High-Effort quadrant, where modest rates are nevertheless well aligned with structure and yield nearly all they can. France, Germany, and Austria populate the High-Collection/Low-Effort quadrant, applying high beer taxes but collecting below capacity—an indication that historical policy inertia or suboptimal rate design could be constraining revenues. A similar pattern emerges for spirits (Table 5c), where countries cluster at both extremes—some combining high rates with efficient administration to approach structural potential, while many other impose very low excises and achieve limited yields—highlighting how policy design and enforcement together shape outcomes.

Applying the same framework to sugar-sweetened beverage excise (Table 5d) yields fresh insights. In the Low-Collection/Low-Effort quadrant (Panel A), countries such as Zambia, Guatemala, Cape Verde, Central African Republic, and Suriname levy negligible SSB duties (0–3% of price) and achieve effort ratios below 0.15, indicating deeply underutilized potential (average capacity ≈ 0.15). The High-Collection/High-Effort quadrant (Panel B) contains only Tonga—an 11% excise and an effort score of 0.30 against capacity 0.38—exemplifying well-calibrated rate-setting and effective administration even at modest absolute yield. The Low-Collection/High-Effort quadrant (Panel C) includes Burkina Faso, Guinea-Bissau, Cambodia, Finland, Mali, and Portugal: These levy relatively low excise shares (5–13%) yet collect nearly all they feasibly can (effort 0.39–0.77), underscoring how strong governance and enforcement can offset constrained headline rates. Finally, the High-Collection/Low-Effort quadrant (Panel D) groups Ecuador, Belize, Kenya, Thailand, Peru, South Africa, Jordan, Tunisia, Rwanda, Bangladesh, United Arab Emirates, Cameroon, and Oman—all with excises above the global mean (9–32%) but effort scores from 0 to 0.64. These countries apply some of the steepest SSB taxes in our sample yet collect well below their feasible frontier, signaling that policy inertia, design flaws, or administrative bottlenecks are impeding full revenue capture.

Across all four tax categories, this unified quadrant framework highlights where countries are over- or under-performing relative to structural potential—and offers clear guidance on where tightening rate structures and strengthening administration could yield substantial fiscal and public health dividends.

TABLE 5a. Mapping tobacco tax performance: Collection, effort, and potential gaps

A. Low Tax Collection, Low Tax Effort					B. High Tax Collection, High Tax Effort				
Country	Current Revenue (% GDP)	Tax Effort	Tax Capacity	Tax Potential	Country	Current Revenue (% GDP)	Tax Effort	Tax Capacity	Tax Potential
ZAF	0.24	0.171	1.38	1.15	ARG	0.43	1	0.43	0
COL	0.07	0.119	0.56	0.5	BLZ	0.66	0.903	0.73	0.07
CRI	0.14	0.044	3.32	3.18	MDG	0.66	0.857	0.77	0.11
HND	0.01	0.021	0.39	0.39	MAR	1.13	0.829	1.36	0.23
PER	0.05	0.101	0.49	0.44	MOZ	0.4	0.708	0.57	0.17
ATG	0.02	0.003	5.29	5.27	NER	0.56	1	0.56	0
DMA	0.03	0.004	7.25	7.23	NRU	3.27	1	3.27	0
GUY	0.16	0.105	1.49	1.33	VUT	1.34	0.389	3.44	2.1
JAM	0.35	0.28	1.26	0.9	TON	2.39	1	2.39	0
SUR	0.22	0.182	1.23	1.01	ARM	0.64	0.418	1.53	0.89
KWT	0.17	0.089	1.89	1.72	CHN	1.03	1	1.03	0
OMN	0.07	0.032	2.33	2.25	MNG	0.56	0.317	1.78	1.22
QAT	0.24	0.073	3.34	3.1					
BRN	0	0	3.08	3.08					
DJI	0.15	0.124	1.23	1.08					
BWA	0.02	0.006	3.83	3.81					
BEN	0.04	0.058	0.64	0.61					
ETH	0.06	0.11	0.59	0.52					
GHA	0.04	0.02	1.92	1.89					
RWA	0.15	0.123	1.23	1.08					
SEN	0.03	0.025	1.33	1.3					
SOM	0	0	0.05	0.05					
TGO	0.19	0.365	0.52	0.33					
UGA	0.05	0.095	0.58	0.52					
ZMB	0.04	0.059	0.67	0.63					
C. Low Tax Collection, High Tax Effort					**D. High Tax Collection, Low Tax Effort**				
Country	Current Revenue (% GDP)	Tax Effort	Tax Capacity	Tax Potential	Country	Current Revenue (% GDP)	Tax Effort	Tax Capacity	Tax Potential
GTM	0.06	0.325	0.18	0.12	BHR	0.5	0.132	3.81	3.31
NIC	0.4	0.95	0.42	0.02	SYC	1.14	0.174	6.55	5.41
PRY	0.23	0.737	0.31	0.08					
LBN	0.22	0.549	0.39	0.18					
AFG	0.06	0.605	0.09	0.04					
COM	0.19	1	0.19	0					
GAB	0.17	0.517	0.33	0.16					
GNB	0.06	0.34	0.17	0.11					
GIN	0.17	0.722	0.23	0.06					
LBY	0.09	1	0.09	0					
MLI	0.3	0.479	0.62	0.32					
SLE	0.15	0.533	0.29	0.13					
TUN	1.7	0.733	2.32	0.62					
BFA	0.3	0.384	0.78	0.48					

Notes: Countries are classified into four quadrants based on tobacco tax revenue (% of GDP) and technical efficiency (effort). High (Low) collection refers to revenue above (below) the global mean, while high (low) effort refers to efficiency above (below) the global median. This yields four groups: Low Collection–Low Effort, High Collection–High Effort, Low Collection–High Effort, and High Collection–Low Effort.

