

How Can Lower-Income Countries Collect More Taxes?

The Role of Technology, Tax Agents, and Politics

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Abstract

This paper examines recent evidence on tax administration interventions aimed at increasing tax revenues in lower-income countries. It focuses on two major themes: the use of new information technology tools—for identifying taxable entities, verifying tax liabilities, and ensuring collection of liabilities—and how the deployment and incentives of tax

officials shape their performance. The paper discusses the promise and pitfalls of interventions in these two areas and the strategic interactions between them. Lastly, it emphasizes the importance of political incentives and considers the conditions under which governments choose to invest in tax capacity and expand tax collection.

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How Can Lower-Income Countries Collect More Taxes? The Role of Technology, Tax Agents, and Politics¹

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Introduction

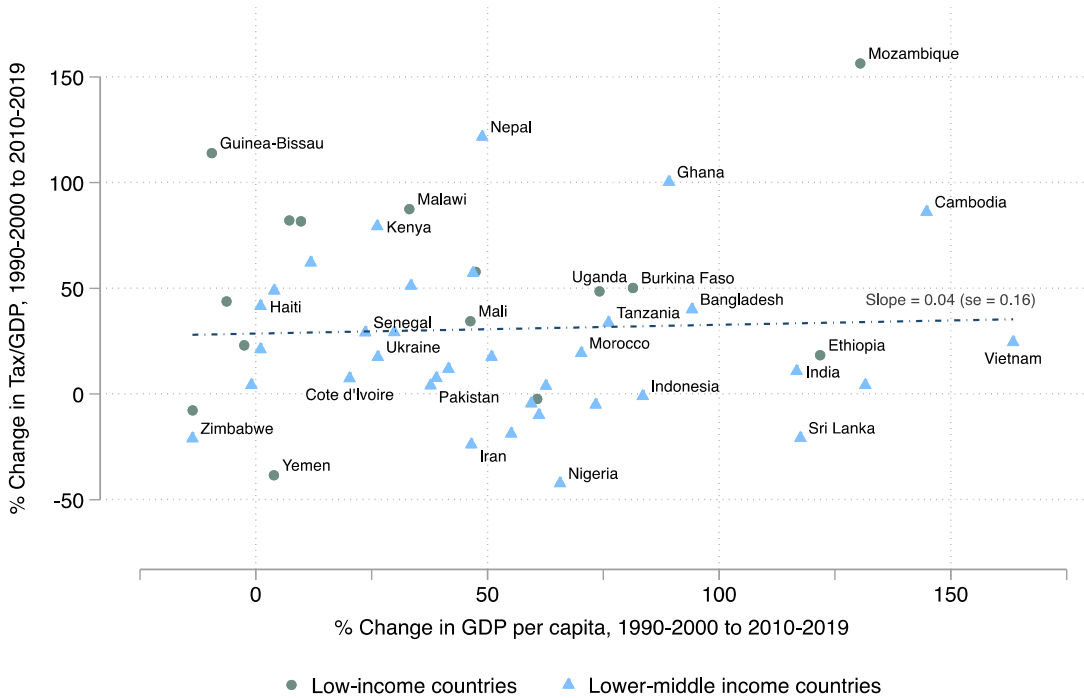
Taxes are the main source of government revenue in most countries and provide funding for public investments in human capital, infrastructure, and social insurance. Increasing tax revenues is thus a major policy goal in many low- and lower-middle-income countries that collect a low share of their GDP as tax revenues. In 2019, for example, the average tax-to-GDP ratio was 12 percent for low-income countries, 18 percent for lower-middle-income countries, 21 percent for upper-middle-income countries, and 30 percent for high-income countries (UNU-WIDER Government Revenue Dataset 2022). Tax-to-GDP ratios among lower-income countries, in fact, resemble those of modern high-income countries at similar stages of development: among 18 developed countries with available historical data, tax-to-GDP ratios in 1919 averaged 12 percent (Besley and Persson 2019; Mitchell 2007). To account for why developing countries tax so little, Besley and Persson (2014) argued that low taxation is an outgrowth of deeper economic and institutional factors constraining development, concluding that “the most important challenge is taking steps that encourage development, rather than special measures focused exclusively on improving the tax system.”

This view might suggest that tax capacity should expand with economic development. However, over the last 30 years, the relationship between GDP growth and taxation levels among low- and lower-middle-income countries has remained essentially flat. Figure 1 plots the relationship between percentage changes from 1990-2000 to 2010-2019 in GDP per capita and tax revenues as a share of GDP for such countries. This pattern suggests economic growth does not automatically generate increases in tax revenue, a point Besley and Persson (2014) also note. Rather, governments must invest in improving the tax system to take advantage of expansions in the tax base that result from increased economic activity.

Improving a tax system requires investments in the ability of the tax administration to carry out its three core tasks: identifying taxpayers, determining how much they owe, and bringing these liabilities into state coffers (Cotton and Dark 2017). Following the framework in Okunogbe (2021), we will refer to these three dimensions of tax capacity as identification, detection and collection capacity. Identification capacity is the ability to uniquely identify individuals (as well as assets or entities) that are liable to taxation through comprehensive registries and databases. Detection capacity entails verifying the amounts of tax liability, often utilizing data from third parties. Collection capacity is the ability to ensure the payment of liabilities. It involves the use of billing

and payment systems to facilitate tax transactions, as well as the imposition of penalties in the face of non-compliance. While policy variables such as tax instruments and tax rates are undoubtedly crucial to the performance of a tax system, this paper focuses on inputs to tax administration. To a large extent, lower-income countries have adopted tax instruments and rates that resemble those in higher-income countries. That low tax revenues persist among the former underscores the value of examining gaps in administrative capacity.

Figure 1: GDP per capita and Tax/GDP, 1990 to 2019



Data source: UNU-WIDER Government Revenue Dataset (2022) and UNU-WIDER World Income Inequality Database (2022).

Notes: This figure displays the relationship between changes in tax revenues as a share of GDP (y-axis) and GDP per capita (x-axis) for low-income and lower-middle-income countries by country income group. Each measure is calculated as the difference between values calculated separately for the periods 1990 to 2000 and 2010 to 2019, divided by the value for the base period (1990 to 2000). We truncate the second period in 2019 to omit the period of the COVID-19 pandemic. We pool annual observations by country within each period as measures for individual years are frequently missing due to intermittent collection of these measures. Values within each period are calculated as the mean of annual observations for each nation within that period. The tax revenues to GDP measure corresponds to tax revenues as a share of GDP within a given year, excluding grants and social security. The income categories are drawn from the World Bank country classifications by income level, as applied in the UNU-WIDER datasets. Low-income countries are displayed as green circles, and lower-middle income countries are displayed as blue triangles. The dashed blue line of best fit is estimated using all displayed observations and has slope 0.04 and robust standard error 0.16.

Over the last decade, with the growing availability of high-quality administrative tax data and a rise in partnerships between researchers and governments, there has been a tremendous increase in the amount of evidence on the impact of different interventions to improve tax capacity and increase tax revenues in low- and middle-income countries. This paper examines two major themes from that body of evidence: first, the deployment of new information technology tools to facilitate identification, detection and collection, and second, the role of tax officials, both in harnessing the potential of technology as well as in complementing it. Despite the availability of viable interventions, an important question is under which conditions governments will choose to invest in tax capacity and expand tax collection. In turn, we will discuss how the current level of taxation, available technology tools, and extent of political competition may affect how the government chooses the nature and level of taxation.

The Role of Technology

Electronic systems that collect, generate, process, and store vast amounts of data can support the implementation of a wide set of tax policy instruments, such as the value-added-tax, income tax withholding, customs, and property tax. In lower-income countries, tax modernization programs often seek to support the tax authority in a transition away from relying on manual processes or outdated technology and in-person interactions with taxpayers towards automated, online processes. Of the taxation-related projects approved in 116 countries by the World Bank between 2010 and 2022, 91 countries (78 percent) had a project that included a tax modernization or information technology component, according to our own analysis of World Bank projects. Examples of these projects are integrated tax administration systems for domestic taxes and customs, electronic registration of taxpayers, electronic tax filing and payment, and risk-based audit selection.²

A well-integrated information technology system enables the tax authority to uniquely identify taxpayers, process information received from taxpayers and third parties to verify liabilities and compliance, and facilitate the remittance of funds to the treasury. We discuss below the use of technology for these three dimensions of tax capacity.

