ONLINE ANNEXES

Online Annex 1.1. Tax Distortions and Output Gains[1]

This annex outlines the data and empirical framework underlying the construction of the tax distortions index and the estimation of its association with changes in aggregate output.

Data

The analysis draws on multiple data sources. GDP per capita, the main outcome variable, is constructed using data from the World Bank (2026) Development Indicators. GDP in current US dollars is converted into constant 2019 US dollars using country-level consumer price indices and divided by population figures from the same source. To control for physical and human capital, the analysis uses Penn World Tables data (Feenstra, Inklaar and Timmer 2015), measuring physical capital as the logarithm of the capital stock at current purchasing power parities (in millions of 2021 US dollars) and human capital using the Penn World Tables Human Capital Index. Additionally, the analysis draws on the Global Macro Database (Müller and others 2025) for some of the control variables explained below. Measures of the level and dispersion of marginal effective tax rates (METRs) across assets, as well as value-added tax (VAT) C-efficiency, are drawn from IMF-constructed datasets. The share of tax revenue collected through more distortionary taxes is computed using the IMF's World Revenue Longitudinal Database (WoRLD) as one minus the share of revenue from property and sales taxes, following Johansson and others (2008). Finally, the labor wedge is proxied using the formulation in Prescott (2004) and McDaniel (2011), who derive the effective tax on labor income that distorts labor supply as:

$$\tau_t^h = \frac{\tau^{ss} + \phi\tau^{inc} + \widetilde{\tau_t^c}}{1 + \widetilde{\tau_t^c}}. \qquad \text{(Eq.1.1)}$$

To construct τ_t^h, three primary data sources are used: the WoRLD database, the Penn World Tables (Feenstra, Inklaar and Timmer 2015), and the Macro-Historical Database compiled by Bachas and others (2026). Payroll taxation, τ^{ss}, is measured as social contributions relative to total labor compensation, with both series obtained from the Macro-Historical Database (Bachas and others 2026). Total labor compensation is proxied by multiplying a country's GDP by its labor share, where the labor share is taken from the Penn World Tables. The effective tax rate on labor income, τ^{inc}, is sourced from Bachas and others (2026). Following Prescott (2004), average income tax rates are converted into marginal rates using a factor of 1.6; this adjustment is applied uniformly across all countries and years. Consumption taxation, denoted by $\tilde{\tau}^{c}$, is computed as the ratio of total revenue from consumption taxes to aggregate consumption. Consumption tax revenue data are drawn from the WoRLD database, while consumption figures come from the World Development Indicators. Data on top Personal Income Tax (PIT) rates and on the standard VAT rate originate from internal IMF sources.

The dataset covers 89 countries: *Albania, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Barbados, Belarus, Belgium, Belize, Bolivia, Botswana, Brazil, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Croatia, Cyprus, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Eswatini, Finland, France, Georgia, Germany, Greece, Grenada, Guatemala, Guinea-Bissau, Guyana, Hungary, Iceland, India, Indonesia, Iran, Israel, Italy, Japan, Jordan, Kyrgyz Republic, Latvia, Lebanon, Lesotho, Lithuania, Luxembourg, Madagascar, Malta, Mauritania, Mauritius, Mexico, Moldova, Montenegro, Morocco, Namibia, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Romania, Russia, Senegal, Seychelles, Singapore, South Africa, Spain, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Switzerland, Tajikistan, Tanzania, Trinidad and Tobago,*

[1] Prepared by Michael Barczay.

Türkiye, Ukraine, United Arab Emirates, the United Kingdom, Vanuatu, and *Vietnam* and covers the years 2001 to 2020. For the estimation that follows, a smaller sample of countries is used, for which all control variables are available for all time periods. This reduces the number of countries to 55 and constrains the estimation sample to 2002-2018.[2]

Empirical Framework

The objective of this analysis is to estimate the association between tax distortions and aggregate macroeconomic outcomes. The focus is on the design and structure of taxes rather than the level of statutory rates. To this end, an index of tax distortions based on five measures commonly discussed in the literature is constructed:

(1) the METR,
(2) the dispersion of METRs across assets,
(3) the share of tax revenue derived from distortionary taxes (see Johansson and others 2008),
(4) VAT C-efficiency, and
(5) the labor wedge.

Components (1) and (2) capture tax distortions to firms' investment decisions. The METR measures the tax burden on a marginal investment: in the absence of taxation, a firm invests up to the point where the pre-tax return equals the cost of capital, and the METR quantifies how far taxation pushes the return above this benchmark, discouraging investment that would otherwise be efficient. The higher the METR, the larger the distortion to the level of capital. Component (2) captures a distinct distortion to the allocation of capital: even holding the average METR fixed, when METRs differ across asset types the tax system reallocates investment toward tax-favored assets and away from the undistorted allocation. Dispersion of METRs across assets measures this misallocation — the undistorted benchmark is a uniform METR under which investment is guided by pre-tax productivity alone and dispersion measures deviation from it. Component (3) captures distortions arising from the composition of the tax mix. Johansson and others (2008) argue that sales and property taxes distort behavior relatively less because they fall on relatively inelastic bases, whereas income and corporate taxes distort saving, investment, and labor-supply decisions more heavily. The component measures the share of tax revenue raised from taxes other than sales and property taxes; a higher share indicates greater reliance on the more distortionary instruments, and thus a larger aggregate efficiency cost of raising a given amount of revenue. Component (4), VAT C-efficiency, captures distortions to consumption choices and the integrity of the VAT base. A perfectly non-distortionary VAT would tax all final consumption at a single uniform rate; C-efficiency is the ratio of actual VAT revenue to the revenue that this benchmark would generate. Shortfalls reflect distortions introduced by reduced rates, exemptions, and zero-rating that alter relative consumer prices and favor some goods over others, as well as revenue lost to non-compliance. In addition to exemptions and differentiated rates, VAT C-efficiency also captures noncompliance and should therefore be interpreted as a broad measure capturing both tax design and tax implementation. Lower C-efficiency therefore signals greater departure from a neutral, broad-based consumption tax. Component (5), the labor wedge, captures distortions to the labor-supply margin. In an undistorted economy the household equates the marginal rate of substitution between consumption and leisure to the marginal product of labor; taxation drives a wedge between the two, leading households to supply less labor than is efficient. Following McDaniel (2011), the labor wedge measures the size of this gap, with a larger wedge indicating a greater distortion to the optimal work decision.

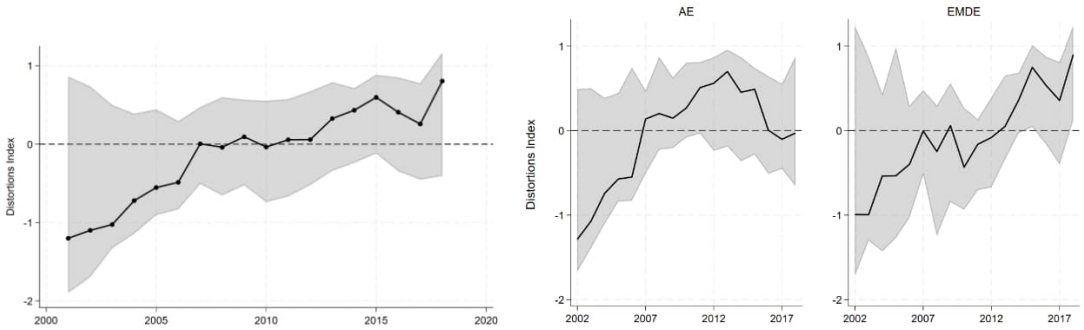
Details of the data used to construct these measures are provided in the previous section. The analysis combines the five measures into a single composite index using Principal Component Analysis (PCA). First, each component is demeaned using the yearly average across countries. This removes global developments affecting distortions in a given year, such as common shocks and worldwide shifts in tax design. Expressing distortions relative to the cross-section also reflects the economics of the mechanism: factors of production respond to a country's tax treatment relative to available alternatives,

[2] The countries used for the estimation below are *Albania, Armenia, Australia, Austria, Belgium, Belize, Barbados, Botswana, Switzerland, Chile, China, Côte d'Ivoire, Colombia, Germany, Denmark, Dominican Republic, Egypt, Spain, Estonia, Finland, France, United Kingdom, Greece, Croatia, Hungary, Indonesia, India, Iceland, Israel, Italy, Jordan, Japan, Lithuania, Luxembourg, Latvia, Morocco, Mexico, Malta, Mauritania, Mauritius, Namibia, Netherlands, Norway, New Zealand, Peru, Poland, Portugal, Romania, Senegal, Singapore, Eswatini, Trinidad and Tobago, Türkiye, Vietnam, South Africa.*

so that a country whose distortions are unchanged while its peers reduce theirs becomes relatively more distorted and less attractive to mobile production factors. The index is therefore interpreted as a measure of relative tax distortions. Second, we conduct a PCA separately for each country, allowing the factor loadings to differ across countries and accommodating heterogeneity in how the underlying distortions are combined. The PCA normalizes each country index to have mean 0 and standard deviation 1. Below we provide robustness checks with alternative approaches to constructing the index.

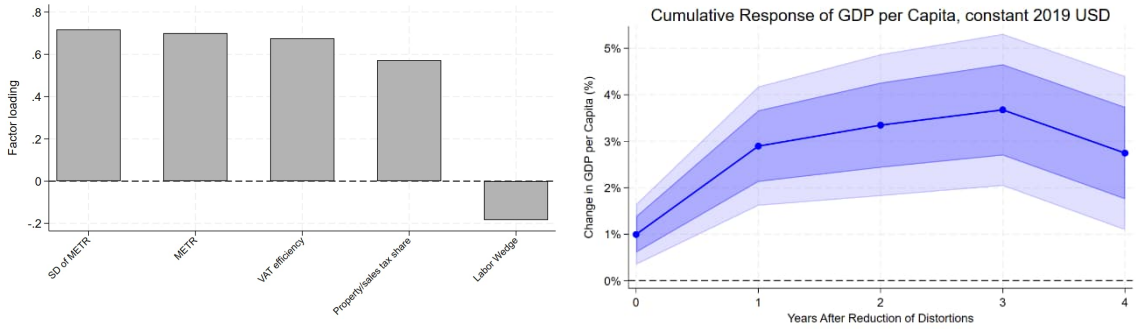
Online Annex Figure 1.1.1 (left panel) presents the median as well as the 25th and 75th percentile of the index distribution over time. The index is constructed such that a higher index stands for a higher level of tax distortions. The median of the distortions index has been increasing in the early 2000s but relatively flat over the period 2007-2018. The dispersion across countries is large—especially in the early years of the sample. Online Annex Figure 1.1.1 (right panel) presents the index by income groups. While there are distinct patterns in each group, the increase in the index in the early 2000s is present in both groups.

Online Annex Figure 1.1.1. The Distortions Index Across Countries



Sources: IMF staff calculations.
Note: Left panel: Median and 25th and 75th percentile of the distortions index. Right panel: Median and 25th and 75th percentile of the distortions index across income groups. The plots present the range of the index used for the estimation below—both in terms of years and countries covered. AE = advanced economy; EMDE = emerging market and developing economy.

Online Annex Figure 1.1.2. Factor Loadings and Individual Effects of Tax Distortions



Sources: IMF staff calculations.
Note: Panel 1 presents the factor loadings of 5 distortion variables on the overall Distortions Index. While the distortions index is created using country-level Principal Component Analysis (PCA), those loadings are approximated and present in the bar graph using a pooled PCA using all countries. Distortion variables are standardized using country-level averages and standard deviations prior to the PCA. Panel 2 presents the main estimation results from estimating the baseline Local Projections Model: $Lny_{c,t+h} - Lny_{c,t-1} = \beta^h DistortionsIndex_{c,t} + \gamma \mathbf{X}_{c,t} + \mu_t + \lambda_c + \varepsilon_{c,t+h}$. The model is estimated using each of the five distortion variables, with control variables specified as in the baseline. The model is estimated using data for 55 countries, 2002–18. $Lny_{c,t}$ is log GDP per capita of country c in year t. The $DistortionsIndex_{c,t}$ is a composite measure, constructed by IMF staff, combining: (i) the marginal effective tax rate (METR) on investment, (ii) the standard deviation of METRs across assets within a country-year, (iii) one minus VAT C-efficiency, (iv) one minus the share of tax revenue from

property and consumption taxes, and (v) the labor tax wedge. Standard errors are clustered at the country level, and shaded areas show 68 and 90 percent confidence bands.

Online Annex Figure 1.1.2 (left panel) presents the factor loadings of each of the distortion variables, approximated by the overall loadings resulting from a PCA pooling all countries. Interestingly, there is little heterogeneity in factor loadings, with the exceptions of the labor wedge. While all variables load positively with loading factors ranging from 0.59 to 0.72, the labor wedge is loaded negatively. However, a simple regression of the distortions index on the labor wedge suggests that the relationship between the index and the underlying distortion is not statistically different from 0 at conventional significance levels.[3]

Validation exercises comparing large changes in the index with contemporaneous policy developments indicate that the index effectively identifies changes in tax systems. Specifically, the largest changes in the index across countries and over time are compared with contemporaneous tax policy developments. In many cases, sizeable movements in the index coincide with major tax reforms, providing support for the empirical validity of the measure and helping to gauge the economic magnitude of the estimated effects. For example, Germany's 2008 corporate tax reform[4] is associated with a pronounced decline in the index by slightly more than two standard deviations, while the increase observed for India in 2017[5] may reflect transitional distortions following the introduction of the Goods and Services Tax.