TABLE 5b. Mapping beer excise performance: Collection, effort, and potential gaps

A. Low Tax Collection, Low Tax Effort					B. High Tax Collection, High Tax Effort				
Country	Beer Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential	Country	Beer Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential
CAN	0.05	0.018	2.76	2.71	SVK	16.12	0.432	37.33	21.2
LBN	0	0.027	0.02	0.02	MLT	9.08	0.488	18.59	9.51
BTN	0	0.037	0.07	0.06	GRC	25.78	0.522	49.4	23.62
MNE	0.01	0.049	0.22	0.21	ROU	7.87	0.53	14.85	6.98
BRA	0.02	0.122	0.19	0.16	BEL	20.67	0.568	36.4	15.73
ISR	0.39	0.212	1.82	1.43	GBR	77.18	0.591	130.59	53.41
DMA	0.08	0.245	0.31	0.23	HUN	18.62	0.667	27.93	9.31
JAM	0.06	0.246	0.23	0.17	BGR	9.27	0.684	13.55	4.29
ARM	0.08	0.268	0.31	0.23	POL	22.88	0.724	31.62	8.74
LKA	0.15	0.269	0.57	0.41					
ALB	0.12	0.279	0.42	0.3					
UGA	0.17	0.281	0.62	0.44					
PRY	0.06	0.288	0.22	0.16					
PAN	0.07	0.3	0.24	0.17					
CHN	0.19	0.303	0.64	0.44					
SRB	0.32	0.309	1.04	0.72					
MUS	0.29	0.314	0.92	0.63					
GTM	0.05	0.323	0.16	0.11					
THA	0.34	0.333	1.02	0.68					
SYC	0.22	0.337	0.64	0.42					
GNQ	0.07	0.337	0.2	0.13					
CRI	0.11	0.341	0.31	0.21					
ARG	0.12	0.345	0.34	0.22					
GUY	0.12	0.346	0.36	0.23					
KHM	0.13	0.356	0.37	0.24					
BDI	0.12	0.358	0.33	0.21					
URY	0.13	0.364	0.37	0.23					
BFA	0.17	0.381	0.44	0.28					
ECU	0.12	0.386	0.31	0.19					
BLZ	0.16	0.389	0.41	0.25					
COL	0.15	0.398	0.39	0.23					
NAM	0.12	0.4	0.31	0.19					
MKD	0.27	0.403	0.67	0.4					

TABLE 5b. (Continued)

C. Low Tax Collection, High Tax Effort					D. High Tax Collection, Low Tax Effort				
Country	Beer Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential	Country	Beer Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential
ZAF	0.28	0.408	0.68	0.4	FRA	10.73	0.295	36.35	25.62
HTI	0.13	0.409	0.33	0.19	DEU	8.44	0.296	28.56	20.12
GNB	0.1	0.413	0.24	0.14	AUT	20.19	0.301	67.15	46.96
SUR	0.16	0.414	0.39	0.23	PRT	15.02	0.307	49.01	33.99
HND	0.09	0.424	0.21	0.12	CZE	11.07	0.315	35.17	24.1
CPV	0.14	0.426	0.33	0.19	LVA	9.68	0.317	30.49	20.82
TKM	0.17	0.436	0.39	0.22	ESP	9.69	0.354	27.35	17.66
MEX	0.18	0.437	0.41	0.23	EST	17.46	0.357	48.94	31.48
CMR	0.21	0.437	0.49	0.28	LTU	10.26	0.359	28.53	18.28
DOM	0.21	0.443	0.48	0.27	LUX	8	0.403	19.85	11.85
BEN	0.12	0.444	0.27	0.15	CYP	16.47	0.406	40.55	24.08
PER	0.23	0.453	0.52	0.28					
TGO	0.11	0.456	0.24	0.13					
NER	0.11	0.457	0.23	0.13					
AZE	0.24	0.457	0.51	0.28					
ETH	0.17	0.464	0.37	0.2					
MDG	0.11	0.465	0.24	0.13					
MDV	0.28	0.471	0.59	0.31					
GAB	0.14	0.472	0.31	0.16					
TJK	0.16	0.473	0.34	0.18					
NPL	0.3	0.48	0.62	0.32					
KEN	0.22	0.483	0.46	0.24					
CAF	0.1	0.483	0.21	0.11					
NIC	0.22	0.501	0.44	0.22					
RWA	0.28	0.508	0.56	0.27					
MLI	0.14	0.511	0.27	0.13					
GHA	0.24	0.523	0.46	0.22					
SLE	0.17	0.523	0.33	0.16					
BRN	0.28	0.528	0.52	0.25					
TUN	0.29	0.528	0.55	0.26					
ZMB	0.22	0.541	0.4	0.18					
MAR	0.32	0.55	0.57	0.26					
MOZ	0.21	0.566	0.38	0.16					
SEN	0.25	0.577	0.43	0.18					
GIN	0.25	0.579	0.44	0.19					
ERI	0.41	0.601	0.68	0.27					

Notes: Countries are classified into four quadrants based on beer excise rates (as a percentage of the retail price) and technical efficiency (effort). High (Low) rate refers to countries with excise rates above (below) the global mean, while high (low) effort reflects technical efficiency above (below) the global median. This yields four groups: Low Rate–Low Effort, High Rate–High Effort, Low Rate–High Effort, and High Rate–Low Effort.