Identification Capacity: Taxpayer Identification and Registration

Identifying taxpayers and developing a taxpayer registry are first-order challenges in many low- and middle-income countries, where proper identification systems often do not exist for individuals nor businesses, properties, and other taxable entities or tax bases. In many countries, people who do not have existing national identification are issued a “Tax ID number” when they enter the tax system. Having a Tax ID that is not linked to an individual’s national identity may serve as a stopgap measure for tax authorities with the most rudimentary systems but may also offer scope for tax avoidance. For example, without a link to personal identity, there is a danger that owners of firms that have accumulated significant tax liabilities could simply shut them down and open new ones to avoid tax penalties. Anecdotally, such maneuvers likely account in part for

² Okunogbe and Santoro (2023a) provide a more comprehensive review of the use of technology in tax administration. Okunogbe and Santoro (2023b) provide applications for African countries.

the high firm death rates observed in low- and middle-income countries (McKenzie and Paffhausen 2019). The lack of identity systems in many low- and middle-income countries is mirrored in low coverage of personal income taxes, which account on average for 26 percent of tax revenues in high-income countries but only 14 percent in low-income countries (UNU-WIDER Government Revenue Dataset 2022).

Recent technology advances have significantly reduced the costs of identifying individuals at scale and linking identity information across different government functions and registries. For example, countries can enroll millions of people in national systems with biometric identification (like fingerprints or retinal scans) across a nation within a few months.³ Such identification can then serve purposes not only related to taxation but also to other government functions like verifying eligibility for public benefits and establishing a financial credit history. In the case of real estate taxation, GIS-enabled systems can capture property location and features at scale (Knebelmann 2022), facilitating the administration of real estate taxes as well as the provision of public services like postal service, electricity, and sewerage.

In an interesting case, Ghana started identifying taxpayers using the “Ghana Card” national identification system in 2021 in place of tax identification numbers issued by the tax authority. Ghanaian tax officials reported that, as a result, they could identify 85 percent of Ghanaians compared to 4 percent under the tax-ID-based system, and the number of filers increased from 4 million to 6.6 million within a few months (GhanaWeb 2022, Ghana News Agency 2021). While this episode does not provide causal evidence, it certainly suggests that an integrated identification system across key sectors of the economy can broaden the reach of the tax authority and may transform a nation’s revenue potential.

However, information technologies are not silver bullets. Too often, tax authorities make large investments in taxpayer identification and registration but fail to observe commensurate increases in tax receipts. Means to act on such advances are pivotal. An illustrative case in this vein comes from a randomized experiment in Liberia (Okunogbe 2021). In 2014, the Liberian Revenue Authority undertook a block-by-block digital mapping exercise of a pilot area in the capital, Monrovia, to construct an electronic database of properties and the identities of owners. This database then served as the basis for evaluating distinct tax enforcement measures. Simply informing taxpayers that the tax authority had identified them as the owners of the properties in question (using a notice that included their name and a photo of the property) did not shift the likelihood that tax liabilities were paid (relative to a generic notice). However, combining this identification signal with information about penalties for delinquency more than quadrupled the payment rate. A second experiment sent a signal that the stated penalties would be enforced on defaulters, which achieved a further increase in compliance. This example highlights that tax authorities must complement technology-assisted identification and registration with enforcement actions to translate those investments into tax receipts.

³ The Kenyan government reportedly registered 36 million citizens for its Huduma Namba digital national ID in the space of two months (Kimani 2019).

Detection Capacity: Third-Party Information and Verification Processes

Information technology enables a tax authority to verify tax liabilities and detect where evasion might be occurring. In particular, technology facilitates the collection and sharing of third-party information, which is central to modern tax administration. Third-party reporting refers to any information provided to the tax authority about liabilities, other than the declarations taxpayers submit directly. The classic example of third-party information in high-income countries is the information firms provide to tax authorities on employee salaries, an innovation as yet of limited relevance in low- and middle-income countries where over 80 percent of the labor force is employed in the informal economy (Elgin et al. 2021). Even among those employed in the formal sector, firms in low- and middle-income countries often report aggregate employee tax liability without linking amounts to individual employees, who in many cases do not have tax ID numbers (Mayega et al 2021, Mascagni and Mengistu 2019).

More evidence on how technology allows collection of third-party information in low- and middle-income countries comes from consumption taxes. The value-added tax is increasingly widespread and is one of the most important sources of tax revenue, accounting for on average 28 percent of taxes collected globally (UNU-WIDER Government Revenue Dataset 2022). As Almunia et al. (forthcoming) discuss, a value-added tax has the important inbuilt feature of collecting third-party information on transactions as firms buy and sell across supply chains. Many countries are moving to digitize this paper trail with the use of electronic fiscal devices, machines that automatically record transactions as they occur and transmit this information to the tax authority through internet or mobile networks. These tools have led to the unveiling of significant revenue previously undisclosed to the tax authority: in Ethiopia, yielding a 48 percent increase in tax revenue (Mascagni, Mengistu and Woldeyes 2021). The promise of digital trails does not seem limited to low-income countries, where one might expect more “low hanging fruit” in revenue gains: electronic invoices that made it more difficult to falsify invoices also increased value-added tax revenues in China (Fan et al 2020), a middle-income country.

Technology can also facilitate digital trails on firms’ revenues when they receive sales payments via credit card or other electronic payment systems. Even when these transaction records are not automatically transmitted to the tax authorities, the existence of the digital trail may be sufficient to induce a compliance response, as evidenced by the tax impacts resulting from India’s efforts to shift away from paper currency (Das et al., 2023) and the introduction of incentives for credit and debit transactions in Uruguay (Brockmeyer and Saenz Somarriba, 2022). For cross-country evidence, Apeti and Edoh (2023) show that the adoption of mobile money increases total tax collections in developing countries. Third-party information can also come from a wide range of sources, such as utility companies, customs, financial records, and procurement. Sophisticated tax administrations are increasingly linking different databases, facilitated by common and unique identifiers for individuals and firms across sources, to get a more comprehensive picture of true tax liability. Alerting taxpayers to the existence of these data can in turn reduce evasion (see, e.g., Brockmeyer et al. 2019 for experimental evidence from Costa Rica).

While an increasing number of low- and middle-income countries are taking advantage of information systems to collect third-party information, two important steps are needed to translate information into revenue. First, it is important for countries to use this information systematically

in tax enforcement. For example, despite how widespread the value-added tax is, many low- and middle-income countries do not automatically or consistently crosscheck invoices and receipts reported by buyers and sellers for the same transactions, which can have sizeable discrepancies. In Uganda, for example, sellers and buyers were found to report different amounts in 79 percent of trading pair-month observations (Almunia et al., 2022). An example of the value of putting third party information to use comes from Pakistan. After many years of collecting third party information on firms paying value-added tax but the information to limited use, Pakistan tax authority achieved a 50 percent reduction in value added tax credits from adopting an automated risk analysis system that rejected suspicious claims in real time (Shah 2023).

Second, it is important to obtain information on a given tax base from multiple sources. A consistent pattern arises in which the tax authority attempts to increase enforcement using third-party information obtained on one margin, but taxpayers then adjust on another margin to undo impacts on their overall liability. For example, when tax authorities are given third-party information on revenues, taxpayers may adjust on their expenses or input deductions: Ecuadoran firms notified that they owed more in taxes responded by reporting higher costs (Carrillo, Pomeranz, and Singhal, 2017). Ethiopian firms responded the same way when newly mandated electronic fiscal devices increased firms reported revenues (Mascagni, Mengistu and Woldeyes, 2021), as did Brazilian firms during an anti-tax evasion program in São Paulo, cutting the initiative's revenue gains in half (Naritomi, 2019). Obtaining information on each input to a tax determination will help forestall such adjustments.

Finally, even as countries close potential loopholes within their domestic tax systems, another potential source of revenue loss lies in international tax evasion and avoidance, such as individuals concealing their income or wealth offshore, outside the reach of tax authorities, or multinationals legally shifting their profits to tax havens. These tax losses can be substantial. For example, an amnesty program on wealth taxation in Argentina revealed hidden assets equivalent to 21 percent of GDP (Londoño-Vélez and Tortarolo 2022). Profit-shifting can be a major source of revenue loss in lower-income countries. Data from the missingprofits.world website (based on Wier and Zucman 2022) suggest that 26 percent of corporate taxes in Nigeria are lost due to profit shifting, 13 percent from South Africa, and 6 percent from India.