Next, the constructed index is used to analyze how economic output responds to tax distortions. To this end, the following Local Projections model is estimated:

$$Lny_{c,t+h} - Lny_{c,t-1} = \beta^h DistortionIndex_{c,t} + \gamma \boldsymbol{X}_{c,t} + \mu_t + \lambda_c + \varepsilon_{c,t+h}. \quad \text{(Eq.1.2)}$$

The aim of this model is to trace the dynamic response of GDP per capita ($y_{c,t}$) to changes in the distortion index at time t affect over subsequent horizons h. The vector $\boldsymbol{X}_{c,t}$ includes a lag of the dependent variable and the distortions index, as well as measures of physical and human capital at time t. Additionally, the estimation controls for changes in the real exchange rate, the current account relative to GDP, the debt-to-GDP ratio, the inflation rate, and the policy rate of the central bank. Since the focus is on tax distortions, rather than the level of taxes, control variables for the statutory level of top corporate income taxes, the top PIT rate, and the standard VAT rate are included. The estimation includes time fixed effects (μ_t) to account for shocks common to all countries in a given year, and country fixed effects (λ_c) to control for time-invariant country characteristics. Local projections are estimated for horizons h = 0,1,2,3,4, allowing for the analysis of the dynamic effect of an innovation in the distortions index on GDP per capita over a four-year horizon. For graphical presentation, the baseline results in the main body and in panel 2 of Online Annex Figure 1.1.2 plot the response to a one-standard-deviation reduction in the distortions index. Overall, the results suggest that a reduction in the distortions index by one standard deviation has significant and persistent effects on output. Three years after the reduction in the index by one standard deviation, GDP per capita is about 3.5% higher than in the

[3] The first factor has an eigenvalue of 1.82 and explains 36.5 percent of the total variance, while the first two factors together account for 58.1 percent. Four indicators load positively on the common factor, whereas the labor wedge exhibits a small negative loading and high uniqueness, suggesting that it shares little common variation with the other measures but does not materially alter the underlying factor structure.

[4] Germany's 2008 corporate tax reform was designed as a "tax-cut-cum-base-broadening" package: it lowered the corporate income tax rate from 25% to 15% and reduced the trade-tax base rate for corporations, bringing the statutory tax burden on retained corporate profits down from about 38.6% to 29.8%. At the same time, the reform broadened the tax base and limited tax-planning opportunities by restricting the deductibility of interest through the new interest barrier, changing trade-tax add-backs, ending the deductibility of trade tax as a business expense, and tightening depreciation rules (Baretti, Radulescu and Stimmelmayr 2008)

[5] India introduced the Goods and Services Tax (GST) on July 1, 2017, which replaced a fragmented system of central and state indirect taxes, including state-level entry taxes that created barriers to trade and raised business costs. The reform established a unified national framework for taxing goods and services (World Bank 2018).

counterfactual world without the change in distortions. This estimate should be interpreted as the average association between reducing tax distortions and GDP per capita across countries.

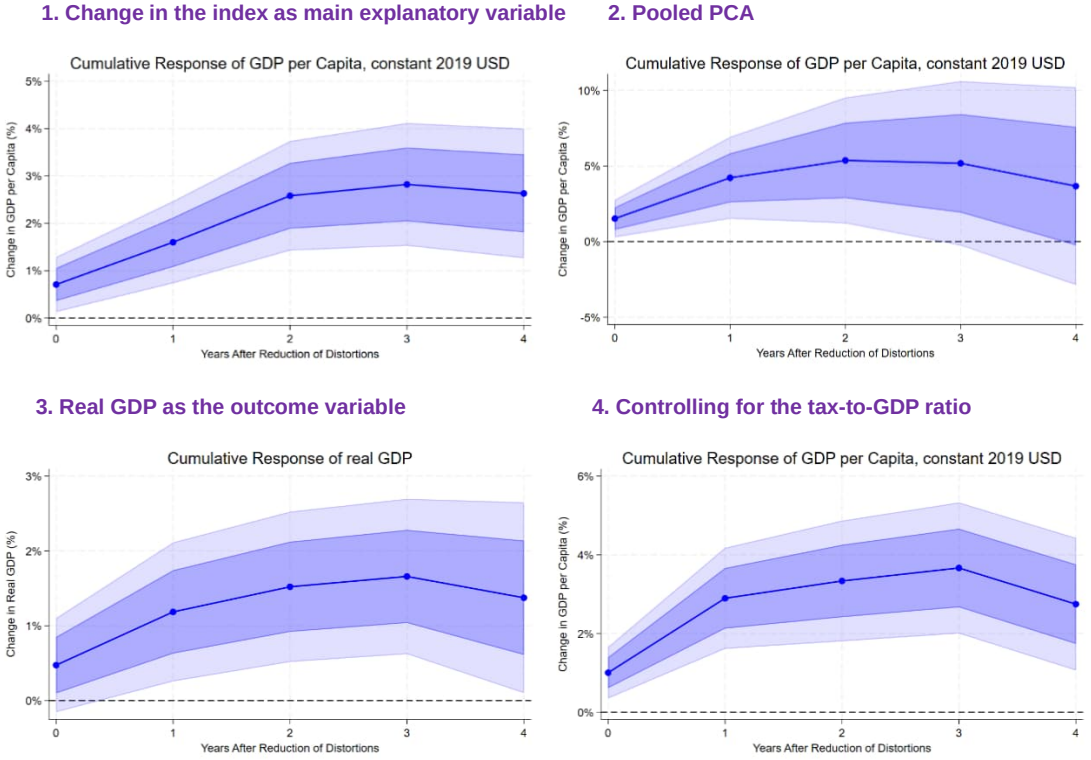
To assess which underlying tax distortions drive the observed effects on output, simple linear relationships between the five individual distortion measures and the overall index are estimated. These estimates are then used to approximate the changes in each component required to generate a one standard deviation increase in the index. For marginal effective tax rates (METRs), such an increase corresponds to a rise of about 11 percentage points relative to its sample mean of 17.1 percent. Similarly, increasing the dispersion of METRs across assets by 8.9 percentage points results in a one-unit increase in the index, equivalent to roughly one-half of a standard deviation of the underlying variable. Alternatively, a decrease in VAT C-efficiency of about 40 percentage points, or in the distortions share of 13 percentage points, would generate a comparable change in the index, starting from sample averages of 49 percent and 63 percent, respectively. Finally, reflecting its negative loading, a reduction in the labor wedge would raise the Distortions Index, although this relationship is not statistically significant at conventional significance levels. Below we discuss the sensitivity of the index with respect to the labor wedge. Given that the index is constructed with country-specific PCAs, the relationship between components and index may differ and the numbers presented above should be interpreted as the average relationship.

To assess the robustness of the results with respect to various features of the estimation, alternative local projections specifications are estimated. In a first step, we estimate the following model

$$Lny_{c,t+h} - Lny_{c,t-1} = \beta^h \Delta DistortionIndex_{c,t} + \gamma \mathbf{X}_{ct} + \mu_t + \lambda_c + \varepsilon_{c,t+h} \quad \text{(Eq.1.3)}$$

Here, the change in the logarithm of GDP per capita is regressed on changes in the distortions index, thereby capturing deviations of the distortions index from its trend. As shown in Online Annex Figure 1.1.3 panel 1, the resulting responses are slightly smaller in magnitude but exhibit a very similar pattern. Second, instead of running the PCA at the country-level, the index is constructed using pooled PCA with all countries. Online Annex Figure 1.1.3 panel 2 shows that the results are very similar compared to the main specification. The confidence bands are slightly wider, suggesting that allowing factor loadings to differ across countries allows for more precise estimation. Finally, Online Annex Figure 1.1.3 panels 3 and 4 estimate the baseline local projections model using real GDP as the dependent variable (panel 3) and by controlling for the tax-to-GDP ratio (panel 4). While the results for real GDP are slightly smaller in magnitude, the qualitative conclusion are identical to the main specification. Controlling for the tax-to-GDP ratio does not affect the results. The confidence bands of the different robustness checks overlap at most horizons, suggesting that the alternative specifications do not differ significantly from the baseline results.

Online Annex Figure 1.1.3. Local Projection (Alternative Specifications)



Sources: IMF staff calculations.
Note: In panel 1, results are obtained from estimating a local projections model in which the change in GDP per capita is regressed on changes in the Distortions Index, using panel data for 53 countries over 2001–2020: $Lny_{c,t+h} - Lny_{c,t-1} = \beta^h \Delta DistortionIndex_{c,t} + \gamma \boldsymbol{X}_{c,t} + \mu_t + \lambda_c + \varepsilon_{c,t+h}$. The dependent variable is log GDP per capita of country c in year t. The Distortions Index is a composite measure constructed by IMF staff, combining: (i) the level of marginal effective tax rates (METRs), (ii) the dispersion of METRs across assets, (iii) VAT C-efficiency, (iv) one minus the share of revenue from property and sales taxes, and (v) the labor tax wedge. The specification captures deviations of tax distortions from their trend. In panel 2, the index is constructed using a principal component analysis pooling all countries and years. Panel 3 shows the local projections results when the dependent variable is real GDP instead of GDP per capita. We use expenditure side real GDP at chained purchasing power parities in million 2021 USD from the Penn World Tables (Feenstra, Inklaar and Timmer 2015). Panel 4 additionally controls for countries' tax-to-GDP ratio. All models include lags of the dependent variable and standard controls for physical and human capital, public debt, changes in the real exchange rate, the current account, and statutory PIT, CIT, and VAT rates, all measured at time *t*. Standard errors are clustered at the country level. Shaded areas represent 68 and 90 percent confidence bands. The estimated responses are slightly smaller in magnitude relative to the baseline but display a similar pattern.

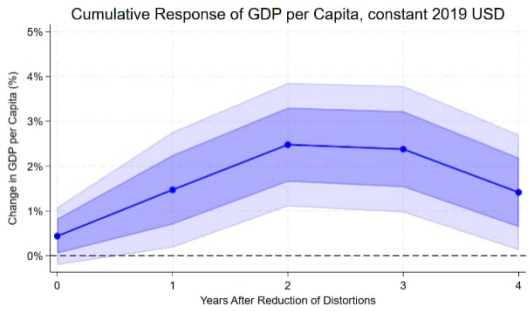
Given the negative factor loading of the labor wedge, a potential concern is that the composite distortions index may be sensitive to the inclusion of specific measures. In particular, a component that loads negatively on the common factor could introduce noise and influence the estimated coefficients. To evaluate the contribution of individual measures and the robustness of the findings, the baseline specification is re-estimated five times, each time omitting one of the distortions measures used to construct the index. Online Annex Figure 1.1.4 presents the results. Overall, the results are highly robust to the exclusion of individual components. In particular, the estimates obtained when the labor wedge is omitted (panel 5) are nearly identical to the baseline results. This suggests that, despite its negative loading on the composite index, the labor wedge does not introduce noise that materially affects the estimation. Beyond assessing robustness, this exercise also provides insights into the relative importance of the underlying distortions measures. Panels 1 and 2, which exclude the METR-related variables, yield somewhat smaller estimated responses than the baseline specification. This finding suggests that distortions captured by the METR measures are important drivers of the overall relationship identified in the baseline results.

Overall, the results suggest that higher tax distortions are associated with weaker output, with effects that build gradually over time. The analysis highlights that distortions related to corporate taxation play a particularly important role. At the same time, the findings should be interpreted in light of the construction of the index, which captures deviations of

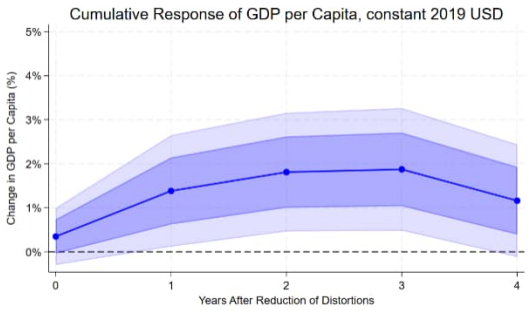
country-specific distortions from global averages rather than absolute levels. As such, the estimates reflect the association of relative tax distortions with economic output.

Online Annex Figure 1.1.4. Local Projection (Leave-one-out estimation)

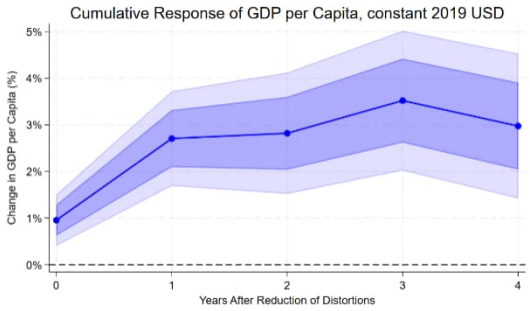
1. Without Standard Deviation of METR



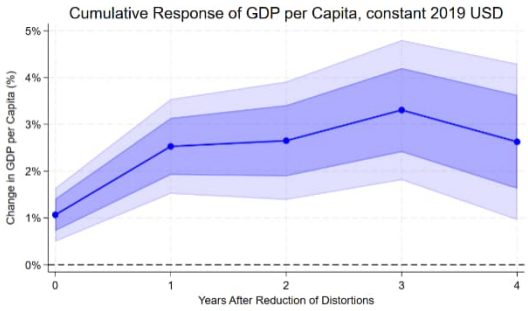
2. Without METR



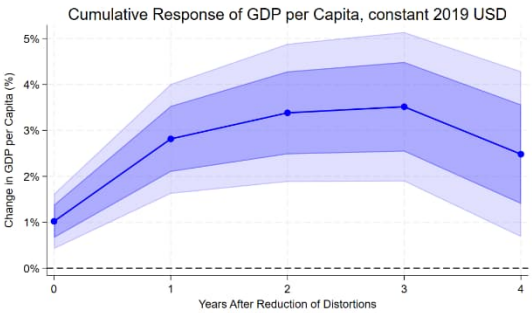
3. Without VAT C-Efficiency



4. Without revenue share from distortionary taxes



5. Without Labor Wedge



Sources: IMF staff calculations.