TABLE 5c. Mapping spirits excise performance: Collection, effort, and potential gaps

A. Low Tax Collection, Low Tax Effort					B. High Tax Collection, High Tax Effort				
Country	Spirits Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential	Country	Spirits Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential
CAN	0.12	0.036	3.34	3.22	BEL	1606.01	0.438	3663.8	2057.79
JPN	0.16	0.05	3.25	3.09	FRA	1620.75	0.504	3214.08	1593.34
AUS	0.56	0.094	6.03	5.47	DEU	1140.18	0.386	2954.13	1813.96
ZAF	0.47	0.343	1.36	0.89	GRC	1765.64	0.445	3971.27	2205.63
ARG	0.23	0.34	0.66	0.44	MLT	1366.67	0.481	2842.16	1475.5
BRA	0.09	0.246	0.37	0.28	CYP	666.39	0.375	1778.16	1111.78
CRI	0.22	0.306	0.72	0.5	BGR	482.12	0.513	938.94	456.82
GTM	0.07	0.353	0.2	0.13	SVK	1033.13	0.397	2605.54	1572.4
HTI	0.13	0.354	0.38	0.24	LVA	1161.86	0.379	3063.56	1901.7
HND	0.1	0.318	0.32	0.22	SRB	651	0.593	1098.06	447.06
PAN	0.1	0.238	0.42	0.32	MNE	650	0.604	1075.93	425.93
PRY	0.08	0.272	0.28	0.2	HUN	886.99	0.527	1683.36	796.37
PER	0.21	0.338	0.63	0.42	HRV	610.75	0.533	1145.08	534.33
URY	0.23	0.311	0.73	0.5	MKD	488	0.624	781.73	293.73
DMA	0.1	0.187	0.55	0.44	POL	1067.38	0.568	1878.57	811.19
GUY	0.12	0.171	0.69	0.57	ROU	696.85	0.484	1441.03	744.18
JAM	0.22	0.285	0.78	0.55					
LBN	0.02	0.229	0.08	0.06					
BGD	0.03	0.236	0.12	0.09					
LKA	0.36	0.265	1.37	1.01					
THA	0.34	0.152	2.24	1.9					
BDI	0.05	0.294	0.16	0.11					
CPV	0.16	0.311	0.51	0.35					
BEN	0.02	0.284	0.08	0.06					
GHA	0.08	0.315	0.24	0.17					
MUS	0.62	0.213	2.91	2.29					
SYC	0.32	0.163	1.94	1.63					
TGO	0.04	0.313	0.12	0.08					
TUN	0.12	0.28	0.44	0.32					
UGA	0.32	0.337	0.95	0.63					
BFA	0.04	0.257	0.17	0.13					
AZE	0.23	0.29	0.78	0.55					
ALB	0.38	0.268	1.43	1.04					
GEO	0.19	0.123	1.52	1.33					
CHN	0.16	0.208	0.78	0.62					
UKR	0.28	0.138	1.99	1.72					
UZB	0.22	0.343	0.65	0.43					
MNG	0.11	0.264	0.43	0.32					

TABLE 5c. (Continued)

C. Low Tax Collection, High Tax Effort					D. High Tax Collection, Low Tax Effort				
Country	Spirits Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential	Country	Spirits Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential
COL	0.32	0.366	0.87	0.55	AUT	900.02	0.336	2679.08	1779.06
DOM	0.36	0.37	0.98	0.62	LUX	1041.15	0.352	2961.4	1920.25
ECU	0.29	0.375	0.78	0.48	PRT	957.49	0.353	2714.52	1757.04
MEX	0.3	0.371	0.81	0.51	ESP	607.87	0.36	1688.26	1080.38
NIC	0.25	0.363	0.69	0.44	CZE	948.14	0.322	2941.34	1993.2
BLZ	0.66	0.387	1.71	1.05	EST	1306.5	0.346	3778.25	2471.76
SUR	0.66	0.38	1.75	1.09	LTU	1141.55	0.358	3185.65	2044.11
IDN	0.4	0.39	1.03	0.63	SVN	932.28	0.295	3160.79	2228.51
PHL	0.51	0.382	1.34	0.83					
CMR	0.27	0.393	0.7	0.42					
CAF	0.24	0.484	0.49	0.25					
ERI	0.25	0.445	0.57	0.31					
ETH	0.33	0.452	0.73	0.4					
GAB	0.31	0.422	0.74	0.43					
GNB	0.12	0.379	0.3	0.19					
KEN	0.19	0.408	0.47	0.28					
MDG	0.06	0.361	0.18	0.11					
MAR	0.4	0.406	0.98	0.58					
MOZ	0.23	0.441	0.52	0.29					
NER	0.13	0.448	0.3	0.16					
ZWE	0.13	0.378	0.35	0.21					
RWA	0.14	0.377	0.37	0.23					
SEN	0.58	0.511	1.14	0.56					
SLE	0.09	0.408	0.21	0.13					
NAM	0.32	0.387	0.82	0.5					
ZMB	0.32	0.466	0.69	0.37					
FJI	0.45	0.363	1.24	0.79					
KIR	0.73	0.464	1.57	0.84					
TON	0.7	0.443	1.58	0.88					
KAZ	2.57	0.401	6.41	3.84					
TKM	79.43	0.645	123.13	43.7					

Notes: Countries are classified into four quadrants based on spirits excise rates (as a percentage of the retail price) and technical efficiency (effort). High (Low) rate refers to countries with excise rates above (below) the global mean, while high (low) effort reflects technical efficiency above (below) the global median. This yields four groups: Low Rate–Low Effort, High Rate–High Effort, Low Rate–High Effort, and High Rate–Low Effort.

TABLE 5d. Mapping SSBs excise performance: Collection, effort, and potential gaps

A. Low Tax Collection, Low Tax Effort					B. High Tax Collection, High Tax Effort				
Country	SSBs Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential	Country	SSBs Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential
ZMB	0	0.027	0.15	0.14	TON	0.11	0.3	0.38	0.26
GTM	0.02	0.059	0.27	0.25					
CPV	0.01	0.07	0.16	0.14					
CAF	0.01	0.12	0.12	0.1					
SUR	0.03	0.131	0.23	0.2					
ZAF	0.04	0.133	0.31	0.27					
MOZ	0.01	0.14	0.1	0.08					
URY	0.05	0.141	0.32	0.28					
MAR	0.03	0.144	0.21	0.18					
PRY	0.04	0.148	0.25	0.21					
DMA	0.03	0.148	0.23	0.2					
HUN	0.03	0.164	0.2	0.17					
MEX	0.05	0.164	0.29	0.24					
ARG	0.07	0.188	0.36	0.29					
MUS	0.07	0.193	0.34	0.28					
CRI	0.06	0.196	0.31	0.25					
GAB	0.03	0.201	0.17	0.13					
SEN	0.03	0.205	0.17	0.13					
TGO	0.03	0.243	0.14	0.11					
HND	0.03	0.26	0.12	0.09					
IND	0.07	0.264	0.27	0.2					
FJI	0.05	0.273	0.19	0.14					
PHL	0.06	0.289	0.22	0.15					
MDG	0.04	0.291	0.12	0.09					
PAN	0.07	0.304	0.23	0.16					
PAK	0.08	0.316	0.26	0.18					
BEN	0.06	0.377	0.16	0.1					
UGA	0.08	0.378	0.21	0.13					
FRA	0.05	0.385	0.14	0.09					