Advances in computer-based data sharing across countries, such as Tax Information Exchange Agreement and Automatic Exchange of Information – Common Reporting Standards provide tools to uncover these attempts at avoidance and evasion as countries can obtain information on the overseas accounts of their citizens. Similarly, in regulating profit shifting, having access to data from other jurisdictions enables tax authorities to compare the price at which a firm wants to transfer an asset among its subsidiaries to a set of comparable transactions to determine whether it complies with arms-length principles--that is, such transactions should happen under the same conditions (including price) as it would between two separate firms. Low- and middle-income countries face challenges gaining access to these data as signing up to these exchanges requires countries to collect the same information in their own countries, for which they may lack capacity. Even after granted access, low- and middle-income countries then are confronted with the crucial step of using these third-party data effectively, through data analytics that match them to tax records and other in-country data sources to detect evasion and avoidance.

Collection Capacity: Electronic Tax Transactions

Another core application of information technology is the processing of tax information and payments. For taxpayers, electronic filing and payment options reduce tax compliance costs. For tax administrators, they reduce the risk of data entry errors and free up personnel who would otherwise be needed for processing paper returns. The generation of tax information and tax withholding at its source by a third-party agent – e.g., employers and financial institutions – is another fiscal innovation that is facilitated by the availability of appropriate data systems. These innovations appear important for tax performance globally, with evidence ranging from individual reforms – e.g., withholding of sales tax by credit card companies in Costa Rica (Brockmeyer and Hernandez, 2022) – to cross-country analysis comparing 100 countries at various levels of development (Jensen, 2022). Electronic processing of tax information and payments can also provide digitized administrative data to the tax authority that may then support the automation of many tax processes, such as advanced analytics for risk-based audits and targeted enforcement efforts.⁴

When a tax authority more often carries out its duties through e-transactions, and less through in-person interactions, there is also less scope for unsanctioned behaviors like extortion and collusion. At the same time, shifts to digitization may weaken tax officials' ability to monitor or gain contextual knowledge about taxpayers. We return to this tradeoff later in the paper when we discuss interactions between tax officials and technology tools.

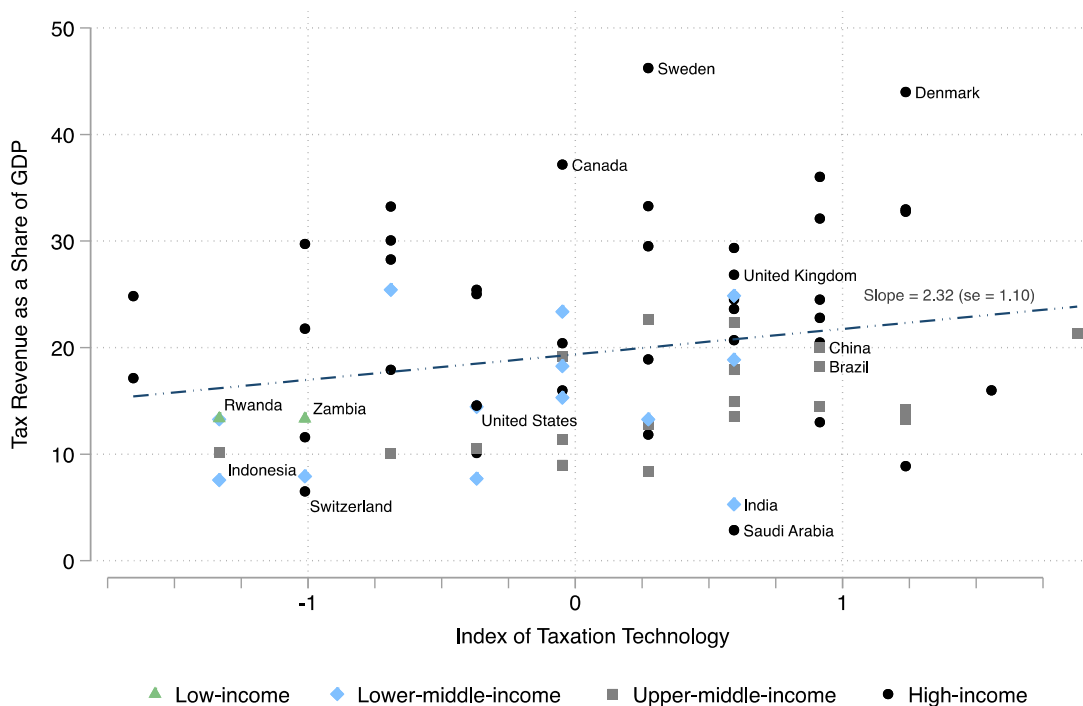
One important concern in the use of electronic systems to facilitate compliance is the potential impacts on equity (Bachas et al. (forthcoming) discuss equity considerations in taxation in lower- and middle-income countries in detail). On the one hand, electronic systems may help lower-income and less-privileged taxpayers. E-filing, e-payment, and withholding can reduce compliance costs, often a larger proportion of income for such taxpayers. Similarly, automated systems that log payments can facilitate installment plans to accommodate liquidity-constrained taxpayers (for evidence from Mexico, see Brockmeyer et al., 2023). On the other hand, evidence across different contexts suggests that taxpayers who are female, rural, less educated, or those heading less-established companies are less likely to use e-services and, where compulsory, may face higher costs of adoption, with evidence from small businesses in Nigeria (Efobi et al., 2019), general use of e-tax services in Rwanda (Santoro et al, 2023), and value-added taxes in Kenya, Tanzania (Eilu, 2018), and Rwanda (Mascagni et al., 2023). Electronic systems, coupled with other features of the tax system can also lead to unintended consequences that disadvantage lower-income taxpayers. For example, if taxes are over-withheld (as is common) and tax filing is optional (due to, e.g., exemptions for taxpayers earning below a minimum threshold), non-filers will face a higher effective average tax rate, with this impact concentrated among lower-income taxpayers (see Hauck and Wallosek (2023) for evidence from Germany).

⁴ In addition to supporting tax compliance monitoring, data from tax systems also supports revenue forecasting and financial reporting. Beyond tax administration applications, information generated for tax purposes can also generate indirect benefits for the design of economic policies more generally. For example, data on firm-to-firm transaction networks can inform about the nature of trading structures, their resilience to financial and climate shocks, and opportunities to diversify supply chains. Likewise, measures of corporate growth – captured through income taxes – can assist in the targeting of industrial policy.

Cross Country Evidence on Use of Technology for Identification, Detection and Collection

To complement these causally identified studies at the country level, we zoom out to a cross-country description of the relationship between the extent of technology use and a country's tax performance using data from the OECD Inventory of Tax Technology Initiative's 2023 Global Survey on Digitalisation. The survey catalogs the tax technologies used in 75 countries, capturing variables can be mapped to our framework to understand how countries use technology to boost their identification, detection and collection capacity.⁵ For identification-related technologies, the survey collects whether the tax authority requires taxpayers to have digital identification with a unique identity number, and whether this ID is based on government-issued documents and/or biometric information, as well as whether taxpayers can register online. For detection, it collects whether the tax authority receives data from third parties such as trade partners, shares databases with other government bodies, requires taxpayers to submit e-invoices or to maintain online cash registers that directly report their sales to the tax authority, or uses artificial intelligence to conduct risk assessments or detect evasion. For collection capacity, the survey records whether taxpayers can file and/or pay taxes online, and whether they can request an extension or set up a payment arrangement online.

Figure 2: Taxation Technology and Tax-to-GDP



⁵ For more information, see: <https://www.oecd.org/tax/forum-on-tax-administration/tax-technology-tools-and-digital-solutions/>.

Data Sources: Tax revenues as a share of GDP measure drawn from the International Survey on Revenue Administration (CIAT, IMF, IOTA, OECD 2022) using values for 2018. Taxation technology measure drawn from OECD Inventory of Tax Technology Initiatives (2023) Global Survey on Digitalisation.