Note: The figure shows the estimated effect of a one-standard-deviation reduction in the distortion index on GDP per capita, based on the specification: $Lny_{c,t+h} - Lny_{c,t-1} = \beta^h DistortionIndex_{c,t} + \gamma X_{c,t} + \mu_t + \lambda_c + \varepsilon_{c,t+h}$, using data for 55 countries, 2002–18. $Lny_{c,t}$ is log GDP per capita of country c in year t. The $DistortionIndex_{c,t}$ is a composite measure, constructed by IMF staff, combining: (i) the marginal effective tax rate (METR) on investment, (ii) the standard deviation of METRs across assets within a country-year, (iii) one minus VAT C-efficiency, (iv) one minus the share of tax revenue from property and consumption taxes, and (v) the labor tax wedge. Higher values indicate greater distortions. The exact mapping varies across countries because the index is standardized separately for each country. Each of the five panels estimate the main specification but remove one of the components from the construction of the index. $X_{c,t}$ includes lags of the dependent variable and controls for physical capital, human capital, general government debt, changes in the real exchange rate, the inflation rate, the current account, the top statutory tax rates on labor and corporate income, and the standard VAT rate. Standard errors are clustered at the country level, and shaded areas show 68 and 90 percent confidence bands.

References

Bachas, Pierre, Matthew Fisher-Post, Anders Jensen, and Gabriel Zucman. 2026. "Globalization, Capital Taxation, and Development Evidence from a Macro-Historical Database." *American Economic Journal: Applied Economics*.

Baretti, Christian, Doina Maria Radulescu, and Michael Stimmelmayr. "Die Unternehmensteuerreform 2008: Deutschlands Antwort auf die Globalisierung-oder doch ein Stückwerk?." *ifo Schnelldienst* 61.02 (2008): 30-38.

Feenstra, Robert C., Robert Inklaar, and Marcel Timmer. 2015. "The Next Generation of the Penn World Table." *American Economic Review* 105 (10): 3150–3182.

Johansson, Åsa, Christopher Heady, Jens Mathias Arnold, Bert Brys, and Laura Vartia. 2008. "Taxation and Economic Growth." OECD Economics Department Working Paper 620, Organisation for Economic Co-operation and Development, Paris.

McDaniel, Cara. 2011. "Forces Shaping Hours Worked in the OECD, 1960–2004." *American Economic Journal: Macroeconomics* 3 (4): 27–52.

Müller, Karsten, Chenzi Xu, Mohamed Lehbib, and Ziliang Chen. 2025. "The Global Macro Database: A New International Macroeconomic Dataset (Version 2026-03)." NBER Working Paper No. 33714, National Bureau of Economic Research, Cambridge, MA.

Prescott, Edward C. 2004. "Why do Americans Work so Much More than Europeans?." *Federal Reserve Bank of Minneapolis Quarterly Review* 28 (1): 2–13.

World Bank. 2018. *Implementation of India's Goods and Services Tax: Design and International Comparison*. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/918831542619297197.

Online Annex 1.2. Value-Added Tax (VAT) Exemptions as Input Taxation[6]

This annex provides details on the measurement of VAT-related production and consumption distortions arising from exemptions and non-registration and assesses their economic implications.

Objective

Building on Beer and Hebous (forthcoming), the analysis proceeds in three steps. First, it explains how gaps in the VAT design—in particular exemptions and non-registration—increase the price of intermediate inputs along the supply chain, and it computes the resulting production tax wedges for 26 countries.[7] Second, it explains how these wedges reduce welfare by distorting both production decisions and consumption choices, and presents the equations used to quantify these effects. Third, it uses World Bank Enterprise Surveys data to illustrate that gaps in the VAT design increase firm-level production costs, distort input choices, and reduce the likelihood of exporting, showing that the theoretically derived tax wedges have real measurable effects.

Measuring VAT Wedges

In the presence of exemptions and non-registration of firms, the effective price firms pay for their intermediate inputs differs from the no-tax benchmark. Consider an economy where N firms produce N differentiated goods and some of those goods are exempt from VAT. A firm that produces *exempt outputs* does not have the legal right to reclaim input VAT, which raises its production costs directly. As is common in VAT modelling, these costs are assumed to be passed forward to business customers and households. Second, some of the firm's *suppliers* are not VAT-registered and therefore those *suppliers* cannot reclaim the VAT paid on their own inputs. The price charged by these suppliers thus embeds unrecovered input VAT, raising input prices faced by the purchasing firm relative to a situation where everyone could reclaim input VAT. Writing $t_i = ln(p_i/p_i^*)$ for the log increase in firm *i*'s price relative to the no-distortion benchmark, these two sources of distortion add up across the input-output network:

$$t_i = (1 - \delta_i) \sum_j \alpha_{ij} \tau_j + \sum_j \alpha_{ij} t_j \quad for \quad i=1,...N, \qquad \text{(Eq.2.1)}$$

where τ_j is the statutory tax rate applied on input j, δ_i is the share of input VAT the firm can recover ($\delta_i = 1$ if registered), and α_{ij} the share of input j in firm i's cost, with $\alpha_i = \Sigma_j \alpha_{ij}$ the intermediate input share. When commodity/firm j is exempt, the firm's output is not taxed and it is unable to recover input VAT, implying $\tau_j = \delta_j = 0$.

To solve the system of equations for N commodities in (Eq.2.1), let S denote the matrix of input cost shares, with elements α_{ij}, and let D collect commodity specific recoverability on the diagonal. The vector of production-stage distortions is hence:

$$t=(1-S)^{-1}(1-D)S\tau. \qquad \text{(Eq.2.2)}$$

When all firms can recover input VAT, $D = 1$, and the producer price increase equals zero. With exemptions or non-registration, producer prices are upward biased and more so in industries with large intermediate input shares (row sums of *S*).

[6] Prepared by Sebastian Beer.

[7] The sample includes Armenia, Belgium, Cyprus, Dominican Republic, El Salvador, Estonia, Ethiopia, Georgia, Honduras, Hungary, India, Kenya, Lithuania, Moldova, Mongolia, Morocco, Namibia, Paraguay, Philippines, Romania, Rwanda, South Africa, Trinidad and Tobago, Uganda, Uzbekistan, and Zimbabwe.

For the empirical analysis, statutory VAT rates (τ) are obtained from tax legislation, recoverability parameters δ are calibrated using information on registration thresholds[8] and sector-specific treatment, and granular input-output tables are used to quantify input requirements per unit of output. The total price increase can be decomposed into the direct and cascading components using equation (2.1). In particular, the implied effective tax rate on intermediate inputs ("VAT wedges"), as presented in Figure 1.3, panel 1 in the chapter, used for the production of commodity i, is given by the sum of these two components:

$$Direct_i = \frac{1-\delta_i}{\alpha_i}\sum_j \alpha_{ij}\,\tau_j\,, \quad Cascading_i = \frac{1}{\alpha_i}\sum_j \alpha_{ij}\,t_j. \qquad \text{(Eq.2.3)}$$

Welfare Implications

Welfare losses from exemptions and non-registration arise on both the production and consumption sides.

Production. VAT wedges distort the optimal input mix and thus increase social costs of producing a given output bundle. To see this, suppose production is described by a nested constant elasticity of substitution function, with the outer nest determining the substitution between labor and intermediate inputs and the inner nest describing substitution between N intermediate inputs.[9] Cost minimization implies that the optimal ratio of intermediate inputs to labor is proportional to their relative price, $\frac{M}{L} \sim \left(\frac{P}{w}\right)^{-\sigma_M}$, with σ_M denoting the elasticity of substitution and the price firms face for the input bundle given by $P = P^*(1+R)$, which deviates from the undistorted materials price P^* because of unrecoverable input VAT, with the per unit proportional increase being $R = t/a$.

Production distortions are measured as the proportional increase in the resource cost required to produce a given level of output, where use of resources in both systems is valued at social costs; which are the undistorted factor prices.[10] Up to second order, this cost increase across the economy can be expressed as:

$$Production\ Loss = \frac{\sigma_M}{2}\sum_i \nu_i\,\alpha_i(1-\alpha_i)R_i^2,$$

where ν_i denotes the supply share of commodity i in total output. Accordingly, aggregate production distortions are a weighted average across outputs, and they are most pronounced when the elasticity of substitution, σ_M, is high (because a small price difference results in larger input distortions), when large shares of total production derive from industries where intermediate inputs and labor account for similar cost shares ($\alpha = 1/2$), and when unrecoverable input VAT increases producer prices. Full input VAT recoverability sets $R = 0$ and thus fully eliminates production distortions. Similarly, there are no distortions in sectors that only use labor or materials. When labor and materials are complementary, $\sigma_M < 1$, production distortions are less pronounced. Based on the empirical results reported below, the simulations use $\sigma_M = 0.5$. The chapter presents production distortions in percent of GDP by multiplying country-specific production losses by output over value added.

Consumption. Final sales to households are subject to a statutory VAT rate τ_i, resulting in consumer prices $q_i = p_i(1+\tau_i)$, where $p_i = p_i^* e^{t_i}$ denotes the producer price inclusive of the cascaded production wedge t_i. The effective tax rate on commodity i, expressed as the log deviation between undistorted and current consumer prices, is the sum of cascaded production wedge and the retail consumption tax wedge: $\Delta \ln q = \hat{\tau}_i + t_i$, where $\hat{\tau}_i = ln(1+\tau_i)$.

[8] VAT systems typically require only firms with turnover above a country-specific registration threshold to register and remit VAT. Firms below the threshold are generally outside the VAT system, although many countries allow them to register voluntarily.

[9] For simplicity, we focus on labor/material distortions and assume the inner nest of the production function is characterized by an elasticity of substitution of zero (Leontief production). With positive elasticity, additional distortions in the inner nest would arise.

[10] An alternative representation of production distortions, leading to the same result, is the difference in consumer prices between the current system and an alternative that raises the same tax revenue but leaves production decisions unaffected, with that difference expressed as a percentage of undistorted unit costs.

Consumer welfare losses are measured using compensating variation. That is, the analysis compares the current system with an alternative VAT system that eliminates exemptions and non-registration while collecting the same tax revenue, and evaluates total household expenditure, given by $E(q, U) = UP(q)$, where necessary in the two systems to yield the same utility, U. When consumer preferences are described by a constant elasticity of substitution utility function with substitution parameter σ_D, this difference is, up to a second order approximation, given by the log change in the price index, $\Delta \ln(P)$, which is

$$\text{Consumer Loss} = \frac{\sigma_D}{2} \sum_i \omega_i \left[(\hat{\tau}_i + t_i) - \overline{(\hat{\tau} + t)} \right]^2 \quad \text{where} \quad \overline{(\hat{\tau} + t)} = \sum_i \omega_i (\hat{\tau}_i + t_i),$$

and ω_i is the expenditure share of households on commodity *i*. Welfare losses are thus increasing in the substitution elasticity σ_D, since households that substitute readily reallocate more in response to a given price gap, and quadratic in the tax rate dispersion. In other words, losses are a function of the consumption-weighted variance in effective tax rates. Full input recoverability sets $t = 0$ and collapses the consumption loss to the dispersion of statutory final rates.

Empirical estimates of the elasticity of substitution vary with the level of aggregation and the margin of substitution considered. Studies that estimate preferences over broad final-expenditure categories typically find limited substitutability across sectors, with estimates often below unity (Herrendorf, Rogerson, and Valentinyi 2013; Comin, Lashkari, and Mestieri 2021), while elasticities estimated for narrowly defined product varieties are often considerably higher (Broda and Weinstein 2006; Feenstra and others 2018). The simulations use $\sigma = 1$, corresponding to Cobb-Douglas preferences. The chapter presents consumer distortions in percent of GDP by multiplying consumer losses by the share of final consumption expenditure in GDP.

Empirical Analysis

The empirical analysis tests the importance of the theoretically derived effective VAT rates using firm-level data from World Bank Enterprise Surveys, which include detailed information on firms' profit and loss accounts along with sector classification for a broad range of countries. Commodity-level tax wedges are translated into country-sector measures using input-output tables: for each sector and country, the wedge is calculated as the weighted average of the wedges on the commodities it produces, with weights given by each commodity's share in sectoral output. The analysis tests whether the constructed tax variables affect decisions along three separate margins:

Average production costs. This specification regresses the logarithm of production costs over sales against sector-, country- and year- fixed effects as well as the theoretically derived cost increase, constructed from input-output tables and tax legislation. The model predicts that unrecovered input VAT increases average production costs one-for-one, suggesting a positive coefficient with a magnitude of 1.

Input mix. This specification regresses firm-level intermediate input shares on the effective tax rate on intermediates. If intermediate inputs and labor are complementary, an increase in intermediate costs caused by unrecoverable VAT reduces the relative use of intermediates in real terms but implies that firms will spend a larger share on them, suggesting a positive coefficient on the effective tax rate. A negative coefficient would indicate that labor and materials are substitutes.

Exporters. This specification relates an indicator variable, that takes the value of 1 if more than 10 percent of total sales are exported, to the input-tax wedge. Since exporters sell at world prices and cannot pass unrecovered input-VAT forward into their output price, a higher wedge is expected to reduce the likelihood of exporting.

Estimation results. Online Annex Table 1.2.1 reports six specifications: for each of the three outcomes, the wedge first enters as a single effective rate and then is decomposed into its cascading and direct components.