TABLE 5d. (Continued)

C. Low Tax Collection, High Tax Effort					D. High Tax Collection, Low Tax Effort				
Country	SSBs Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential	Country	SSBs Excise (% of Retail Price)	Tax Effort	Tax Capacity	Tax Potential
BFA	0.07	0.393	0.17	0.1	ECU	0.11	0.401	0.28	0.17
GNB	0.06	0.419	0.14	0.08	BLZ	0.12	0.427	0.27	0.15
GNQ	0.09	0.437	0.2	0.11	KEN	0.11	0.432	0.26	0.15
SYC	0.09	0.451	0.19	0.11	VUT	0.13	0.525	0.25	0.12
KHM	0.07	0.49	0.14	0.07	BDI	0.09	0.546	0.17	0.08
FIN	0.07	0.537	0.13	0.06	NER	0.11	0.604	0.18	0.07
MLI	0.08	0.589	0.13	0.05	ERI	0.1	0.642	0.16	0.06
PRT	0.09	0.685	0.13	0.04	THA	0.15	0.643	0.24	0.09
LVA	0.05	0.772	0.06	0.01	PER	0.17	0.68	0.25	0.08
BEL	0.05	1	0.05	0	ETH	0.14	0.735	0.19	0.05
					NIC	0.1	0.75	0.14	0.03
					GHA	0.11	0.79	0.14	0.03
					SAU	0.29	0.791	0.37	0.08
					JOR	0.1	0.91	0.11	0.01
					TUN	0.17	0.979	0.17	0
					RWA	0.21	1	0.21	0
					BGD	0.25	1	0.25	0
					ARE	0.32	1	0.32	0
					CMR	0.17	1	0.17	0
					OMN	0.32	1	0.32	0

Notes: Countries are classified into four quadrants based on SSBs excise rates (as a percentage of the retail price) and technical efficiency (effort). High (Low) rate refers to countries with excise rates above (below) the global mean, while high (low) effort reflects technical efficiency above (below) the global median. This yields four groups: Low Rate–Low Effort, High Rate–High Effort, Low Rate–High Effort, and High Rate–Low Effort.

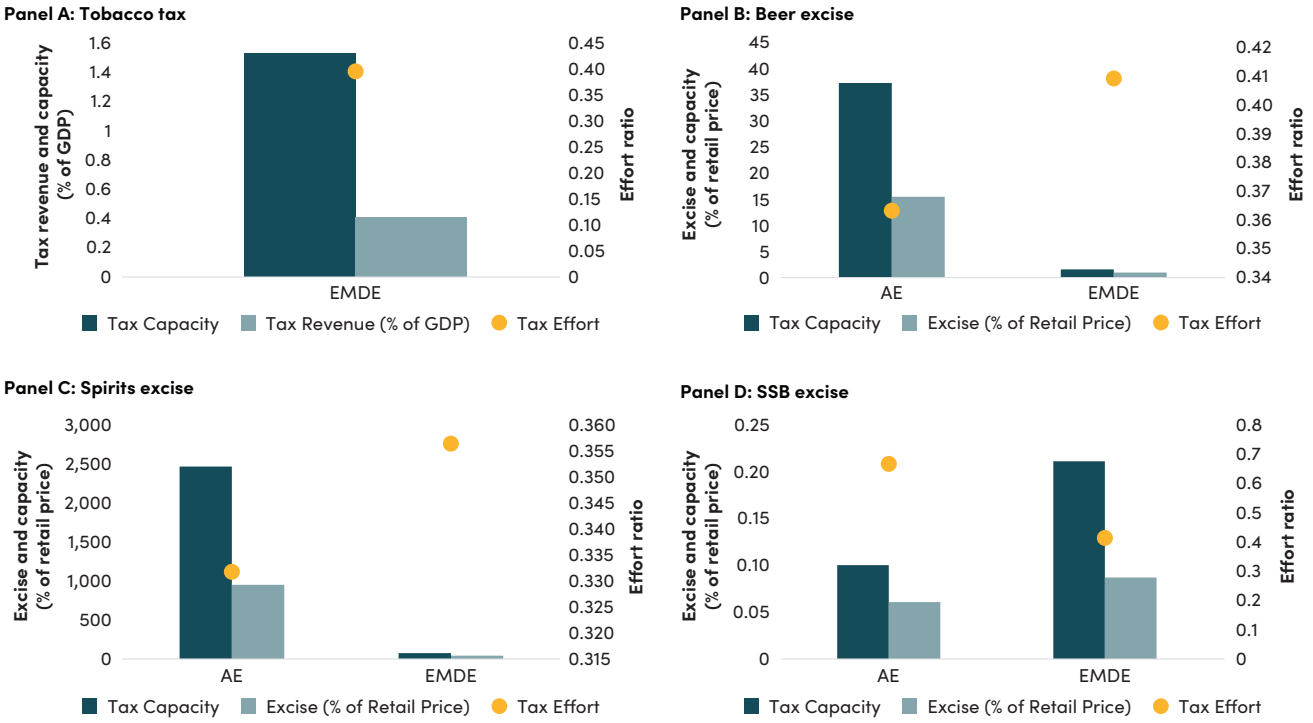
Figure 3 presents cross-country averages of tax capacity, actual collection, and tax effort for four categories of health-related taxes. Panel A examines tobacco taxes across 54 emerging and developing economies (EMDEs). Here, the average theoretical capacity—the maximum revenue attainable under current structural and institutional conditions—stands at approximately 1.5 percent of GDP. Actual tobacco revenues, by contrast, average only 0.4 percent of GDP, implying a tax effort ratio (actual over potential) of around 0.27. This sizable gap highlights widespread underperformance in tobacco revenue mobilization and points to substantial scope for policy reforms in areas such as rate design, enforcement, coverage expansion, and compliance.