Notes: This figure displays the relationship between tax revenues as a share of GDP and an index of taxation technology for 75 individual countries. The tax revenues as a share of GDP measure is drawn from the International Survey on Revenue Administration (CIAT, IMF, IOTA, OECD 2022) using values for 2018. We fill in missing values for 7 out of 75 countries using UNU-WIDER (2022) data in 2018. The index of taxation technology is computed from individual measures drawn from the OECD Inventory of Tax Technology Initiatives (ITTI) (2023) Global Survey on Digitalisation. The index includes variables capturing tax authorities' use of third-party information, taxpayer identification systems, taxpayer services, and innovation in technology use. More details on these measures are provided in the text and Appendix I. Classifications of country income level are drawn from World Bank Development Indicators. Low-income countries are represented by green triangles, lower-middle-income by blue diamonds, upper-middle by gray squares, and high-income by black circles. The line of best fit is estimated using all observations and has slope 2.32 (robust standard error 1.10).

For each dimension of tax capacity, we construct an index that counts how many of the possible technologies a country uses, as well as an overall index that sums across the three groups.⁶ The horizontal axis of Figure 2 shows the standardized scores for each country (in standard deviation units relative to mean zero). Figure 2 reveals a positive correlation between the extent of technology use (captured by the overall index) and tax revenue as a share of GDP, consistent with the case-specific evidence we discuss above. We examine these relationships using exploratory regressions reported in Appendix Table 1 and find that this correlation persists while holding constant country income level. Further, the relationship appears driven by technology applications for identification and detection in contrast to the collection index, which does not have a detectable relationship with tax performance. Of course, these relationships are simply correlations and should by no means be interpreted as causal as many factors can affect both the use of technology as well as tax performance. Nevertheless, the patterns in cross-country data are consistent with findings from well-identified studies at the level of individual countries.

The Role of Tax Officials

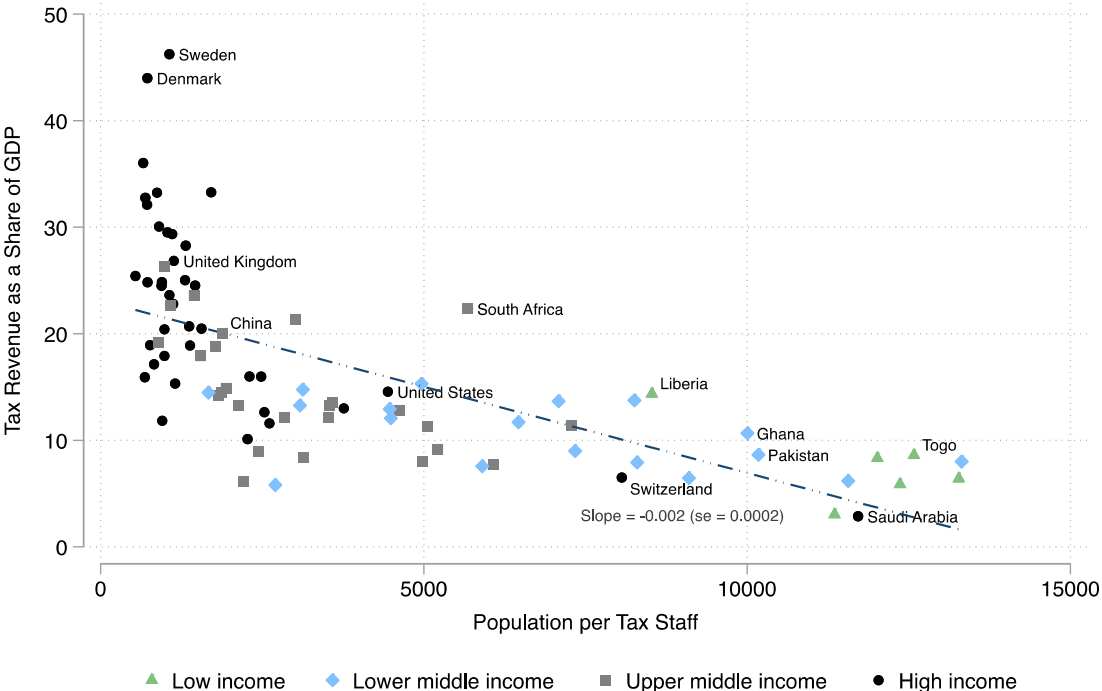
Technology supplies data and tools that, ultimately, will assist tax personnel in the work of tax collection. What this work entails depends on the underlying tax system. In more advanced tax systems, tax personnel are deployed mostly in the higher-level tasks of maintaining and updating information technology systems, processing returns, analyzing data, and undertaking audits. In less advanced systems, particularly in the context of local taxation in many lower-income countries, tax collection proceeds manually, with officials soliciting payments and undertaking enforcement efforts in-person.

As a starting point, we examine how the relative strength of a nation's tax staff relates to its fiscal capacity. Figure 3 illustrates a negative relationship between tax-to-GDP and population-to-tax-staff, using data from the International Survey on Revenue Administration (CIAT, IMF, IOTA,

⁶ Appendix I provides further details on the construction of these variables and summary statistics.

OECD 2022). For ease of illustration, the sample excludes small island nations – which cluster primarily in the low population-to-staff, low tax/GDP quadrant, and where the personnel to tax capacity relationship may fundamentally differ due to reduced scale and their prominence as tax havens – but the observed relationship is robust to including them.

Figure 3: Population per Tax Staff and Tax-to-GDP



Data Sources: Both measures are drawn from the International Survey on Revenue Administration (CIAT, IMF, IOTA, OECD 2022) using values for 2018.

Notes: This figure displays the relationship between tax revenues as a share of GDP and population per tax staff. Classifications of country income level are drawn from World Bank Development Indicators (YEAR). Low-income countries are represented by green triangles, lower-middle by blue diamonds, upper-middle by gray squares, and high-income by black circles. The line of best fit is displayed in blue, is estimated using all observations, and has slope -0.002 (robust standard error 0.0002) which translates to an average decrease in the tax-to-GDP ratio of 2 for every additional 1,000 tax personnel.

The ratio of population-to-tax-staff is an order of magnitude smaller in high-income countries. For example, the United Kingdom reported 68,722 full-time-equivalent staff in 2018, or 1,133 citizens per staff, and Sweden 10,486 in total tax staff, or 1,064 citizens per staff. By contrast, middle-income countries like Pakistan (10,176 population per staff) and Ghana (10,006 per staff) – and low-income nations – e.g., DRC (12,811 population per staff) and Togo (12,582 per staff) – possess almost systematically higher ratios. Specialization of tax staff varies with the nature of the economy and the tax system. According to the CIAT, IMF, IOTA, OECD (2022) database, while the shares of staff assigned to registration, service, and payment activities (at roughly 30 percent)

and debt collection (roughly 11 percent) is relatively constant across income groups, high-income countries dedicate a substantially higher share of personnel to audit and investigations (28 percent) than in low-income countries (16 percent).

Deployment of Tax Officials

The effectiveness of tax authorities depends in part on how personnel are deployed in the work of identification, detection, and collection. While strengthening technological capacity may reduce the need for manual functions that can be digitized, the low citizen-to-tax-staff ratios observed in richer countries suggest that personnel remain integral to collection capacity even as economies grow. The specialization of tax staff – and the requisite qualifications – may simply evolve as per capita GDP rises: for example, from in-person registration and monitoring and manual checking of returns to wrangling third-party data to detect evasion.

Another margin for adjustment lies in how personnel are deployed across tax bases, both across the types of taxes a government collects and even the characteristics of taxpayers within bases. In a 2002 policy experiment, Indonesia introduced a corporate tax administration reform that created “medium taxpayer offices” to oversee enforcement of the top several hundred taxpayers in each region. These offices tripled the staff-to-taxpayer ratios assigned to handle such firms. As a result, tax revenue more than doubled, with evidence suggesting this increase derived from more business-reported taxable income and wage bills being reported to the tax authority (Basri et al. 2021). The response implies a sizeable elasticity of collections with respect to the strength and focus of personnel.⁷

As the cross-country pattern in Figure 3 implies, increasing staff—especially in high-return tax functions—could offer a powerful way to ratchet up tax capacity. For example, tax authorities might pursue endeavors with potential to generate large increases in revenue, like concentrating monitoring efforts on large taxpayers or those in evasion-prone sectors. They might also seek to strengthen enforcement in a broad-based way, by training staff to effectively leverage third-party information. Tax authorities must then also weigh the benefits of such actions against the cost of staff resources that would be expended, as well as costs associated with reallocating personnel away from other functions.