The results are consistent across outcomes. The effective input-tax wedge is associated with a higher cost-to-sales ratio (column 1), and the estimated coefficient is statistically indistinguishable from one, consistent with the theoretical prediction that unrecoverable input VAT raises production costs approximately one-for-one. When the tax rate is decomposed, the effect is concentrated in the cascading component (column 2), while the direct component and the

intermediate-share control are not statistically significant. The input-mix regressions point in the same direction: higher wedges are associated with a larger intermediate cost share (columns 3-4), with the cascading component carrying the effect. The estimates imply that the expenditure share of intermediates rises when intermediates become more expensive, consistent with complementarity between materials and labor.[11] Finally, higher input-tax cost wedges reduce the probability of exporting (columns 5-6), consistent with exporters having less scope to pass unrecovered input VAT into output prices.

The results suggest that the constructed effective rates capture a cost wedge embedded in production networks. Sectors more exposed to cascaded taxes from suppliers have higher measured costs, higher intermediate input shares, and lower export participation. The direct component is insignificant throughout the specifications, likely reflecting the limited variation left after sector- and country-specific fixed effects have been included. Overall, the results should be interpreted with caution because the tax wedges reflect policy choices. This is especially important for the exporter result, where estimates could be driven by reverse causality.

Online Annex Table 1.2.1 Firm Responses to the Constructed Input-Tax Wedge

	Cost-to-sales		Input share α		Exporter	
	(1)	(2)	(3)	(4)	(5)	(6)
Wedge R (combined)	2.64***		0.62**		-1.07***	
	(0.97)		(0.26)		(0.33)	
Cascading		4.30**		1.97***		-2.13***
		(2.14)		(0.75)		(0.79)
Direct		1.54		-0.02		-0.41
		(1.43)		(0.32)		(0.53)
Intermediate share α_{sc}	0.21	0.21			0.06	0.06
	(0.19)	(0.19)			(0.05)	(0.05)
Observations	34,151	34,151	34,216	34,216	39,769	39,769

Source: IMF staff calculations.
Note: Country, NACE 4-digit, and year fixed effects are included in all specifications. Standard errors clustered by sector-country are reported in parentheses. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. In the cost and exporter columns, the wedge enters as the output-cost increase $\alpha_{sc}\, R_{sc} = t_{sc}$, with the intermediate share α_{sc} as a control; in the input-share and materials/labor columns the wedge enters as the per-unit rate R_{sc}. The exporter regressions are linear probability models. The input-share variables are expenditure-based, so a positive coefficient corresponds to $\sigma_M < 1$.

References

Beer, Sebastian, and Shafik Hebous. Forthcoming. "VAT Exemptions as Input Taxation." IMF Working Paper, International Monetary Fund, Washington, DC.

Broda, Christian, and David E. Weinstein. 2006. "Globalization and the Gains from Variety." *Quarterly Journal of Economics* 121 (2): 541–585.

Comin, Diego A., Danial Lashkari, and Martí Mestieri. 2021. "Structural Change with Long-Run Income and Price Effects." *Econometrica* 89 (1): 311–374.

Feenstra, Robert C., Philip Luck, Maurice Obstfeld, and Katheryn N. Russ. 2018. "In Search of the Armington Elasticity." *Review of Economics and Statistics* 100 (1): 135–150.

Herrendorf, Berthold, Richard Rogerson, and Ákos Valentinyi. 2013. "Two Perspectives on Preferences and Structural Transformation." *American Economic Review* 103 (7): 2752–2789.

[11] See Beer and Hebous (forthcoming).

Online Annex 1.3. Cost of Capital, Allocative Efficiency, and Investment[12]

This annex presents the computation of forward-looking effective tax rates (ETRs), firm- and sector-level regression analyses of the effects of ETRs on investment and allocative efficiency, and the framework used to assess the aggregate investment effects of changes in the cost of capital.

A. Cost of Capital and ETRs

Derivation

The derivation of the cost of capital and the forward-looking ETRs is fully documented in Hebous and Mengistu (2026) and follows King and Fullerton (1984) and Devereux and Griffith (2003). The King–Fullerton framework focuses on marginal investment decisions and provides the basis for the cost of capital and the *marginal* effective tax rate (METR), while the Devereux–Griffith framework extends the analysis to discrete investment projects earning economic rents, allowing for the computation of the average effective tax rate (AETR).

The net cost of capital is defined as:

$$\rho = \frac{(r+\delta)(1-\tau A)}{1-\tau} - \delta - \frac{\alpha(1-\tau\varphi)\tau i}{(1-\tau)(1+\pi)}, \quad \text{(Eq.3.1)}$$

where, r denotes the real required rate of return net of tax; i the nominal interest rate on debt; α the share of the investment financed with debt; φ depreciation allowance in the year of investment (including any initial allowance); δ the rate of economic depreciation; τ statutory corporate income tax rate; and A present value of depreciation allowances per unit of investment.

The *net* cost of capital represents the minimum pre-tax rate of return required for an investment to break even after taxes. More generous depreciation allowances (a higher A) reduce the cost of capital and thereby strengthen investment incentives.

The *gross* cost of capital is obtained by adding back economic depreciation and is therefore given by

$$R \equiv \rho + \delta, \quad \text{(Eq.3.2)}$$

which is equal to the marginal product of capital in the neoclassical investment model (Hall and Jorgenson 1967).

The METR measures the tax wedge on a marginal investment that earns just enough to cover break even. It is defined in Figure 1.4, panel 1, in the chapter, as:

$$METR = \frac{\rho - r}{r}. \quad \text{(Eq.3.3)}$$

The normalization used in Figure 1.4, panel 1 of the chapter has the advantage of a particularly intuitive interpretation: it measures the percentage increase in the pre-tax rate of return required for a marginal investment relative to a benchmark without tax-induced investment distortions.

The METR can be alternatively defined as:

$$METR = \frac{\rho - r}{\rho}. \quad \text{(Eq.3.4)}$$

[12] Prepared by Salma Khalid, Andualem Mengistu, and Alexandra Solovyeva.

Both METR expressions capture the proportional difference between the pre-tax and post-tax required rates of return, differing only in their normalization. A higher METR indicates a larger distortion to marginal investment decisions, while a METR of zero corresponds to tax neutrality at the margin.

While the METR is relevant for marginal investment decisions, the AETR captures the tax burden on infra-marginal returns and is therefore particularly relevant for location decisions and large discrete investments.

Following Devereux and Griffith (2003), the AETR is defined as:

$$AETR = \frac{\text{pre} - \text{tax economic rent} \; - \; \text{post} - \text{tax economic rent}}{\text{net present value of the pre} - \text{tax income stream}}.$$

Under the standard Devereux–Griffith assumptions, the AETR can be expressed as:

$$AETR = \tau\left(1 + \frac{\delta}{p}\right) - \tau A\frac{r + \delta}{p} - \frac{\alpha(1 - \tau\varphi)\tau i}{p\,(1 + \pi)}, \qquad \text{(Eq.3.5)}$$

where p denotes the real pre-tax rate of return on the investment project. The AETR depends on both statutory tax parameters and the assumed profitability of the investment. The AETR is computed for a project with a 20 percent real pre-tax rate of return.

Empirical Implementation

The analysis computes the cost of capital, the METR, and the AETR using asset-specific tax depreciation provisions, asset weights, and financing structures (debt and equity shares) at the country–sector–year level for the period 2000–2025. Data on tax depreciation rules for 2000–2020 and financing structures (i.e., debt and equity shares at the sector level) are drawn from Mc Auliffe, Thunecke, and Wamser (2023). The analysis extends this dataset through 2025 using publicly available information from national tax legislations, as well as corporate tax guides published by Ernst & Young, the International Bureau of Fiscal Documentation, and PricewaterhouseCoopers. The calculations assume a real interest rate of 3 percent and an inflation rate of 2 percent, applied uniformly across countries and years, to focus on the tax system implications for the ETRs[13]. In addition, following OECD (2023), the following economic depreciation rates are assumed:

Buildings and structures	3.3%
Machinery	12.6%
Office equipment	15.5%
Computers	37.0%
Vehicles	20.2%
Intangible assets	15.0%

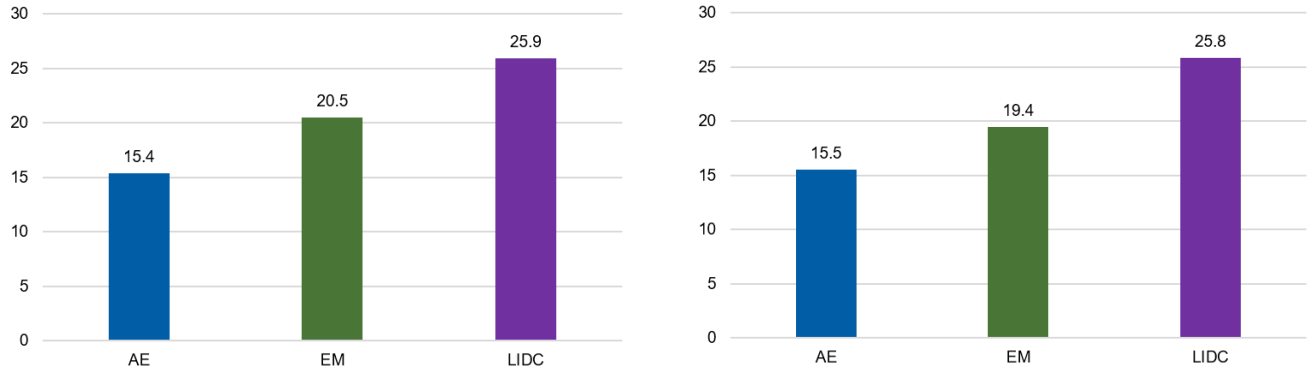
All computations are undertaken using the Stata-based effective tax rate routine (ssc install etr) developed by Hebous and Mengistu (2026).

[13] These baseline parameters are chosen to facilitate comparisons with other international databases, particularly the OECD's annual METR publication. The average real interest rate in advanced economies during 2020–2025, including a 5 percentage point risk premium, was approximately 3.5 percent. This suggests that the real interest rate assumption used by the OECD in its METR calculations closely reflects the financing conditions prevailing in advanced economies over the period.

Note that although the underlying dataset covers the period 2000–2025, all figures presented in the chapter and annex are based on the 2020–2025 sample period.

The METR based on the baseline assumptions is presented in Figure 1.4, panel 1 of the chapter. As equation (3.1) demonstrates, however, the METR depends on macroeconomic variables, particularly inflation and the real interest rate. To focus the cross-country comparison on the effect of the tax system on the cost of capital, Figure 1.4 panel 1 of the chapter assumes the same real interest rate and inflation across countries. The figure below illustrates how the estimated METR changes under alternative assumptions regarding these variables, comparing the baseline specification with one that incorporates country-specific measures of inflation and the real interest rate.

Online Annex Figure 1.3.1. Impact of Macro Economic Environment on the Cost of Capital (Percent)



Source: IMF staff calculations.
Note: Both panels report the simple average forward-looking marginal effective tax rate (METR) on investment by income group for the period 2020–2025. The METR is defined as $(\rho - r)/r$, where r is the required post-tax rate of return and ρ is the cost of capital. It therefore measures the percentage increase in the cost of capital for a marginal investment attributable to tax-induced distortions. In the left panel, inflation is measured as the country-specific five-year moving average inflation rate, while the real interest rate is fixed at 3 percent across all countries and years. The averages are based on a sample of 186 countries. In the right panel, inflation is measured in the same way, but the real interest rate is country- and year-specific, based on the real yield implied by the 10-year government bond yield, with a 5-percentage point risk premium added to the implied real interest rate. Owing to the limited availability of long-term government bond yield data, the averages in the right panel are based on a sample of 90 countries. AE = advanced economy; EM = emerging market; LIDC = low-income developing country.

Online Annex Table 1.3.1. Summary Statistics

Variables	Unit	Mean	Median	Standard Deviation	25th Percentile	75th Percentile	Observations
Log Fixed Assets	Logarithm of 2015 constant USD	11.73	11.68	2.36	10.21	13.19	15,356,963
METR	Percent	21.76	24.45	12.83	10.60	31.68	15,356,963
Log Sales	Logarithm of 2015 constant USD	13.69	13.50	1.86	12.42	14.77	15,356,963
Sales growth	Percent	3.86	0.14	35.13	-12.39	13.57	15,356,963
Number of employees	Total number of employees	62.11	6.00	1685.36	3.00	17.00	15,356,963
Long-term debt share	Percent of total assets	17.61	7.62	70.22	0.00	24.34	15,356,963
Profit margin	Ratio	0.04	0.03	0.12	0.01	0.08	15,356,963
Cash flow rate	Ratio	1.00	0.27	3.30	0.08	0.77	15,356,963

Sources: Bureau van Dijk's Orbis database; and IMF staff calculations.