Panel B compares beer excise outcomes between advanced economies (AEs) and EMDEs. AEs exhibit a high capacity to tax beer—on the order of 38 percent of the retail price—yet actual excise collections average just 16 percent, yielding a tax effort of roughly 0.36. EMDEs, by contrast, have a much lower capacity (around 2 percent of retail price) but collect nearly 1 percent, translating into a slightly higher effort ratio of about 0.41. This contrast suggests that despite their limited structural potential, many EMDEs succeed in capturing a larger share of their feasible beer-tax frontier, whereas AEs leave significant room for improvement in rate-setting or administrative effectiveness.

Panel C turns to spirits excise taxes. Advanced economies have a much higher structural capacity—averaging roughly 2.5 percent of the retail price—but collect only around 0.9 percent, yielding a tax effort near 0.33. EMDEs have a capacity of about 1.0 percent and collect approximately 0.2 percent, resulting in a slightly higher effort ratio of 0.36. These results highlight that while advanced economies have the structural potential for more aggressive spirits excise regimes, political, economic, and administrative constraints temper actual rates. EMDEs, in contrast, operate on a narrower frontier but generally make fuller use of their capacity.

Finally, Panel D presents sugar-sweetened beverage (SSB) excises. In this category, AEs display a capacity of around 10 percent of retail price and collect about 6 percent, resulting in a relatively high tax effort of roughly 0.68. EMDEs exhibit a higher absolute capacity (approximately 21 percent) but actual collections of only 9 percent, yielding a lower effort of about 0.42. Interestingly, this pattern diverges somewhat from beer and spirits: although advanced economies generally have higher capacity, some middle-income countries—particularly in Latin America, such as Chile, Mexico, and Colombia—have implemented relatively aggressive SSB taxes in response to urgent public health challenges like rising diabetes rates. This leads to a higher relative tax effort in these EMDEs despite their lower structural capacity. The SSB pattern also helps explain the previously observed negative coefficient on the advanced-economy dummy, reflecting political economy constraints and differing fiscal priorities that temper SSB taxation in many high-income countries. Across all four panels, these comparisons highlight specific opportunities for countries to tighten health-tax regimes, narrow efficiency gaps, and better align revenue mobilization with public health objectives.

FIGURE 3. Tax effort by health tax category



Notes: This figure illustrates tax effort across four health-tax categories. In each panel, the teal bar shows tax capacity (the modelled or statutory maximum revenue under ideal conditions) and the teal gray bar shows actual revenue collected, with units as follows: in Panel A (Tobacco) both capacity and revenue are expressed as a percentage of GDP, while in Panels B–D (Beer Excise, Other Alcohol, and SSBs) both capacity and revenue are expressed as a percentage of the final retail price. The yellow dot plots tax effort—the ratio of actual to potential revenue—on the secondary axis. The closer the yellow dot lies to the top of its teal bar, the more fully the country is exploiting its revenue-raising potential for that tax category.

4.3 Robustness

To assess the robustness of the baseline findings in the case of tobacco revenue in percent of GDP, Table A1 compares estimates from four alternative stochastic frontier specifications against the selected baseline (Spec R1: half-normal inefficiency). These alternatives include: an exponential inefficiency model (Spec R2), two heteroskedastic specifications where inefficiency varies with corruption control (Specs R3 and R5), and a trimmed exponential model including institutional covariates (Spec R4). Across all specifications, the signs and statistical significance of key variables remain stable, supporting the robustness of the main results. Log GDP per capita is consistently negative and highly significant, indicating that higher-income countries tend to collect less tobacco tax revenue relative to their potential, consistent with saturation effects or stronger demand-side regulation. Trade openness is positively associated with collection efficiency in all models and highly significant ($p < 0.01$), suggesting structural links between trade exposure and excise policy. Government effectiveness and rule of law are both significant and positively signed in all

models that include them, reinforcing the role of institutional strength. Corruption control is also consistently positive and significant when included, although in heteroskedastic models its role extends to shaping the variance of inefficiency. While the exponential specification (R2) is a plausible alternative, it does not improve overall model fit: AIC and BIC values are higher than in the baseline, and lambda is somewhat smaller, suggesting a weaker inefficiency signal. Spec R4 yields the best AIC (199.3) but is more restrictive and drops covariates of interest. Heteroskedastic models (R3, R5) introduce complexity without clear gains in fit or interpretability, and their lambda values are not reported. Despite not having the lowest AIC, the baseline model (R1) is retained due to its larger sample size, balanced inclusion of institutional and structural covariates, strong variance decomposition diagnostics ($\lambda \approx 9.15e{+}06$), and overall robustness. These attributes make it the most reliable basis for the estimation of tobacco tax effort and potential.

Robustness checks for all three rate-based excise measures—beer, spirits, and sugar-sweetened beverages (SSBs)—were conducted using alternative stochastic frontier specifications and are available upon request. These include models with different distributional assumptions for inefficiency (e.g., exponential), heteroskedastic forms where inefficiency variance depends on institutional quality (e.g., corruption control), and trimmed or restricted specifications. Across all variants, the sign and statistical significance of key structural covariates remain stable, and overall patterns of efficiency are preserved. These results confirm the robustness of the main findings and support the validity of the baseline specifications used for estimating tax effort across product categories.