Ultimately, strengthening tax capacity will occur iteratively, and must respond to evolving conditions. Yet improved staff allocation can offer a feasible means of raising collections even absent complementary reforms to tax regimes, administrative processes, or technologies. In an experimental study in Peru, Kapon et al. (2022) show that “prioritized iterative enforcement” of tax debts – which targets enforcement efforts by trading off expected collection and expected capacity use – can yield collection gains relative to randomly-targeted enforcement efforts. Evidence from the significantly lower capacity setting of the Democratic Republic of Congo suggests revenue gains as large as 26 percent can be achieved through resource-neutral reallocations of staff (Bergeron et al. 2022).⁸ The nature of gains from assignments – in the

⁷ This elasticity can be interpreted as a form the “enforcement elasticity of tax revenue” conceptualized by Slemrod and Keen (2017) as an input to identifying optimal interventions by a tax administration.

⁸ Even larger gains may derive from engaging non-traditional personnel in tax collection: in the same setting in the Democratic Republic of Congo, engaging local chiefs in taxation generated a 44 percent increase in revenues,

Congolese case, resulting from high-ability types being more effective when paired with similarly high-ability teammates, particularly when collecting from households with higher payment likelihoods – will likely vary across contexts, but could be fruitfully identified through policy experimentation.

In short, the available evidence is consistent with more staff being able to bring in more revenues, while reallocation of tax officials towards higher return activities can yield non-trivial revenue gains, potentially achieved at low cost, for resource-constrained authorities.

Incentives of Tax Officials

The incentives that tax officials encounter will shape their effectiveness, and by extension, a tax authority's collection capacity. Ample evidence from the public sector suggests incentives can modulate what types of individuals accept roles within bureaucracies and how well they perform. Higher wages or better career benefits offered for public sector positions can attract more able applicants without compromising motivation (as Dal Bo et al. (2013) show in Mexico and Ashraf et al. (2020) in Zambia).

In theory, when designing incentive structures, tax authorities should seek to trade off gains in tax collections against the costs of monetary and non-monetary incentives for staff. In practice, tax administrations operate within government bureaucracies that may constrain options through rigid salary structures, limits on performance incentives, and political considerations. Within the scope of feasible incentive structures, how much can we expect the incentives facing tax officials to matter?

One factor consists in how elastic collections are to effort and skills – or other factors like dishonesty – within a certain job. For tax officials engaged in customs, as one example, there might seem less scope for pure effort to impact tax revenues (because of rote processing of total shipments), but larger scope for skills like attentiveness (monitoring product misclassification and underdeclaration to evade tariffs) and dishonesty (bribes in exchange for misclassification) to influence trade tax collections. For service staff tasked with registering informal firms, sheer effort in identifying, locating, and communicating the process of formalization to such businesses may matter comparatively more.

In lower-income countries, the work of taxation still largely involves in-person interactions with taxpayers. On average, 74 percent of firms in low-income countries say they are required to meet with tax officials and on average 3.4 meetings are held per year, compared to 26 percent of firms and 1.8 meetings in high-income countries (World Bank Enterprise Surveys). Tax collectors receive payments, often in cash, from individuals and firms, audits require inspection visits to premises rather than examining taxpayer financial accounts, and registration drives involving physical outreach are periodically undertaken to extend the tax net over sizeable informal economies. The interpersonal nature of this work – along with officials' discretion over outcomes – naturally increases opportunities for greater revenue but also corruption.

suggesting that governments with low staff capacity can realize revenue gains by involving agents outside the official state administration (Balán et al., 2022).

Consider an example of how these tensions emerge from the lower middle-income country of Pakistan. In the largest province – Punjab – tax officials are directly responsible for the assessment of property taxes. Tax staff manually construct the property register, including updating for new construction or changes in property values, and wield considerable discretion in determining tax liability through the application of valuation tables and granting of exemptions. At the same time, the wages of these officials are not linked to performance and few audit mechanisms exist, creating scope for low tax collections and corruption, achieved via coercion or collusive agreements between tax officials and taxpayers. This context mirrors the nature of local tax administration in many low- and middle-income countries.

On one hand, tying officials' incentives more closely to revenue generation could raise collections; on the other hand, raising the return to formal collections could also increase officials' bargaining power when extracting bribes (in exchange for undervaluation or misclassification) from property owners. To assess how performance incentives affect tax collections, the Punjab government ran an experiment in collaboration with researchers in 2011 providing bonuses to tax officials in some jurisdictions – in the form of a share of revenue raised for increasing collections (Khan et al. 2016).⁹ Revenue in jurisdictions with the new performance pay scheme grew by close to 50 percent. The gains derived from a small number of high-value properties being newly taxed at their true value. At the same time, most properties in incentivized areas did not pay more, but reported paying higher bribes. Were properties more homogeneously low in value, it is unclear whether the average effect of performance incentives of revenues would have been positive, though the average value of bribes would still likely have increased. A subsequent scheme to incentivize revenue generation through merit-based assignment of postings in Punjab – under which we might expect collusive corruption to be less attractive as a substitute for the reward of obtaining a preferred posting to a new area – resulted in even larger increases in revenue (Khan et al. 2019).

The example from Pakistan demonstrates that in settings where scope for collusive corruption is high, the objective function of tax officials should be conceptualized as including their personal gain from wages and formal incentives as well as those from bribes, subject to the costs of being detected. The integration of technology into tax collection may impact this calculus in several ways, as we consider next.

Interaction of Tax Officials and Technology

Thus far, we have discussed the role of technology and tax staff as independent forces. In reality, the two may act as substitutes or complements within specific tax functions. On the one hand, technology may almost wholly obviate the need for staff in certain functions (e.g., a shift to online tax registration removes the need for manual registration staff) but may also increase the relative return to deploying staff in other roles. For example, the adoption of automatic personal income

⁹ The revenue-based incentive scheme rewarded revenue increases over predetermined benchmarks based on collections in previous years. Bonuses were inversely scaled to the size of jurisdictions to reflect the greater difficulty of increasing revenues in smaller jurisdictions. Additional incentive schemes adjusted performance bonuses based on taxpayer satisfaction and assessment accuracy or evaluations of performance determined by a committee of senior tax officials.

tax payment through withholding by employers observed in the second half of the 20th century among high-income nations (Besley and Persson 2014) likely freed up resources dedicated to marshaling tax collections through visits, in-person collections, and so on. This shift could account to some extent for the greater shares of staff in audit and investigation roles in higher-income countries relative to lower-income countries we note above.

On the other hand, technology can clearly offer productivity gains for staff by expediting formerly cumbersome processes – like managing tax records or checking returns for errors – and facilitating reallocation of effort towards higher-return activities. The introduction of a digital tax collection technology within a Ghanaian municipality sheds light on this dynamic. In 2021, the municipal tax authority provided a tablet-based technology containing a geospatial database of properties and revenue management software that helped property tax collectors more easily locate properties in the field. A randomly selected subset of local property tax collectors – whose task is to deliver tax bills and collect payments manually – were provided with this new technology. These collectors delivered almost one-third more bills and collected double the amount of revenues compared to collectors persisting in the old, entirely manual system (Dzansi et al. 2022). The timeline of the evolution of visits and payments suggests that the technology assisted collectors in learning more quickly which households were willing and able to make payments and to target their in-person collection efforts accordingly. Technology can thus have high returns in even low resource, low compliance settings.

However, tax authorities face two major challenges. The first is how best to strike a balance between using technology to improve on potential error, bias, or manipulation in the work of human agents — while retaining the value of rich contextual knowledge of an environment that tax officials can acquire from repeated interactions with taxpayers. The tradeoffs involved likely vary with the nature of the task, even within the same setting. As an example, in Senegal, property assessment officials using a “discretionary” method produced real estate valuations that with more regressive tax implications than those produced by a computer algorithm (Knebelmann et al., 2023), while officials charged with identifying firms with high evasion for audit performed better than a newly-introduced algorithm directed toward the same purpose (Bachas et al., 2023).