B. Regressions

Investment

Data: The analysis uses firm-level financial data from Bureau van Dijk's Orbis database. Data cleaning steps follow, Díez, Fan, and Villegas-Sánchez (2021), including converting flow variables and fixed assets into real variables denominated in 2015 constant USD using the 2-digit NACE-level deflators and the World Bank World Development Indicators

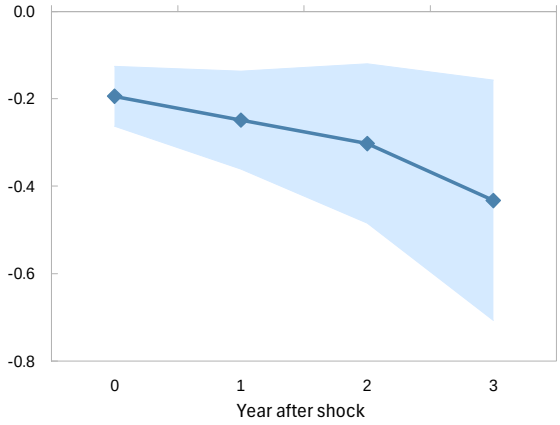
investment deflators at the country level for fixed assets. The sample consists of about 2.5 million firms from 28 advanced and 10 emerging market economies over 2001–2020.[14]

Specification: The baseline regression specification follows the local projections framework (Jordà 2005) and is given by:

$$\Delta^h lny_{i,c,t} = \beta^h \Delta METR_{c,s,t} + \sum_{j=1,2} \delta_j^h \Delta METR_{c,s,t-j} + \sum_{j=1,2} \gamma_j^h \Delta lny_{i,c,t-j} + \theta^h X_{i,c,t} + \alpha_i^h + \lambda_{c,s}^h + \mu_{s,t}^h + \epsilon_{i,+h}^h \quad \text{(Eq.3.6)}$$

where $\Delta^h lny_{i,c,t} = lny_{i,c,t+h} - lny_{i,c,t-1}$, $lny_{i,c,t}$ denotes the logarithm of fixed assets of firm i, in country c in year t, and horizon $h \in \{0,1,\dots,4\}$. β^h captures the percentage change in fixed assets following a 1 percentage point change in the sector-specific METR ($\Delta METR_{c,s,t}$), where sectors are defined at the NACE Level 1 classification. Regressions include a set of firm-specific controls $X_{i,c,t}$, such as the lag of the logarithm of the number of employees ($lnEmployees_{i,c,t-1}$), the lag of the logarithm of sales ($lnSales_{i,c,t-1}$), the lag of the sales growth rate ($Sales\ growth_{i,c,t-1}$), the lag of the profit margin ($Profit\ margin_{i,c,t-1}$) calculated as a ratio of earnings before interest and taxes (EBIT) and sales, and the cash flow rate ($CF\ rate_{i,c,t}$) defined as the ratio between the cash flow in year t and fixed assets in the previous year.[15] The regression also includes lagged changes in the METR and fixed assets, $\Delta METR_{c,s,t-j}$ and $\Delta lny_{i,c,t-j} = lny_{i,c,t-j} - lny_{i,c,t-j-1}$, respectively. α_i^h, $\lambda_{c,s}^h$ and $\mu_{s,t}^h$ are firm, country-sector and sector-year fixed effects. Standard errors are clustered at the firm and country-sector levels.

Online Annex Figure 1.3.2. Impact of Changes in Marginal Effective Tax Rate on Fixed Assets
(Coefficient estimates)



Sources: Bureau van Dijk's Orbis database; and IMF staff estimates.
Note: Lines represent point estimates for cumulative changes in the logarithm of fixed assets associated with changes in the METR. Shaded areas represent 90 percent confidence intervals.

Results: The estimates indicate that increases in the METR are associated with progressively larger cumulative declines in firms' fixed assets over the projection horizon (Online Annex Table 1.3.2): a 1 percentage point increase in the METR is associated with about a 0.2 percent decline within a year and 0.4 percent after 3 years.[16]

[14] The sample includes 28 advanced economies (*Austria, Australia, Belgium, Bulgaria, Czech Republic, Switzerland, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Ireland, Iceland, Italy, Japan, Korea, Lithuania, Luxembourg, Latvia, Netherlands, Norway, New Zealand, Portugal, Sweden, Slovenia, the United Kingdom*) and 10 emerging market economies (*Chile, China, Hungary, India, Malaysia, Poland. Romania, Russia, Thailand, Vietnam*). The sample period coverage varies by country. The sample includes both non-multinational firms and affiliates of multinational corporations, with the latter accounting for approximately 12 percent of observations.

[15] Following Mc Auliffe, Thunecke, and Wamser (2023), sales growth, profit margin ratio, and cash-flow rate are winsorized at the 1st and 99th percentiles.

[16] The estimated response of firms' fixed assets to changes in the METR captures the average effect across both non-multinational firms and affiliates of multinational corporations. For a detailed discussion of international allocation of investment through multinational corporations see October 2026 *World Economic Outlook* Chapter 3 (IMF, forthcoming).

Allocative Efficiency

Data: The country sample consists of 38 advanced and emerging market economies. Firms in the estimation sample are drawn from all economic sectors excluding financial services and sectors with a large public component (Utilities, Public Administration, Health, Education and Arts), where sectors are defined at the NACE Level 1 classification. The baseline unbalanced panel consists of 379 country-sectors over the 2001–2020 period.

Specification: Following Hsieh and Klenow (2009), firm-level real productivity (TFPQ) is estimated and used to construct measures of allocative efficiency at the country-sector level.[17] The main outcomes are productivity, capital, labor, and allocative efficiency. The analysis relates these outcomes to changes in sector-level METRs.

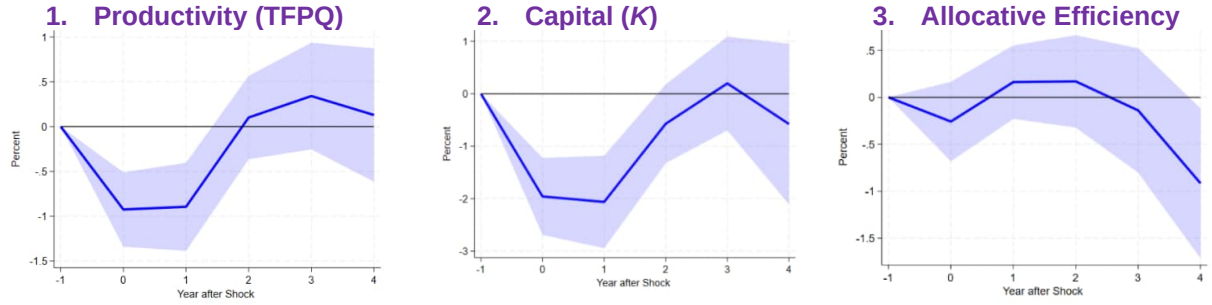
The baseline panel regression specification follows a Jordà (2005) local projections model:

$$\Delta^h lny_{s,c,t} = \beta^h \Delta METR_{c,s,t} + \sum_{j=1,2} \delta_j^h \Delta METR_{c,s,t-j} + \sum_{j=1,2} \gamma_j^h \Delta^h lny_{s,c,t-j} + \alpha_{c,s}^h + \mu_{s,t}^h + \epsilon_{c,s,t+h}^h \quad \text{(Eq.3.7)}$$

where $\Delta^h lny_{s,c,t} = lny_{s,c,t+h} - lny_{s,c,t-1}$ and $lny_{s,c,t}$ is the logarithm of TFPQ, *K* and *L* for the median firm in the sector and sector level allocative efficiency for sector *s* in country *c*, estimated at time horizons *h*=0, 1, 2, 3, 4 relative to the time period, *t*. $\Delta METR_{c,s,t}$ denotes changes in the METR in sector *s* of country *c* between years *t-1* and *t*. The regression includes two lags of changes in the independent variable - $\sum_{j=1,2} \delta_j^h \Delta METR_{c,s,t-j}$ - and two lags of the outcome variable - $\sum_{j=1,2} \gamma_j^h \Delta lny_{i,c,t-j}$. The regression also includes country-sector ($\alpha_{c,s}^h$) and sector-year fixed effects ($\mu_{s,t}^h$), and standard errors are clustered at the country-sector level.

Results: The baseline results show that increases in METRs are associated with lower productivity and capital for the median firm over the first few years after a METR increase. A 1 percentage point increase in the METR is followed by a decline in real productivity in the first two years. Capital inputs for the median firm display a similar short-run decline before recovering. Labor inputs respond more briefly, with the decline concentrated in the year of the METR change. Allocative efficiency changes little in the short run but tends to deteriorate over the medium term, suggesting that higher tax wedges may gradually worsen the allocation of resources across firms.

Online Annex Figure 1.3.3. Impact of Change in Marginal Effective Tax Rates on:
(Coefficient estimates and 90 percent confidence intervals)



Source: IMF Staff estimates.
Note: Shaded areas represent 90 percent confidence intervals.

C. The Response of Investment to Tax Policy Changes

The elasticity of investment and capital with respect to the cost of capital depends on both the time horizon and the level of aggregation. Moreover, empirical estimates reported in the literature are not directly comparable because studies differ

[17] See Online Appendix of April 2024 *World Economic Outlook* Chapter 3 for methodological details on estimation of TFPQ and allocative efficiency based on Hsieh and Klenow (2009).

in their specification of both dependent and explanatory variables. To derive a coherent range of estimates, the available evidence must therefore be converted into a common framework.

Short-run (one-year) Elasticities and Comparability of Empirical Estimates

The empirical literature estimates a variety of investment specifications. Dependent variables include the level of investment, the investment-to-capital ratio, the logarithm of investment, and changes in the capital stock. Likewise, explanatory variables differ across studies and include the present value of depreciation allowances (A), the net-of-tax cost of investment $(1-\tau A)$, the gross cost of capital (R), and the $METR$.

Because the underlying specifications differ, estimated coefficients are not directly comparable across studies. To facilitate comparison, all estimates are converted into elasticities of investment with respect to the gross cost of capital. The conversion maps each study's reported policy variation into its implied change in the gross cost of capital and then scales the estimated investment response by that change; where the outcome is capital rather than investment, an additional capital-to-investment adjustment is applied.[18] The resulting short-run (one-year) elasticities are: −4.27 as in Chodorow-Reich and others (2024); −4.7 in Curtis and others (2021); −7.3 in Zwick and Mahon (2017); −9.4 in the above regressions; and −10.7 in Maffini, Xing, and Devereux (2019).

Taken together, these studies suggest a short-run firm-level elasticity of investment with respect to the gross cost of capital in the range of approximately −4.3 to −10.7.

Level of aggregation

Firm level. Individual firms take output prices, wages, interest rates, and aggregate demand as given. In this environment, a lower user cost of capital induces firms to increase their demand for capital. Because capital and labor enter production jointly, higher capital demand also increases labor demand and firm-level output. These elasticities correspond to standard partial-equilibrium investment responses.

Neoclassical investment theory implies that the firm-level long-run elasticity of capital and investment with respect to the cost of capital is expressed as follows:[19]

$$\frac{dlog(K)}{dlog(R)} = -\frac{1-\beta^*\left[\eta+\frac{1-\eta}{\alpha^*+\beta^*}\right]}{\left[1-\alpha^*-\beta^*\right]}, \qquad \text{(Eq.3.8)}$$

where η is the elasticity of substitution between labor and capital, and α^* and β^* are the shares of capital and labor, respectively.

Economy-wide level. When many firms adjust simultaneously, product prices, wages, and factor intensities may all shift in equilibrium. In particular, industry output cannot expand at fixed prices, since demand curves are downward sloping. Consequently, firm-level elasticities do not map one-for-one into industry-level elasticities. The equilibrium adjustment instead depends on demand elasticities, the degree of substitutability between capital and labor, and the extent to which labor supply is fixed over the relevant horizon.

In this setting, neoclassical investment theory implies that the long-run elasticity of capital and investment with respect to the cost of capital is expressed as follows:[20]

[18] Detailed study-level conversion calculations and the methodology for translating short-run estimates into long-run firm-level elasticities are available upon request.

[19] See Coen (1969) and Chodorow-Reich (2025). Note that the firm level response assumes that firms can expand production and hire labor without a decrease in demand.

[20] Barro and Furman (2018) and Chodorow-Reich (2025). This assumes that labor is fixed in the long-run.

$$\frac{dlog(K)}{dlog(R)} = \frac{1}{\left[\left(1+\frac{1-\eta}{(\alpha^*+\beta^*)\eta}\right)\frac{\varepsilon}{\varepsilon-1}\alpha^* - \frac{1}{\eta}\right]}, \quad \text{(Eq.3.9)}$$

where ε is the price elasticity of demand, η is the elasticity of substitution between labor and capital, and α^* and β^* are the share of capital and labor, respectively.

At the macro level, where the tax treatment is the same for all firms, the $\varepsilon \approx \infty$, and, assuming constant returns to scale production function ($\alpha^* + \beta^* = 1$), thus the response becomes $\frac{dlog(K)}{dlog(R)} = -\frac{\eta}{1-\alpha}$.

Using an elasticity of substitution in the range of 0.7 to 1, and under a conventional capital share of $\alpha \approx 1/3$, this implies an aggregate long-run *capital* elasticity of approximately −1.04 to −1.5, substantially smaller than the firm-level elasticities estimated in micro econometric studies.[21]

Online Annex Table 1.3.2 summarizes the implied responses of investment and capital to the observed changes in the cost of capital. The analysis conservatively uses a relatively modest empirical investment elasticity from the literature (−4.27; Chodorow-Reich and others 2024).

Sensitivity analysis: The simulated GDP effects resulting from eliminating the tax-induced component of the cost of capital—reported in Figure 1.4, panel 2 in the chapter—assume that α=1/3 and η=1. Figure 1.3.4 presents the GDP impacts under alternative values of η and α. The effects are sensitive to these assumptions and become smaller when either η or α is lower.[22] For instance, holding the capital share at 33 percent while lowering the elasticity of substitution to 0.5 reduces the estimated GDP gains from 2.1 to 1.06 percent in advanced economies and from 2.7 to 1.35 percent in LIDCs.

[21] See Bond and Xing (2015) for the elasticity of substitution between capital and labor.