5. Conclusion and policy implications

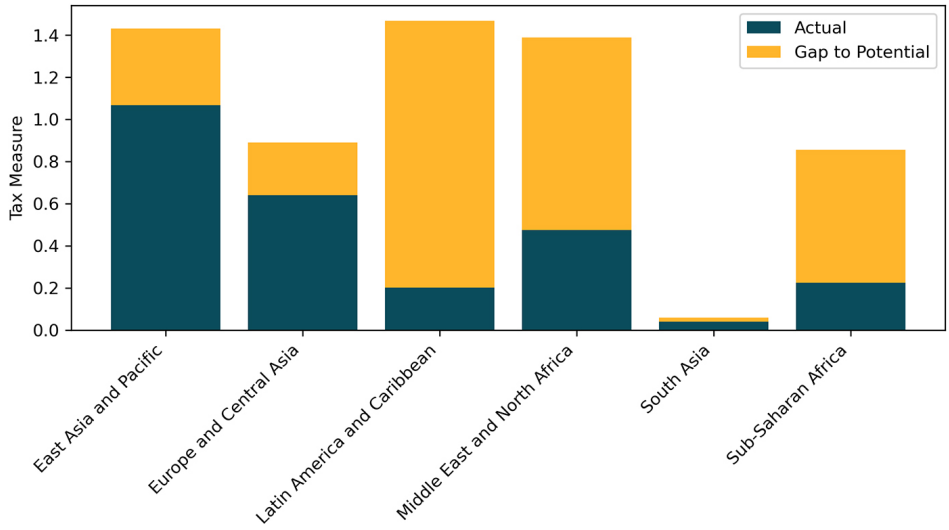
This paper presents the first systematic, cross-country benchmarking of health-tax revenue potential, tax effort, and untapped capacity across three key categories: tobacco, alcohol (beer and spirits), and SSBs. Amid rising fiscal pressures and increasing burdens from noncommunicable diseases, there is an urgent need to evaluate how much revenue countries can feasibly mobilize through taxes on these commodities and identify opportunities for improving efficiency.

Using a global panel of up to 97 IMF member countries, we employ a stochastic frontier analysis (SFA) framework separately for each product category. For tobacco, we estimate a revenue-based frontier, measuring maximum real excise collections given GDP per capita, consumption patterns, demographic structure, and governance indicators. For beer, spirits and SSBs—where consistent revenue data are limited—we estimate rate-based frontiers of excise as a share of reference retail prices. By comparing actual collections or statutory burdens to these frontiers, we derive tax-effort scores bounded between zero and one, indicating the extent to which countries are harnessing their structural tax capacity.

Our main findings are as follows:

- *Tobacco excises:* On average, countries collect just 0.4 percent of GDP in tobacco excise revenue, despite an estimated structural capacity of 1.5 percent—realizing less than 50 percent of their tobacco-revenue frontier. A handful of high performers (e.g., Argentina, China, Niger) operate near capacity. Many others—particularly in Sub-Saharan Africa and small island states—fall into the low collection, low effort quadrant, collecting far below what their income and demographic profiles would suggest is feasible. These countries would benefit from foundational technical assistance focused on strengthening administrative capacity, simplifying tax structures, and improving compliance. Conversely, countries with relatively high collection but low effort may require targeted policy reforms to address inefficiencies in tax design and enforcement. Figure 4 presents a regional summary of the results.

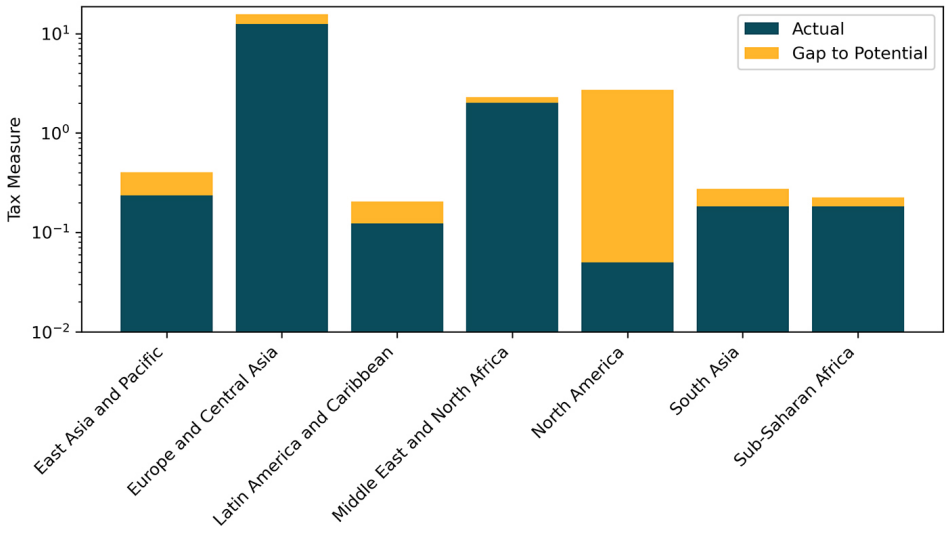
FIGURE 4. Tobacco tax: Actual vs. gap potential by region



Notes: The gap between actual and potential revenue reflects both rate-setting policy and administrative capacity. Closing this gap may therefore involve either increasing rates, strengthening enforcement, or both.

- *Beer excises:* Rate-setting efficiency is more dispersed. Advanced economies such as Norway, Finland, and Croatia impose beer duties close to their estimated rate frontier (effort scores 0.67–0.75). In contrast, major consumers like Canada, Lebanon, and Brazil fall into the low collection, low effort quadrant, applying statutory rates that are low in absolute terms and relative to structural capacity (effort < 0.13). These countries likely need technical assistance to enhance rate-setting frameworks and enforcement mechanisms. Figure 5 provides a summary of the results across regions.