An example from Tajikistan, in which a set of small- and medium-sized businesses in were experimentally encouraged to adopt e-filing (Okunogbe and Pouliquen 2022), highlights the tensions around using technology to replace interactions between taxpayers and officials. Firms that adopted the electronic filing system – replacing a process by which taxes were filed in-person with tax officials – reduced their time spent on tax matters by 40 percent and also freed up the time of tax officials previously tasked with receiving declarations. However, e-filing did not change the average amount of taxes or bribes paid by firms, due to counterbalancing patterns among two types of businesses. One type of firm, identified as being more likely to evade pre-adoption, approximately doubled their amount of taxes paid. The study suggests that e-filing disrupted previous collusion between these firms and tax officials that had reduced tax liabilities. For the other type of firms, those deemed less likely to evade, e-filing reduced taxes paid, which is consistent with e-filing leading to less direct monitoring by officials who could have had private

information to enforce compliance with firms' true liability.¹⁰ In addition, firms flagged as less likely to evade taxes paid fewer bribes, presumably because e-filing reduced extortion opportunities. This case thus provides a nuanced view of how new technology systems can lead to divergent impacts depending on the nature of existing relationships and interactions between tax officials and taxpayers.

A second major challenge is that tax officials often resist, manipulate, and in some cases sabotage technology reforms that constrain or monitor their behavior. After all, digitization of information permits greater scrutiny of staff activities, through automatic flagging of errors or data manipulation, generation of reports, and investigation of specific activities (for example, verifying that the outcomes of audits can be replicated with official records). However, in practice, these systems are often difficult to implement successfully, similar to findings among civil servants in other sectors (for example, Banerjee, Duflo and Glennerster (2008) document public sector nurses evading monitoring efforts in India).

A revealing case comes from customs officers in Madagascar. An information technology system was developed to assign customs inspectors randomly to customs declarations, at which import shipments are reviewed and tariffs are assessed. However, in practice, inspectors were able to contravene the official process to assign declarations to particular staff (Chalendar et al. 2023). The manipulation of the assignment process suggests that import brokers bribed staff to be paired with a preferred inspector, who would then facilitate evasion. Upon discovering this scheme, customs management outsourced the assignment process to a third party that used its own software to assign inspectors to declarations randomly. Even then, after a few months inspectors began withholding a portion of the declarations shared with the third party in order to continue to circumvent random assignment. This case drives home the strength of the incentives that tax officials often possess to engage in corruption and the need for bureaucratic reforms to create alternative incentives (e.g., by meaningfully raising the cost of being caught).

Political Incentives and Constraints on Tax Collection

Taxation is ultimately the coercion of resources from private citizens to the state, and, beyond the tools and personnel of a tax administration, high level political support is arguably the most important determinant of effective taxation. There is substantial evidence from low- and middle-income countries of tax liabilities that are known to the tax authority that go uncollected, despite the availability of relatively low-cost interventions that could be adopted. For example, for property taxes – where the tax base is visible and immobile, and thus presumably easy-to-tax – collection rates range between 5 and 16 percent in cities in Haiti (Krause, 2020), Liberia (Okunogbe 2021), Senegal (Knebelmann 2023), Ghana (Dzansi et al 2022), DRC (Bergeron et al., 2022), and Uganda (Manwaring and Regan 2023). This suggests that, in many cases, there is insufficient political motivation to pursue the collection of these liabilities by enforcing tax laws and imposing financial penalties and legal prosecution on non-compliant taxpayers, some of whom may be economically and politically powerful. A full discussion of the politics of taxation,

¹⁰ Some firms reported that this effect resulted from tax officials no longer being able to force them to pay more than their true liability to meet officials' revenue targets.

including bargains with elite taxpayers, reform design to manage resistance from the general population, and politics within the tax administration is beyond the scope of this paper and is extensively discussed in the political science literature (e.g. Martin 2023, Moore et al 2018, Pritchard 2019, Brautigam et al 2008, among others). Instead, we focus the discussion below on evidence relating to factors that determine political choices to invest in tax capacity or to deploy existing capacity.

Broadly, we can consider politicians as weighing the expected benefits and costs of taxation for re-election prospects. On the one hand, higher tax revenues may support re-election by funding the provision of public services, infrastructure investments, social protection, and other public programs that citizens value. On the other, taxing citizens may harm re-election by raising citizen expectations and demands for accountability. Interestingly, this accountability effect can be triggered by simply demanding taxes regardless of whether those taxes are paid. A study of a door-to-door property tax campaign in Kananga, DRC, found higher levels of citizen engagement even among those who were visited by tax authorities but did not comply (Weigel, 2020). More broadly, there exists cross-country evidence that tax collection declines prior to competitive elections, suggesting that governments act strategically to avoid negative backlash from citizens (Prichard, 2018).

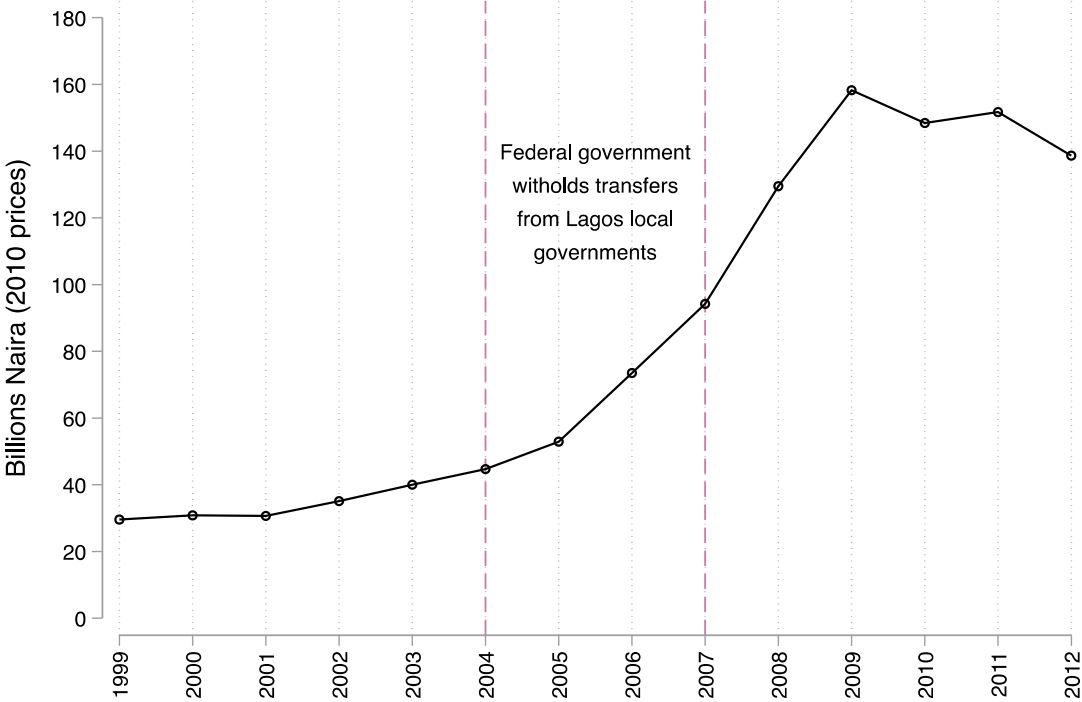
We discuss below three key factors that may shape the cost-benefit calculus of politicians in determining how much taxation to pursue: alternative revenue sources, political competition, and available technologies for reducing the salience and cost of collection. Alternative revenue sources may outright dampen the impetus to tax. Oil-rich states are a prominent example of a low-tax, low-accountability setting, where oil revenues support a high level of public spending without the need to tax citizens. For instance, oil rich gulf countries collect on average 3.6 percent of GDP as taxes (UNU-WIDER Government Revenue Dataset 2022). At the subnational level, transfers from the central government may dampen the motivation for local taxation. In Brazil, jurisdictions hit by a negative shock to federal transfers resulting from an update in their population count increased local tax collection by approximately 30 percent (Ferraz et al., 2023). Localities achieved these expansions of tax collection by broadening the tax base through increased investment in tax capacity, like improving property-tax registers and higher spending on tax agents.