[22] Oberfield and Raval (2021) find that η ranges between 0.5 and 0.7, and Casey and Horii (2024) show that, in a three-factor model calibrated to US data, the share of reproducible capital is 28.5 percent

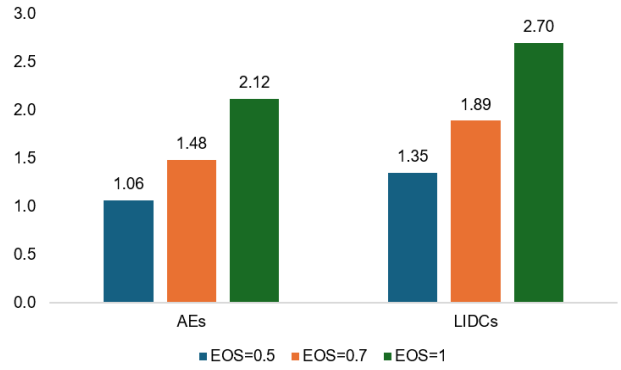
Online Annex Table 1.3.2. Investment and Capital Responses to the Cost of Capital, by Income Group

	Cost of capital before tax[23]	Cost of capital after tax	Short-run investment response (%)[24]	Long run macro response of capital (constant elasticity of substitution=0.7)	Long run macro response of capital (constant elasticity of substitution =1)[25]
Advanced Economies	10.28	10.72	-18.4	-4.50	-6.43
Emerging Market Economies	10.31	10.85	-22.4	-5.48	-7.83
Low Income Developing Countries	10.55	11.12	-23.4	-5.72	-8.17

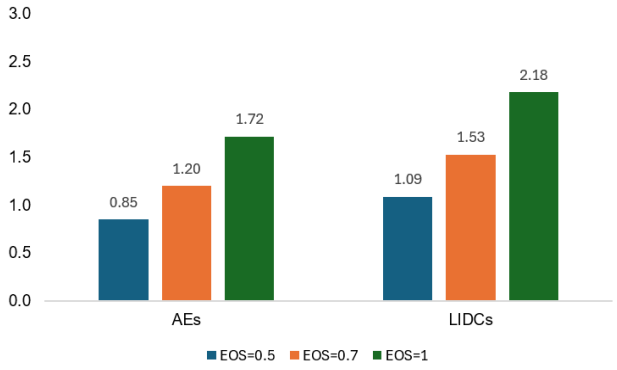
Source: IMF staff analysis.

Online Annex Figure 1.3.4. The Response of GDP to the Cost of Capital, by Income Group, under Alternative Parameter Assumptions

1. Share of Capital (α=0.33)



2. Share of Capital (α=0.285)



Source: IMF staff analysis.
Note: The y-axis shows the percentage change in GDP. Panel 1 assumes a capital income share, α, of 0.33, while panel 2 α = 0.285. In both panels, the elasticity of substitution (EOS) between capital and labor, η, takes values of 0.5, 0.7, and 1. AE = advanced economy; EM = emerging market economy; LIDC = low-income developing country.

References

Barro, Robert J., and Jason Furman. 2018. "The Macroeconomic Effects of the 2017 Tax Reform." *Brookings Papers on Economic Activity* 49 (1): 257–345.

Bond, Stephen, and Jing Xing. 2015. "Corporate Taxation and Capital Accumulation: Evidence from Sectoral Panel Data for 14 OECD Countries." *Journal of Public Economics* 130: 15–31.

Casey, Gregory, and Ryo Horii. 2024. "A Generalized Uzawa Growth Theorem." *Journal of Political Economy Macroeconomics* 2 (2): 336–373.

[23] Cost of capital before tax is $r + \delta$. The difference across country groups is due to δ as we assume similar real interest rate r.

[24] Short − run investment response = $\left[\frac{\text{Cost of capital after tax}-\text{Cost of capital before tax}}{\text{Cost of capital before tax}}\right] \times (short - run\ firm - level\ investment\ elasticity) = \left[\frac{\text{Cost of capital after tax}-\text{Cost of capital before tax}}{\text{Cost of capital before tax}}\right] \times (-4.3)$.

[25] Long − run macro response of capital = $\left[\frac{\text{Cost of capital after tax}-\text{Cost of capital before tax}}{\text{Cost of capital before tax}}\right] * (long - run\ macro\ capital\ elasticity) = \left[\frac{\text{Cost of capital after tax}-\text{Cost of capital before tax}}{\text{Cost of capital before tax}}\right] \times (-1.5)$.

Chodorow-Reich, Gabriel. 2025. "The Neoclassical Theory of Firm Investment and Taxes: A Reassessment." NBER Working Paper 33922, National Bureau of Economic Research, Cambridge, MA.

Chodorow-Reich, Gabriel, Matthew Smith, Owen M. Zidar, and Eric Zwick. 2024. "Tax Policy and Investment in a Global Economy." NBER Working Paper 32180, National Bureau of Economic Research, Cambridge, MA.

Coen, Robert M. 1969. "Tax Policy and Investment Behavior: Comment." *American Economic Review* 59 (3): 370–79.

Curtis, E. Mark, Daniel G. Garrett, Eric C. Ohrn, Kevin A. Roberts, and Juan Carlos Suárez Serrato. 2021. "Capital Investment and Labor Demand." NBER Working Paper 29485, National Bureau of Economic Research, Cambridge, MA.

Devereux, Michael P., and Rachel Griffith. 2003. "Evaluating Tax Policy for Location Decisions." *International Tax and Public Finance* 10 (2): 107–26.

Díez, Federico J., Jiayue Fan, and Carolina Villegas-Sánchez. 2021. "Global Declining Competition?" *Journal of International Economics* 132: 103492.

Hall, Robert E., and Dale W. Jorgenson. 1967. "Tax Policy and Investment Behavior." *American Economic Review* 57 (3): 391–414.

Hebous, Shafik, and Andualem Mengistu. 2026. "Forward-Looking Effective Tax Rates under the Global Minimum Corporate Tax." *IMF Economic Review.*

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics* 124 (4): 1403–48.

International Monetary Fund (IMF). Forthcoming. "Spillovers from Corporate Income Taxation." World Economic Outlook, Washington, DC.

Jordà, Òscar. 2005. "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95 (1): 161–82.

King, Mervyn A., and Don Fullerton, eds. 1984. *The Taxation of Income from Capital: A Comparative Study of the United States, the United Kingdom, Sweden, and West Germany*. Chicago: University of Chicago Press.

Maffini, Giorgia, Jing Xing, and Michael P. Devereux. 2019. "The Impact of Investment Incentives: Evidence from UK Corporation Tax Returns." *American Economic Journal: Economic Policy* 11 (3): 361–89.

Mc Auliffe, Sean, Georg U. Thunecke, and Georg Wamser. 2023. "The Tax-Elasticity of Tangible Fixed Assets: Heterogeneous Effects of Homogeneous Tax Policy Changes." Working Papers 2023-25, Max Planck Institute for Tax Law and Public Finance.

Oberfield, Ezra, and Devesh Raval. 2021. "Micro Data and Macro Technology." *Econometrica*, 89 (2): 703-732.

Organisation for Economic Co-operation and Development (OECD). 2023. *Corporate Tax Statistics 2023*. Paris: OECD Publishing.

Zwick, Eric, and James Mahon. 2017. "Tax Policy and Heterogeneous Investment Behavior." *American Economic Review* 107 (1): 217–48.

Online Annex 1.4. Optimal Labor Taxation[26]

This annex presents the optimal labor tax analysis underlying Figure 1.7, panel 2 in the chapter.

Model setup

The government maximizes a social welfare function representing all individuals in the economy, specified as a weighted sum of individual utilities, where the weights reflect the social value placed on the additional consumption of individuals at different income levels.[27] Policymakers have an aversion to inequality and face a budget constraint with exogenous revenue requirements. Individuals have different productivities, and hence earnings, and their welfare depends on their own consumption (with higher consumption increasing welfare) and labor (with work entailing some disutility). Individuals respond to net-of-tax wages by choosing whether to work or remain outside the labor force (the extensive margin) and, conditional on working, how many hours to work (the intensive margin). The general solution to this exercise is a continuous, non-linear schedule of 'optimal' tax rates that balances (i) revenue needs; (ii) efficiency costs (with taxes affecting labor supply decisions); and (iii) redistribution motives (given social marginal welfare weights).

Data and calibration inputs

The model uses country-specific data for the analysis. The sources of information include the distribution of earnings, and the tax and benefit systems for a selected group of economies, and calibrated values for exogenous elasticity parameters:

- *Household survey data*: The analysis focuses on the working-age population and excludes students, retirees, and workers in the agricultural sector. The latter exclusion is motivated by the fact that most workers and the self-employed in the agricultural sector in emerging economies are excluded from the tax system, either through formal or effective exemption. The following Emerging Market and Developing Economies (EMDEs) are included: Brazil, Côte d'Ivoire, Georgia, Peru, Poland, and Vietnam. The set of Advanced Economies (AE) includes Canada, Germany, Spain, the United Kingdom, Israel, Japan, and Sweden. The economies were selected to provide a representative group across levels of development, regions, and data availability. All household survey data were extracted from the Luxembourg Income Study database (LIS). Examples of variables used from the household surveys include individual labor earnings, employment status, household composition, age of children, housing tenure and sampling weights. Nominal values are inflation-adjusted to represent income distributions in 2024.

- *Tax and transfer parameters*: Information for each country's labor income taxes, social contributions, and individual and household transfers is used. Detailed parameters by income level, demographic characteristics, family type and structure are from the IMF's TAXFIT for Brazil, Côte d'Ivoire, Georgia, Peru and Vietnam. The remaining countries' tax and benefit systems are taken from the OECD's TaxBEN calculator. The analysis uses marginal effective tax rates (METRs) to capture the total labor supply incentives embedded in each country's tax and benefit system.

- *Elasticities*: To facilitate the comparison across countries, the analysis assumes a constant intensive labor supply elasticity of 0.2 (that is, a 10-percent increase in after-tax earnings increases labor supply by 2 percent at the margin); and an average extensive margin elasticity of 0.25 (that is, a 10-percent increase in after-tax income increases the propensity to participate in the labor market by 2.5 percent). The extensive margin elasticity is assumed to be the

[26] Prepared by Philippe Wingender.

[27] The approach follows the sufficient-statistics framework for optimal labor income taxation in Saez (2001) and Jacquet, Lehmann and Van der Linden (2013). Appendix A.1. from Piketty and Saez (2013) provide helpful methodological details.

highest for low- and high-income earners.[28] These elasticities are broadly aligned with the upper end of estimates in the empirical literature for advanced and emerging market economies.[29] These values are deliberately chosen toward the upper end of the empirical range to place relatively greater weight on the behavioral costs of taxation when deriving the optimal reform schedule.

- *Social preferences through reverse engineering:* The analysis uses the current observed METRs by country to infer the redistribution preferences implicit in existing tax-benefit systems. This is done using an 'inverse tax and transfer' approach, which assumes existing tax-benefit systems have been chosen to optimize the trade-off between equity and efficiency (Bourguignon and Spadaro 2012; Jacobs, Jongen and Zoutman 2017). Conditional on the assumed labor-supply elasticities, the observed METRs at each income level can be inverted to recover the social marginal welfare weights that rationalize the existing tax-benefit schedule.[30]

Estimating the inequality aversion parameter

Consider a social welfare function that is a weighted sum of individuals' utilities u_z, with z denoting individual earnings, given by

$$W = \int_0^\infty \omega_z G(u_z) f_z(z) dz, \qquad \text{(Eq.4.1)}$$

where $f_z(z)$ is the density of earnings among workers. The social welfare weights in W consist of (i) an exogenous term ω_z that only depends on the underlying skill of individual with earnings z_n, and (ii) an endogenous component $G(u_z)$ that depends on the individual's utility level given their individual earnings z under a given tax and benefit system. The analysis further assumes that G is described by an isoelastic function of the form

$$G(u_z) = \frac{u_z^{1-\gamma} - 1}{1-\gamma}, \qquad \text{(Eq.4.2)}$$

where γ is the inequality aversion parameter. This specific form assumes that the government or society values the marginal consumption of two individuals based only on their relative income levels. If one individual earns 10 times less than another individual, society assigns 10^{γ} times as much value to an additional unit of consumption for the lower-income individual. Using country-specific estimates indicates that the estimated inequality aversion implicit in the tax and

[28] A higher participation elasticity at the very bottom of the earnings distribution is required to rationalize the observed participation rates for low-income earners given the typically high benefit withdrawal rates that characterize tax and benefit systems across several economies in our sample.

[29] Our review of the empirical literature for 21 AEs and 8 EMDEs indicates broadly similar intensive margin elasticities on average for the two groups. There is limited evidence on extensive margin elasticities for EMDEs.

[30] The point-by-point welfare weights recovered in this step rationalize the observed tax-benefit schedule, conditional on the assumed behavioral elasticities. If these unrestricted weights were used directly in the same optimal-tax problem, the observed schedule would be recovered. Instead, the recovered weights are used to estimate the inequality-aversion parameter γ of the isoelastic social welfare function in equation (4.2), and the reform schedule is derived using the welfare weights implied by that parametric specification. Thus, the reform preserves the estimated overall degree of inequality aversion embedded in the existing system but does not require the local pattern of revealed welfare weights—and hence the existing tax-benefit schedule itself—to remain optimal.

benefit systems of the group of EMDEs is 0.2 on average. This is lower than the average estimate for the selected group of AEs of 0.7, indicating that tax and benefit systems are less redistributive among the former group.