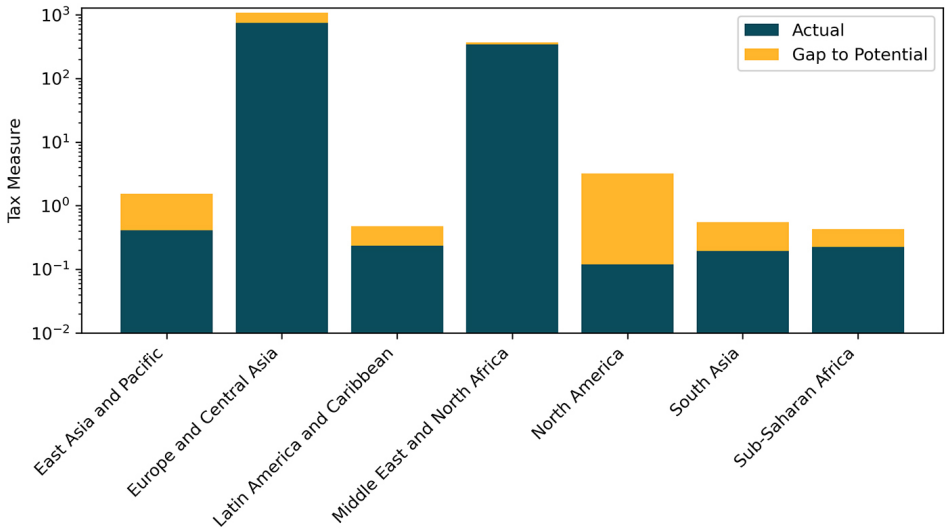
FIGURE 5. Beer tax: Actual vs. gap potential by region



Notes: In the case of beer, the rate-based frontiers measure how intensively a product is taxed relative to structural peers, without observing actual revenue realization. In this case, "effort" should be interpreted as policy effort in rate-setting, which may be shaped as much by political economy constraints as by structural fundamentals.

- *Spirits excises:* Adult population share and baseline consumption strongly predict feasible rate frontiers. High-efficiency countries (e.g., Turkmenistan, North Macedonia) levy spirits duties near their frontier, whereas major advanced producers (Canada, Japan, Australia) exhibit very low efficiency scores (< 0.10). Countries with low effort despite higher collection may require improved compliance monitoring and policy refinement. Figure 6 consolidates the results by region.

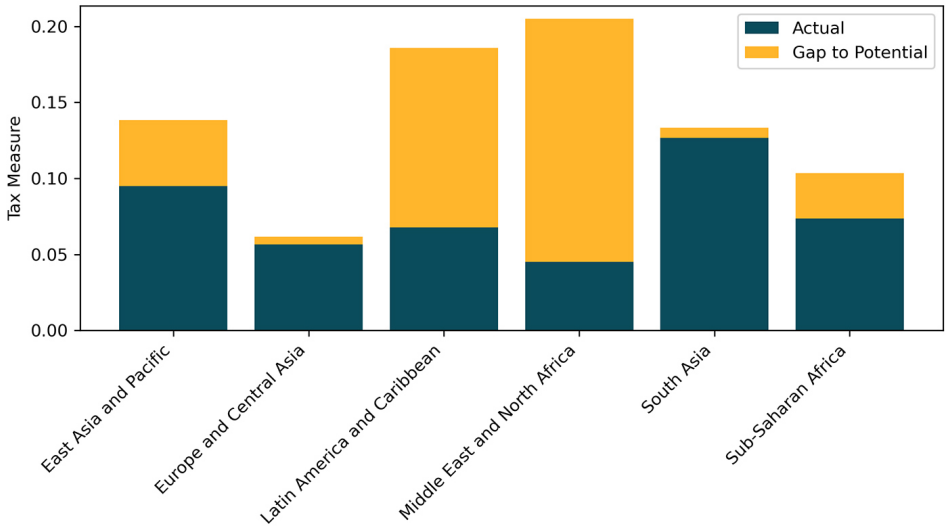
FIGURE 6. Spirits tax: Actual vs. gap potential by region



Notes: In the case of spirits, the rate-based frontiers measure how intensively a product is taxed relative to structural peers, without observing actual revenue realization. In this case, "effort" should be interpreted as policy effort in rate-setting, which may be shaped as much by political economy constraints as by structural fundamentals.

- *SSB excises:* Despite growing global attention, only a handful of countries—Bangladesh, Oman, UAE, Rwanda, and Cameroon—tax SSBs near their maximum feasible rate. Many low- and middle-income countries are in the low collection, low effort quadrant, levying minimal or no SSB duties and capturing less than 10 percent of their estimated frontier potential. Technical assistance focused on policy design, administrative capacity, and stakeholder engagement could help these countries bridge efficiency gaps. Figure 7 presents a regional summary of the results.

FIGURE 7. SSBs tax: Actual vs. gap potential by region



Notes: In the case of SSBs, the rate-based frontiers measure how intensively a product is taxed relative to structural peers, without observing actual revenue realization. In this case, "effort" should be interpreted as policy effort in rate-setting, which may be shaped as much by political economy constraints as by structural fundamentals.

The results highlight the potential for some countries to raise taxes on sin goods, provided they have the necessary administrative capacity. Policymakers must then assess how best to allocate limited administrative resources, based on the relative revenue potential of sin taxes versus alternatives such as the VAT. If VAT is well-designed and already generating expected revenues, the case for increasing sin taxes becomes even stronger. In setting tax policy, however, policymakers must also consider other objectives—such as equity—which is particularly relevant when broadening taxes on income and capital income. Ultimately, the optimal level of sin taxation is country specific and must be assessed considering administrative capacity. That capacity, in turn, is shaped by factors such as regional tax policies and the risk of smuggling from low-tax jurisdictions.

That said, disaggregating by income group reveals contrasting policy challenges and opportunities. Advanced economies benefit from robust excise frameworks and strong administrative capacity, enabling them to set and enforce tobacco and beer rates near their structural frontiers. Paradoxically, however, they underperform on spirits and SSB—largely due to political-economy constraints and competing fiscal priorities. In these cases, even modest rate increases, or improved indexing could yield significant additional revenues.

By contrast, a subset of EMDEs such as Rwanda and Bangladesh have implemented SSB and tobacco taxes at rates close to their feasible intensity, supported by targeted public health campaigns and earmarking of revenues. Yet many other EMDEs collect less than half their potential across all sin-tax categories due to weak enforcement, fragmented multi-tier regimes, and large informal markets.