The remarkable expansion of tax collection in Lagos State, Nigeria, offers an interesting historical case indicating the role of political competition, alongside other factors, in generating political support for taxation. Nigeria's government has a strong reliance on oil revenues and correspondingly low levels of non-resource tax collection, with only about 6 percent of GDP collected in non-oil taxes. Following the return to democracy in 1999, Lagos state recorded a dramatic growth in annual tax revenues (Figure 4), from about ₦30 billion in 1999 to over ₦150 billion in 2011 (measured in Nigerian naira in 2010 prices),¹¹ amounting to a fivefold increase in a little over a decade, before the growth tapers off. This revenue growth was greater than in the rest of the country.

¹¹ At 2010 exchange rate of 150 Naira to 1 USD, this is equivalent to growth from 200 million USD to 1 billion USD.

Analyses of this case have highlighted political, economic and personal factors (De Gramont 2015, Gaspar et al 2016, Cheeseman and De Gramont 2017, Bodea and LeBas, 2016). The ruling party in Lagos was an opposition party in stiff competition with the central government, and, in the nascent democracy, was keen to show that it could provide a better model of government and public services. Providing a steady source of domestic revenues was thus important not only for meeting the severe needs of road infrastructure, waste management, and security in a congested city, but also in securing funding to consolidate and expand political influence. Although the drive to increase taxation was already underway, the need for tax revenues was underscored in 2004 when the central government withdrew government transfers to Lagos local governments following a dispute over the creation of new local governments. The social conditions in Lagos, with a strong middle class and active civil society, pushed the local government to deliver public goods to win elections rather than the commonplace strategy of relying on patronage politics. Because Lagos is one of the most populous states and the commercial center of the country, the robust formal sector could support an expansion of personal income taxation through employer withholding. There were also widespread allegations that the leadership of Lagos state held a personal stake in the consulting company that was contracted to process the electronic tax payments, including a lawsuit by the company founder against the former governor of Lagos (Olawoyin 2020). Thus, personal benefit and the ability to solidify political power through access to finances may have provided an added incentive.

Figure 4: Tax Revenues in Lagos State



Data Source: Lagos State Government Digest of Statistics 2006, 2010, 2013.

Notes: Adjusted for inflation using the World Bank World Development Indicators Consumer Price Index with 2010 as the base year. Data on tax revenue is from the Lagos State Government Digest of Statistics 2006, 2010, 2013. The period between the red vertical lines indicates when the federal government withheld transfers from Lagos local governments.

In Lagos, the specific actions taken by the tax administration focused on deploying technology by introducing electronic payments and tax withholding, by creating an autonomous tax agency separate from the civil service, and by hiring and incentivizing skilled professionals. There was political support for enforcing tax laws, like imposing fines and sealing delinquent businesses. In addition, there was significant taxpayer education and outreach, and publicity campaigns to foster tax morale by linking the visible public infrastructure investments to the expansion in tax payments. Overall, this case suggests that success in increasing tax collection requires a combination of factors, including a well-motivated government and an ability to deploy diverse tools, particularly those relating to technology and personnel.

Another key factor that may influence a government's decision of how much to enforce taxes is the availability of technology tools that reduce the political and economic costs of taxation by making tax collection more automated and less salient. For example, using employers to withhold personal income taxes removes the need to require citizens to remit payments, and consumption taxes like the value-added tax may be less salient to citizens. Such tools or instruments may lead to less political resistance—but they only work well if the government has access to appropriate technology tools for implementing them. As an example from the United States context, Cabral and Hoxby (2012) show that property taxes are less salient to property owners who use the technology-aided practice of bundling their taxes with their monthly mortgage payment through a tax escrow account, compared to other homeowners with mortgages who make one or two large direct tax payments a year to the government. Areas with higher rates of escrow use also have higher property tax rates, suggesting that the lower salience and automation of collection allows those jurisdictions to collect more revenues.

One contemporary example of how the availability of technology can influence the tax choices of governments in low- and middle-income countries is the emergence of taxes on mobile money transactions in a number of African countries. Digital payments via mobile phones have seen substantial growth in the region, serving as a major driver of financial inclusion (Suri and Jack 2016). For governments, a major justification for taxes on mobile money transactions is to expand the tax net over large informal sectors that are traditionally outside the current reach of tax authorities. A mobile money tax is relatively easy to monitor and can be collected by telecommunication companies and service providers, without the need for a tax authority to make costly investments in identification, detection, and collection capacity. Critics have called it a “lazy tax” (Karombo 2022). Tellingly, the salience of the tax has led to stiff public opposition, with some countries having to reduce the tax rate (for example, Ghana, Tanzania, Uganda) and others to completely abandon it (like Malawi).

Lastly, the decision of whether or not to pursue investments in tax capacity may depend on the current levels of tax collection. In settings with low levels of tax collection, initial investments in tax capacity – such as building a tax database or establishing technology for tax monitoring –

typically have high financial costs but may yield only marginal revenue gains initially. As a result, at the early stages of trying to expand taxation, governments in this position can be caught in a bind: they do not yet have sufficient resources to significantly expand public good provision to respond to the increased demands, public scrutiny, and backlash that strengthening tax capacity might trigger among citizens. As such, political factors may contribute to the persistence of low tax-low accountability traps (Besley and Persson 2009).

Discussion

Transforming a nation's tax capacity requires intentional investments in the development of tax systems. Based on the growing body of evidence on this topic, we have highlighted the role that two factors – information technology and tax officials – can play in this process in low- and middle-income countries. We have discussed many of the relevant studies, and in Figure 5, we attempt to summarize recent work showing the range impacts from successful interventions.

Figure 5 displays effect sizes observed in experimental or quasi-experimental studies published since 2011 that examine tax interventions in low- and middle-income countries. We include five types of interventions that map to our framework and preceding sections: 1) identification focuses on interventions that help to identify or register taxpayers; 2) detection/third-party information refers to interventions that provide information on the liabilities of taxpayers; 3) collection-facilitation are interventions that make it easier to pay taxes; 4) collection-enforcement are interventions focused on the penalties for non-compliance; and 5) tax officials- incentives/deployment are interventions in these areas. Panel A shows effects on the extensive margin of compliance, the percentage of taxpayers that pay the tax, with effects measured in percentage point changes relative to the mean of the comparison group. It includes 19 interventions across 13 studies. Panel B shows the gains in tax revenues, expressed as a percent of the comparison sample mean. It includes 39 separate interventions across 26 different studies. As the goal is to show the relative effect sizes of successful interventions, in both panels, we include only headline effects that are statistically significant at the 10 percent level or lower. In addition, because low initial levels may magnify gains when expressed in percentage terms, darker dots indicate higher values of comparison means: that is, a given change is judged more substantial if achieved relative to a larger reference level.

The studies summarized in Figure 5, as well as the broader case study evidence discussed throughout the paper, suggest a wide menu of tax administration choices available to low- and middle-income countries. In Panel A, effect sizes are broadly similar across intervention categories, suggesting that extensive margin compliance can be increased from a variety of inputs to strengthening capacity.¹² Panel B shows that the largest revenue gains observed within this set of studies come from interventions aimed at improving collection via enforcement, deployment of tax officials (largest gains observed in this category are from studies of deployment rather than incentives), and improving detection via third-party information. In the most striking cases,