Deriving optimal tax rates

A general formula for optimal tax rates can be expressed in terms of four sufficient-statistic objects. These are: (i) the redistributive value of transferring resources to and from individuals above a given earnings level z, (ii) the fiscal cost of extensive-margin labor supply responses $\bar{\pi}_z$, (iii) the local thickness of the earnings distribution α_z, and (iv) the responsiveness of earnings to net-of-tax marginal rates ε_z. The optimal marginal tax rate at earnings level z can be written as

$$T'(z) = \frac{1-\bar{g}_z-\bar{\pi}_z}{1-\bar{g}_z-\bar{\pi}_z+\varepsilon_z\alpha_z}. \qquad \text{(Eq.4.3)}$$

The term

$$\bar{g}_z = \frac{1}{1-F_z(z)}\int_z^{\bar{z}} g_y f_z(y)dy, \qquad g_y = \frac{\omega_y G'(u_y)}{\lambda},$$

is the average normalized social marginal welfare weight among workers with earnings above z. It measures the social value of an additional unit of consumption for workers above that earnings level, expressed relative to the marginal cost of public funds λ. A larger value of $\bar{g}_z$ lowers the optimal marginal tax rate because raising the marginal tax rate at z reduces disposable income for all workers above that point.

The term

$$\bar{\pi}_z = \frac{1}{1-F_z(z)}\int_z^{\bar{z}} \frac{\Gamma_y}{1-\Gamma_y}\pi_y f_z(y)dy,$$

is the average extensive-margin fiscal externality among workers with earnings above z. Here Γ_y is the participation tax rate and π_y is the participation elasticity. This term captures the fiscal loss from individuals leaving employment when participation incentives are weakened.

Finally,

$$\alpha_z = \frac{zf_z(z)}{1-F_z(z)},$$

is the local Pareto parameter of the earnings distribution among workers, and ε_z is the intensive elasticity of earnings with respect to the net-of-tax rate. The product $\varepsilon_z\alpha_z$ summarizes the intensive-margin efficiency cost of raising the marginal tax rate. When ε_z is high, workers are more responsive to taxation. When α_z is high, there are many workers close to earnings level z relative to the number of workers above z, so the behavioral cost of raising the marginal tax rate is large relative to the mechanical revenue gain.

The formula highlights the main economic trade-offs. Optimal marginal tax rates are higher when the mechanical revenue gain from taxing workers above z is large and when the government places relatively low social welfare weight

on those workers. They are lower when intensive labor supply responses are stronger, when the earnings distribution is locally dense, or when extensive-margin participation responses generate large fiscal losses.

Reform simulations

The reform simulations follow the sufficient-statistics approach of Saez (2001) and Jacquet, Lehmann and Van der Linden (2013). Household survey data and sampling weights are first used to estimate the baseline earnings distribution and the relevant earnings-density objects. Equation 4.3 is then used to derive the optimal reform schedule. Aggregate labor-supply and earnings effects are computed directly from changes in effective marginal and participation tax rates, the estimated densities, and the calibrated intensive- and extensive-margin elasticities. The resulting effects are reported for hours worked, employment, and total earnings; changes in hours and earnings are expressed in percent terms, while changes in employment are expressed in percentage points.

Online Annex Table 1.4.1 suggests that the resulting reform packages mainly extend in-work support farther up the lower part of the earnings distribution. In the average EMDE in our sample, the income cutoff for the in-work tax credit rises from 43 to 59 percent of median income, while the share of exempt workers increases from 16 to 24 percent. In the average AE, the maximum in-work tax credit rises slightly, from 24 to 27 percent of median income, and the income cutoff rises from 51 to 56 percent, increasing the share of exempt workers from 20 to 23 percent. At the same time, the reforms reshape marginal effective tax rates along the earnings distribution rather than uniformly reducing them: in EMDEs, the average METR falls from 25 to 21 percent at the 10th percentile but rises from 16 to 22 percent at the median. Online Annex Figure 1.4.1, panel 1 shows the full schedule of current METRs along with the Reform schedule for the average EMDE in our sample. In AEs, METRs rise from 47 to 51 percent at the 10th percentile and from 36 to 42 percent at the median, before declining at the 90th percentile from 44 to 36 percent. As shown in Online Annex Figure 1.4.1, panel 2 these changes lead to lower participation tax rates for workers below the median and above the 90th percentile of the earnings distribution on average for AEs in our sample.

Online Annex Table 1.4.1. Average Taxes and Benefits: Current and Reform Scenarios

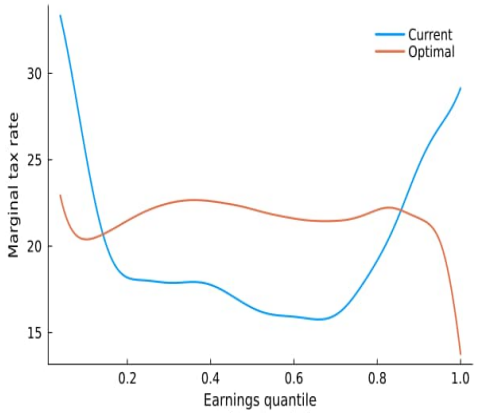
	EMDEs		AEs	
	Current	Reform	Current	Reform
In-work tax credit				
Maximum amount (percent of median income)	17	17	24	27
Income cutoff (percent of median income)	43	59	51	56
Share of exempt workers (percent)	16	24	20	23
Marginal effective tax rates (percent)				
10th percentile	25	21	47	51
50th percentile	16	22	36	42
90th percentile	26	21	44	36

Source: IMF staff calculations.

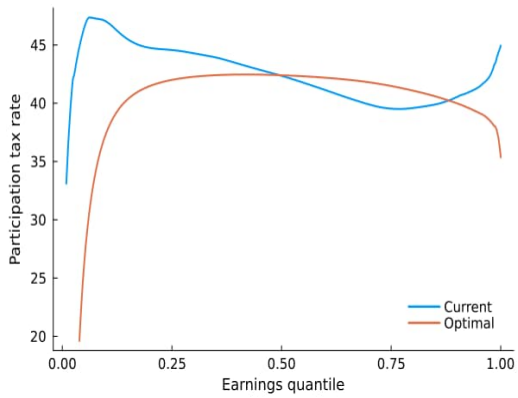
The earnings effects of the reform also vary markedly across the earnings distribution. In EMDEs, earnings gains are concentrated in the lower half of the distribution, peaking at around 7.5 percent near the bottom decile, and then gradually decline, turning slightly negative in the upper half before rising again for top earners. In AEs, by contrast, earnings gains are largest at the very bottom and the very top of the distribution, reaching about 6 to 8 percent at both ends, while middle-income earners tend to experience small losses, with the trough around the middle of the distribution. This suggests that the reform produces a more hump-shaped profile of earnings changes in EMDEs, compared with a more clearly U-shaped pattern in AEs.

Online Annex Figure 1.4.1. Average Tax Rate Schedules for Current and Reform Scenarios

1. Reform Lowers Hours-of-Work Disincentives in EMDEs for Low and High Incomes

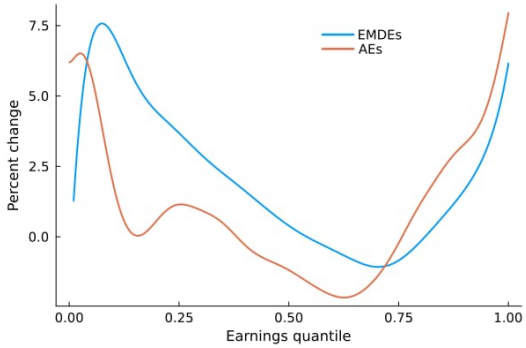


2. Reform Lowers Entry-to-Work Disincentives in AEs for Low and High Incomes



Sources: Luxembourg Income Study (LIS) Database, OECD TaxBEN, IMF TAXFIT and IMF staff calculations.
Note: Group averages for EMDEs and AEs are calculated as unweighted averages across countries within each group.

Online Annex Figure 1.4.2. Earnings Gains Under Reform Scenarios



Sources: Luxembourg Income Study (LIS) Database, OECD TaxBEN, IMF TAXFIT and IMF staff calculations.
Note: Group averages for EMDEs and AEs are calculated as unweighted averages across countries within each group.

References

Bourguignon, François, and Amedeo Spadaro. 2012. "Tax-Benefit Revealed Social Preferences." *Journal of Economic Inequality* 10: 75–108.

Jacobs, Bas, Egbert L.W. Jongen and Floris T. Zoutman. 2017. "Revealed Social Preferences of Dutch Political Parties." *Journal of Public Economics* 156: 81–100.

Jacquet, Laurence, Etienne Lehmann and Bruno Van der Linden. 2013. "Optimal Redistributive Taxation with Both Extensive and Intensive Responses." *Journal of Economic Theory* 148 (5): 1770–1805.

Piketty, Thomas, and Emmanuel Saez. 2013. "Optimal Labor Income Taxation." In *Handbook of Public Economics*, vol. 5, edited by Alan J. Auerbach, Raj Chetty, Martin Feldstein, and Emmanuel Saez. Amsterdam: Elsevier: 391–474.

Saez, Emmanuel. 2001. "Using Elasticities to Derive Optimal Income Tax Rates." *The Review of Economic Studies* 68 (1): 205–229.

Online Annex 1.5. Tax Compliance Costs, Tax Complexity, and Firm Performance[31]

This annex presents the data and empirical methodology used to analyze how tax administration quality and tax framework complexity affect firm performance, compliance costs, and firms' perceptions, with a focus on small and young firms.

Objective

The objective is to assess whether high-quality tax administration and simpler tax frameworks disproportionately benefit small and young firms. The analysis decomposes the question into three links: (i) tax administration quality and firm performance; (ii) tax administration quality, compliance costs, and perceptions of the business environment; and (iii) tax framework complexity and firm performance. The estimation draws on Atsebi, Dabla-Norris, and Mopa (forthcoming) and extends Dabla-Norris and others (2020).

Data

Firm-level data are from the World Bank Enterprise Surveys. Tax administration quality is measured by the Tax Administration Quality Index (TAQI), constructed from the Tax Administration Diagnostic Assessment Tool (TADAT) assessments. The index is based on taxpayer information services, filing and payment procedures, post-filing processes, and transparency and accountability. It ranges from 1 to 4, with higher values indicating lower compliance costs. The TAQI covers 63 countries and 72 country-survey year observations over 2013-2025.[32] To maximize coverage, TADAT scores are assumed to remain unchanged for four years after an assessment.[33] Tax framework complexity is measured using the Euler and others (2024) corporate income tax complexity index, denoted TAXCOMP, which ranges from 0 to 1. Specifications using this index cover 23 countries over 2015-2024.

Empirical Strategy

Three firm-level specifications are estimated. The first links firm performance to the interaction between firm type (small or young) and TAQI. The second links compliance costs and perceptions to the same interaction. The third adds the interaction between firm type and the tax framework complexity index (TAXCOMP).

All specifications include country-industry-survey year fixed effects. Identification therefore comes from comparing small or young firms with larger or older firms within the same country, industry, and survey year. The key assumption is that smaller and younger firms benefit more from reforms that reduce fixed compliance burdens and make tax rules easier to navigate (Dabla-Norris and others 2020). The three baseline specifications are:

$$Performance_{iscv} = \beta_1 FirmType_{iscv} + \beta_2 (FirmType_{iscv} \times TAQI_c) + X_{iscv} + \mu_{csv} + \varepsilon_{iscv}, \quad \text{(Eq.5.1.)}$$

$$Costs/Perceptions_{iscv} = \gamma_1 FirmType_{iscv} + \gamma_2 (FirmType_{iscv} \times TAQI_c) + X_{iscv} + \mu_{csv} + \varepsilon_{iscv}, \quad \text{(Eq.5.2.)}$$

$$Performance_{iscv} Percformances_{iscv} = \theta_1 FirmType_{iscv} + \theta_2 (FirmType_{iscv} \times TAXCOMP_c) + X_{iscv} + \mu_{csv} + \varepsilon_{iscv}. \quad \text{(Eq.5.3.)}$$

[31] Prepared by Jean-Marc Atsebi.

[32] The sample includes Albania, Armenia, Belarus, Belgium, Benin, Bhutan, Bosnia and Herzegovina, Botswana, Bulgaria, Cambodia, Chad, Colombia, Congo, Democratic Republic of the, Côte d'Ivoire, Czech Republic, Dominican Republic, Ecuador, Egypt, The Gambia, Georgia, Ghana, Greece, Guatemala, Indonesia, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Lebanon, Lesotho, Liberia, Madagascar, Malaysia, Mali, Malta, Moldova, Morocco, Mozambique, Nepal, Niger, North Macedonia, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Romania, Rwanda, Serbia, Sierra Leone, Slovak Republic, South Africa, Spain, Tajikistan, Tanzania, Tonga, Trinidad and Tobago, Tunisia, Ukraine, Uzbekistan, and Zambia.

[33] Acknowledging that TADAT assessments may trigger corrective measures or reforms, we confirm that the results remain robust when we do not make this assumption and match firms only to contemporaneous assessments.

$FirmType_{iscv}$ is a dummy indicating a small firm or in some specifications a young firm. Small firms have 20 or fewer employees, whereas young firms are nine years old or younger. Firm controls include government ownership, exporter status, and foreign ownership. The subscripts (*i*), (*c*), (*s*), and (*v*) denote firm, country, industry, and survey year, respectively. Firm $Performance$ is measured by labor productivity, labor productivity growth, and annual sales growth. Compliance costs are measured by annual hours spent on tax compliance. Perceptions cover whether tax administration is the biggest obstacle, whether value-added tax (VAT) refunds are too slow or complicated, and whether the firm competes with informal or unregistered firms. Since the World Bank Enterprise Surveys consists of repeated cross-sections, firm fixed effects cannot be included in the specifications.

As a key robustness check, we interact $FirmType_{iscv}$ with alternative country-level variables, including governance and tax complexity, and use alternative definitions of small and young firms (Online Annex Table 1.5.3 and Online Annex Table 1.5.4). The main results remain robust and statistically significant across these specifications.