Tailored support is therefore essential across both groups. Advanced economies may benefit from strategies to address to address political resistance and pushbacks, while EMDEs require technical assistance to simplify excise structures, strengthen track-and-trace systems, and bolster revenue authorities. Peer-to-peer learning through WHO FCTC forums and IMF workshops can facilitate the transfer of best practices in tax design, compliance monitoring, and complementary measures such as marketing restrictions and cessation support.

The quadrant-based taxonomy introduced in this paper allows countries to diagnose their relative performance by comparing actual tax levels and efficiency. This diagnostic reveals where excise regimes are close to capacity, where collection is strong but inefficient, and where rates or enforcement could be raised without breaching structural limits. Aligning excise policy with estimated potential—whether through rate reform, improved enforcement, or cross-sectoral coordination—can unlock significant fiscal and public health dividends. Peer learning, international benchmarking, and targeted technical support from multilateral institutions can help close these gaps and accelerate progress on both domestic revenue mobilization and the prevention of noncommunicable diseases.

This paper's cross-sectional SFA approach offers robust snapshots of tax capacity and effort, but it is constrained by data limitations that preclude a true panel SFA over time. Harmonized, time-series data on excise revenues (especially for alcohol and SSBs) remain scarce, limiting our ability to track dynamic efficiency gains or to assess the impact of specific policy reforms. Future research should focus on compiling extended time series of product-level excise revenues and statutory rates, using administrative records and household surveys to construct comprehensive panel datasets. These can support the application of dynamic stochastic frontier models that jointly estimate frontier shifts and evolving inefficiency over time-capturing the effects of policy changes, institutional reforms and global shocks such as pandemics.

With these enriched data and methods, researchers could assess health and equity outcomes by linking improvements in tax-efficiency to reductions in consumption, changes in disease incidence, and distributional impacts across income groups and vulnerable populations. Future work should also explore complementary fiscal instruments—including environmental taxes and digital levies—within a unified frontier framework to inform more integrated domestic resource mobilization strategies. By deepening the temporal dimension and broadening the policy lens, such studies can generate richer diagnostics and stronger evidence to guide sin-tax reforms that advance both public health and fiscal resilience.

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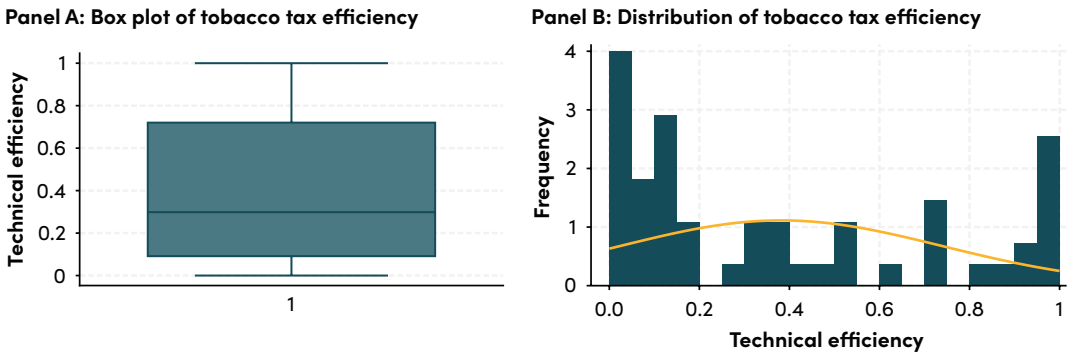
Appendix

TABLE A1. Comparison of alternative stochastic frontier models—tobacco revenue efficiency

Variable	Spec R1: Half-normal	Spec R2: Exponential	Spec R3: uhet (corr_control)	Spec R4: Exponential (Gov + RoL)	Spec R5: uhet (corr_control) Trimmed
Log GDP per capita	−0.422 (0.000)***	0.574 (0.000)***	−0.422 (0.000)***	−0.173 (0.000)***	−0.186 (0.000)***
Trade openness	0.007 (0.000)***	0.001 (0.000)***	0.007 (0.000)***	0.005 (0.000)***	0.005 (0.000)***
Aged 15+ population	0.034 (0.000)***		0.034 (0.000)***		
Government effectiveness	0.127 (0.000)***		0.127 (0.000)***	0.521 (0.000)***	0.556 (0.000)***
Rule of law	1.522 (0.000)***		1.522 (0.000)***	1.316 (0.000)***	1.148 (0.000)***
Corruption control	0.231 (0.000)***		0.231 (0.000)***		0.135 (0.000)***
Constant	1.207 (0.000)***	−4.006 (0.000)***	1.207 (0.000)***	1.630 (0.000)***	1.712 (0.000)***
Log Likelihood	−99.890	−115.079	−99.874	−92.644	−100.248
AIC	217.78	240.16	219.75	199.29	218.50
BIC	235.85	250.46	239.82	213.34	236.56
$Sigma_u$	2.975	2.675	2.975	1.983	2.182
$Sigma_v$	1.39e−07	2.06e−07	2.55e−07	8.19e−08	1.69e−07
Lambda	9.15e+06	1.30e+07	N/A	2.42e+07	N/A

Notes: This table reports estimates from alternative stochastic frontier models of tobacco revenue efficiency. Coefficients are shown with p-values in parentheses. All models assume a log-linear frontier; some allow for exponential inefficiency or heteroskedasticity. Log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC) are reported for model comparison. $Sigma_u$ and $Sigma_v$ are the standard deviations of the inefficiency and noise components, respectively, and Lambda is their ratio ($Sigma_u$/$Sigma_v$). N/A indicates the statistic is not reported due to model structure. Specification R1 is used as the baseline model in the main analysis.

FIGURE A1. Distribution of technical efficiency scores in tobacco revenue collection



Notes: The figure comprises two panels providing additional insights into the distribution of technical efficiency scores for tobacco revenue collection across emerging markets and developing economies (EMDEs). Panel A presents a boxplot illustrating the median, interquartile range, and extent of variation, highlighting that most countries exhibit relatively low efficiency. Panel B provides a histogram, revealing a skewed distribution with clusters at both extremes, particularly at very low and near-perfect efficiency scores.