Results

The estimates point to three consistent findings. Better tax administration is associated with stronger performance among small and young firms; it also lowers compliance burdens and improves perceptions of the tax administration and the business environment. In addition, greater tax framework complexity is associated with weaker relative performance among small and young firms.Online Annex Table 1.5.1 links TAQI to firm performance. The interaction terms between TAQI and the small-firm and young-firm indicators are positive and statistically significant across all performance measures, indicating that better administration narrows performance gaps between small and large firms, and between young and older firms. The magnitudes are economically meaningful. Moving from the 25th to the 75th percentile of TAQI narrows the labor-productivity gap from about 29 to 17 percent for small firms and from about 22 to 12 percent for young firms. It also strengthens labor-productivity growth and nearly closes total factor productivity gaps. The results suggest that lower compliance frictions help smaller and younger firms translate resources into higher productivity and growth. In addition, Online Annex Table 1.5.4 shows that high-quality tax administration improves firm performance in both emerging markets and low-income developing countries, with larger effects in low-income developing countries, where performance gaps are greatest. This suggests that improvements in tax administration can deliver greater gains where the scope for improvement is largest.

Online Annex Table 1.5.2 shows that high-quality tax administration lowers compliance costs and improves perceptions among small and young firms. The relevant TAQI interactions are negative and statistically significant: as tax administration quality improves, these firms spend less time complying with taxes, are less likely to identify tax administration as their main obstacle, report fewer VAT refund difficulties, and perceive less informal competition.

Online Annex Table 1.5.3 adds the tax complexity index to the performance specifications. The interaction between TAXCOMP and the small-firm and young-firm indicators is negative in all specifications and statistically significant in most cases. This indicates that complex tax frameworks widen performance gaps, while simpler frameworks support stronger relative productivity and growth among smaller and younger firms. The estimated effects are sizable. Moving from high to low tax complexity reduces the small-firm labor-productivity gap from about 28 percent to 4 percent and narrows the young-firm gap from about 22 percent to 12 percent, holding TAQI at its mean. Lower complexity is also associated with higher labor-productivity growth, stronger sales growth, and better total factor productivity outcomes for small and young firms.

Overall, the evidence suggests that administrative quality and legal simplicity are complementary. Better administration reduces the cost of interacting with the tax authority, while simpler tax rules make compliance and planning less burdensome. Both channels matter most for firms with fewer internal tax resources.

References

Atsebi, Jean-Marc, Era Dabla-Norris, and Modeste Mopa. Forthcoming. “Who Benefits from Better Tax Administration? Evidence from Firms’ Performance and Perceptions.” IMF Working Paper, International Monetary Fund, Washington, DC.

Dabla-Norris, Era, Florian Misch, Duncan Cleary, and Munawer Khwaja. 2020. "The Quality of Tax Administration and Firm Performance: Evidence from Developing Countries." *International Tax and Public Finance* 27 (3): 514–51.

Euler, Isabell, Simon Harst, Deborah Schanz, Caren Sureth-Sloane, and Johannes Voget. 2024. "Tax Complexity and Foreign Direct Investment." International Taxation Research Paper 2024–10, Vienna University of Economics and Business, Vienna.

Online Annex Table 1.5.1. Tax Administration Quality and Firm Performance of Small and Young Firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables:	LABPRO	LABPROGR	ANSALESGR	LABPRO	LABPROGR	ANSALESGR
Government	-0.255**	-1.981	-3.315*	-0.252**	-1.961	-3.268*
	(0.101)	(1.826)	(1.796)	(0.101)	(1.834)	(1.805)
Exporter	0.256***	0.822*	0.877*	0.253***	0.803*	0.841*
	(0.026)	(0.449)	(0.461)	(0.026)	(0.449)	(0.462)
Foreign	0.412***	2.775***	1.562***	0.416***	2.803***	1.609***
	(0.039)	(0.540)	(0.539)	(0.038)	(0.537)	(0.536)
Small	-0.682***	-2.182*	-6.347***	-0.247***	1.808***	0.046
	(0.088)	(1.223)	(1.198)	(0.027)	(0.413)	(0.411)
Young	-0.203***	0.790	4.405***	-0.508***	-3.231***	-1.684
	(0.026)	(0.491)	(0.566)	(0.079)	(1.099)	(1.333)
Small X TAQI	0.211***	1.935***	3.103***			
	(0.041)	(0.519)	(0.539)			
Young X TAQI				0.162***	2.127***	3.227***
				(0.038)	(0.551)	(0.661)
Observations	30088	26213	26820	30088	26213	26820
Adj. R2	0.672	0.124	0.166	0.672	0.124	0.166
Number of countries	63	63	63	63	63	63
Number of industry	18	18	18	18	18	18
Country X Industry X Survey FE	Yes	Yes	Yes	Yes	Yes	Yes
Estimator	OLS	OLS	OLS	OLS	OLS	OLS

Sources: IMF staff calculations.

Note: The table reports OLS estimates of equation (5.1). The dependent variables are labor productivity (logs), labor productivity growth, and annual sales growth. Columns (1)-(3) use the Small x TAQI interaction; columns (4)-(6) use the Young x TAQI interaction. Robust standard errors, clustered at the country-industry-survey level, are reported in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Online Annex Table 1.5.2. Tax Administration Quality, Tax Compliance Costs, and Firm Perceptions of Small and Young Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variables:	HRCOMP	ADMBIGOBS	REFOBS	INFCOMP	HRCOMP	ADMBIGOBS	REFOBS	INFCOMP
Government	-0.238	-0.238*	-0.070	-0.062	-0.241	-0.241*	-0.067	-0.063
	(0.154)	(0.126)	(0.142)	(0.041)	(0.154)	(0.125)	(0.145)	(0.041)
Exporter	0.199***	0.052*	0.051*	-0.034***	0.202***	0.051*	0.053**	-0.033***
	(0.051)	(0.028)	(0.026)	(0.012)	(0.051)	(0.028)	(0.026)	(0.012)
Foreign	0.085	0.011	-0.076**	-0.129***	0.086*	0.008	-0.078**	-0.129***
	(0.052)	(0.034)	(0.033)	(0.016)	(0.052)	(0.034)	(0.033)	(0.016)
Small	0.006	0.310***	0.200***	0.147***	-0.285***	0.011	0.002	0.073***
	(0.139)	(0.109)	(0.072)	(0.038)	(0.044)	(0.029)	(0.019)	(0.011)
Young	-0.114***	-0.046	-0.036*	0.011	0.113	0.403***	0.072*	0.085**
	(0.032)	(0.038)	(0.019)	(0.011)	(0.094)	(0.135)	(0.043)	(0.036)
Small X TAQI	-0.139**	-0.151***	-0.102***	-0.038**				
	(0.062)	(0.049)	(0.036)	(0.018)				
Young X TAQI					-0.118**	-0.251***	-0.064***	-0.040**
					(0.048)	(0.070)	(0.025)	(0.018)
Observations	12677	17844	7730	30103	12677	17844	7730	30103
Adj./Pse. R2	0.261	0.005	0.004	0.010	0.261	0.008	0.003	0.010
Number of countries	35	53	34	63	35	53	34	63
Number of industry	17	17	17	17	17	17	17	17
Country X Industry X Survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Estimator	OLS	CLOGIT	CLOGIT	CLOGIT	OLS	CLOGIT	CLOGIT	CLOGIT

Sources: IMF staff calculations.

Note: The table reports estimates of equation (5.2). HRCOMP is the log of annual hours spent on tax compliance. ADMBIGOBS, REFOBS, and INFORM are binary indicators for tax administration as the biggest obstacle, VAT refund difficulties, and competition from informal firms. OLS is used for HRCOMP; conditional logit marginal effects are reported for binary outcomes. Columns (1)-(4) use the Small x TAQI interaction; columns (5)-(8) use the Young x TAQI interaction. Robust standard errors are clustered at the country-industry-survey year level. * p < 0.1, ** p < 0.05, *** p < 0.01.

Online Annex Table 1.5.3. Tax Framework Complexity and Firm Performance of Small and Young Firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables:	LABPRO	LABPROGR	ANSALESGR	LABPRO	LABPROGR	ANSALESGR
Government	-0.099	-5.246	-7.991*	-0.092	-5.232	-7.994*
	(0.255)	(3.865)	(4.124)	(0.256)	(3.906)	(4.139)
Exporter	0.301***	0.565	0.402	0.299***	0.577	0.395
	(0.036)	(0.605)	(0.644)	(0.036)	(0.609)	(0.651)
Foreign	0.365***	2.935***	1.537*	0.361***	2.876***	1.500*
	(0.055)	(0.787)	(0.814)	(0.056)	(0.784)	(0.803)
Small	0.048	6.854**	2.701	-0.190***	2.768***	1.151**
	(0.197)	(2.722)	(2.845)	(0.041)	(0.553)	(0.558)
Young	-0.195***	1.904***	6.033***	-0.120	6.332*	10.964***
	(0.034)	(0.711)	(0.790)	(0.211)	(3.533)	(3.604)
Small X TAQI	0.189***	1.044*	2.264***			
	(0.049)	(0.597)	(0.611)			
Small X TAXCOMP	-1.961***	-18.933**	-19.433**			
	(0.534)	(7.806)	(8.402)			
Young X TAQI				0.092	0.798	1.506*
				(0.056)	(0.897)	(0.910)
Young X TAXCOMP				-0.816*	-18.043**	-23.978**
				(0.453)	(9.114)	(10.328)
Observations	15758	13888	14252	15758	13888	14252
Adj. R2	0.591	0.127	0.171	0.589	0.127	0.170
Number of countries	23	23	23	23	23	23
Number of industry	18	18	18	18	18	18
Country X Industry X Survey FE	Yes	Yes	Yes	Yes	Yes	Yes
Estimator	OLS	OLS	OLS	OLS	OLS	OLS

Sources: IMF staff calculations.

Note: The table reports OLS estimates of equation (5.3), combining TAQI and TAXCOMP interactions. The dependent variables are labor productivity (logs), labor productivity growth, and annual sales growth. The sample includes 23 countries. Columns (1)-(3) use the Small x TAQI and Small x TAXCOMP interactions; columns (4)-(6) use the Young x TAQI and Young x TAXCOMP interactions. Robust standard errors are clustered at the country-industry-survey year level. * p < 0.1, ** p < 0.05, *** p < 0.01.

Online Annex Table 1.5.4. Tax Administration Quality and Firm Performance of Small and Young Firms (Robustness Checks)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Specifications:	AEs	AEs	EMs	EMs	LIDCs	LIDCs	Small2	SME	Young2	Add GEE	Add GEE
Government	-0.499	-0.496	-0.219*	-0.211*	-0.312*	-0.333*	-0.247**	-0.219**	-0.244**	-0.262***	-0.255**
	(0.348)	(0.348)	(0.120)	(0.119)	(0.189)	(0.191)	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)
Exporter	0.367***	0.365***	0.236***	0.236***	0.276***	0.271***	0.262***	0.282***	0.256***	0.257***	0.254***
	(0.052)	(0.052)	(0.033)	(0.033)	(0.051)	(0.051)	(0.025)	(0.025)	(0.026)	(0.026)	(0.026)
Foreign	0.425***	0.427***	0.306***	0.307***	0.578***	0.579***	0.419***	0.441***	0.412***	0.412***	0.415***
	(0.057)	(0.057)	(0.056)	(0.055)	(0.061)	(0.061)	(0.039)	(0.039)	(0.039)	(0.038)	(0.039)
Small	-0.314**	-0.146***	-0.659***	-0.241***	-0.909***	-0.294***			-0.259***	-0.558***	-0.248***
	(0.122)	(0.047)	(0.116)	(0.035)	(0.179)	(0.057)			(0.027)	(0.090)	(0.027)
Young	-0.103	-0.073	-0.162***	-0.242***	-0.265***	-0.761***	-0.218***	-0.232***		-0.202***	-0.378***
	(0.063)	(0.347)	(0.031)	(0.087)	(0.045)	(0.110)	(0.026)	(0.026)		(0.026)	(0.089)
Small X TAQI	0.070		0.195***		0.346***					0.160***	
	(0.051)		(0.054)		(0.091)					(0.040)	
Young X TAQI		-0.015		0.039		0.298***					0.108***
		(0.144)		(0.042)		(0.059)					(0.041)
Small2							-0.577***				
							(0.099)				
Small2 X TAQI							0.193***				
							(0.047)				
SME								-0.465***			
								(0.103)			
SME X TAQI								0.182***			
								(0.047)			
Young2									-0.436***		
									(0.099)		
Young2 X TAQI									0.159***		
									(0.049)		
Small X WGI GEE										0.161***	
										(0.059)	
Young X WGI GEE											0.105**
											(0.051)
Observations	2604	2604	18891	18891	8593	8593	30088	30088	30088	30088	30088
Adj. R2	0.282	0.281	0.403	0.402	0.755	0.755	0.671	0.670	0.671	0.673	0.672
Number of countries	6	6	32	32	25	25	63	63	63	63	63
Number of industry	17	17	18	18	18	18	18	18	18	18	18
Country X Industry X Survey FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

Sources: IMF staff calculations.

Note: The dependent variable is labor productivity (logs). Columns (1)-(6) present the results by income groups. Columns (7)-(9) use alternative definitions of firm size and age. Columns (10)-(11) control for institutional quality. Robust standard errors are clustered at the country-industry-survey year level. * p < 0.1, ** p < 0.05, *** p < 0.01. AE = advanced economy; EM = emerging market; LIDC = low-income developing country.