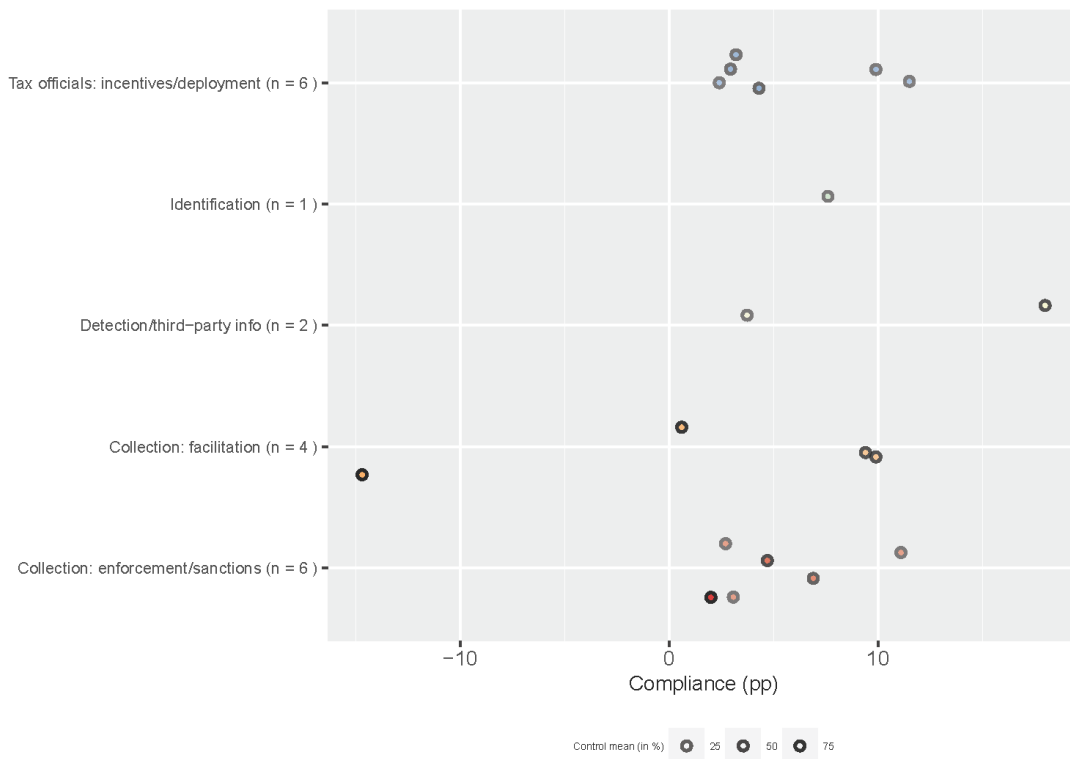
¹² The outlier, with a negative impact, is the Tajikistan e-filing result (Okunogbe and Pouliquen 2022) discussed previously, which likely resulted from reduced scrutiny by officials.

revenues have more than doubled or even tripled, even at substantial levels of existing tax collection.

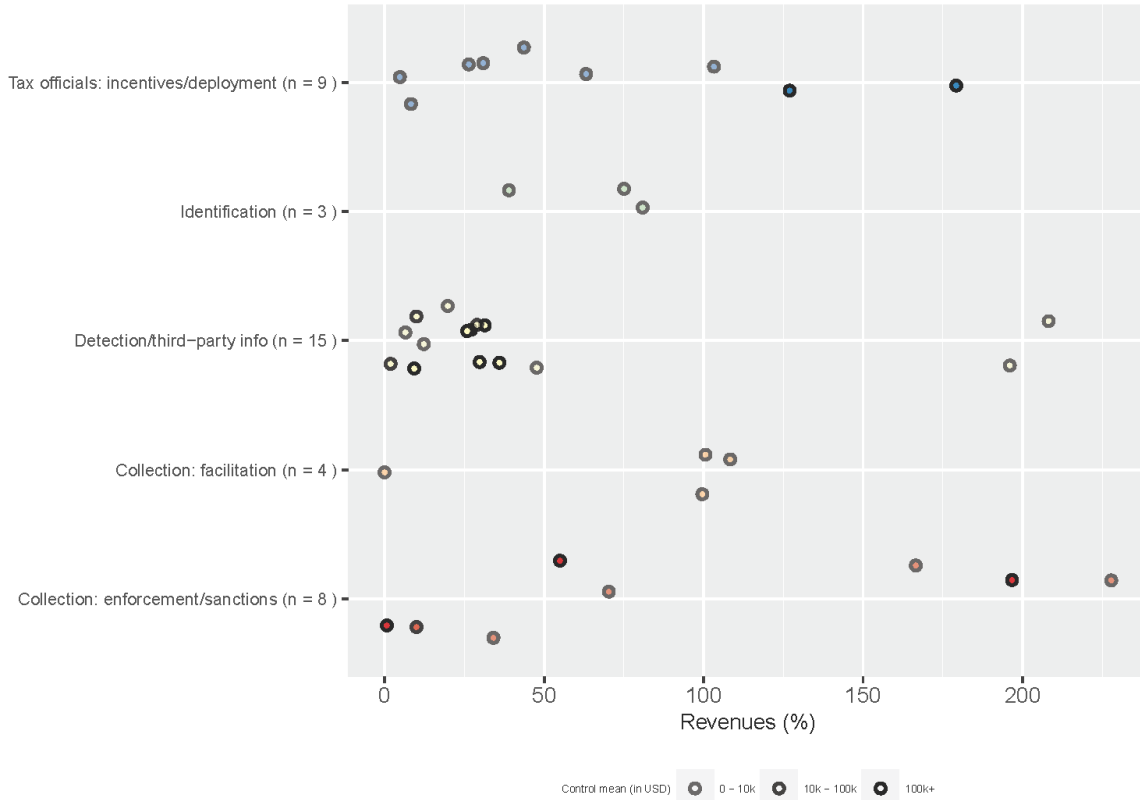
Of course, in interpreting the results in Figure 5, it is important to remember that many of these studies were done in local areas, not entire countries, and cover a range of different taxes. The interventions considered by this body of work are also a function of where research has thus far been feasible, and of where the interests of researchers have aligned with those of policymakers. Thus, both the evidence summarized in Figure 5 and the case studies we have called attention to in this paper are not meant to suggest a comprehensive nor “one size fits all” approach to tax administration choices for developing countries. After all, deliberations about tax mobilization will inevitably confront an array of issues, both economic and political. Instead, we intend our discussion to offer inspiration – and caveats – for governments and tax authorities considering the value of technologies and what implications their use carries for the direction of tax personnel.

Figure 5: Impacts of Tax Interventions

A. Compliance Impacts



B. Revenue Impacts



Source: The full list of studies and results compiled by the authors is available in Appendix II.

Notes: This figure displays the effect sizes of tax interventions from existing studies. The full list of studies and corresponding details can be found in the replication materials. The y-axis displays the type of interventions considered, followed by the number of effect sizes included for each type (denoted by n). For Panel A, the x-axis displays the change in tax compliance in percentage points. For Panel B, the x-axis displays changes in revenues in percentages. The opacity of encircled dots is relative to the size of the control means (denoted in % for Panel A, and in US dollars for Panel B) – that is, darker dots indicate higher value control means. In both the panels, each intervention type is captured by a different color of the encircled dots. Panel A includes 19 interventions compiled from 13 studies, and Panel B includes 39 interventions compiled from 26 studies.

There remains much to learn beyond our current understanding of how these factors contribute to tax capacity. One clear area for future exploration in particular is understanding how to take advantage of potential complementarities between technology and tax officials, where staff recruitment and skills will likely play important roles. Moreover, technological advances will undoubtedly pose evolving challenges for taxation, including how to tax digital activities and incorporate digital currencies. Finally, given how fundamental political support is for deploying tax capacity, it is imperative to build our understanding of the factors that shape how governments choose when, how, and how much to tax.

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Appendix

Appendix I: Cross Country Evidence on Use of Technology for Identification, Detection and Collection

As discussed under “Cross Country Evidence on Use of Technology for Identification, Detection and Collection”, we construct indices of taxation technology computed from individual measures drawn from the OECD Inventory of Tax Technology Initiatives (ITTI) (2023) Global Survey on Digitalisation, which collects measures of uses of technology and data for tax purposes. More information about the tax technology measures can be found at <https://www.oecd.org/tax/forum-on-tax-administration/tax-technology-tools-and-digital-solutions/>.

We construct indices from indicators for variables included in each set, described in detail below. To build each index we first sum the indicators and then standardize the resulting sum so that it has a mean of zero and standard deviation equal to 1. Appendix Table 1 below summarizes the estimates of the relationships between indices and tax-to-GDP in 2018.

- a. The taxpayer identification index is calculated from the indicators listed below. The unstandardized index (sum) has mean 3.51 and standard deviation 0.74.
 1. whether the tax authority requires taxpayers to have a digital ID
 2. the digital ID is built on an existing system
 3. a digital ID can be established using a unique identity number, government issued documents, or biometric information
 4. whether there are online services for registration for any tax type (PIT, CIT, VAT)
- b. The detection index is calculated from the indicators listed below. The unstandardized index (sum) has mean 4.41 and standard deviation 1.81.
 1. whether the tax authority receives data on taxpayers
 2. whether the tax authority receives data from third parties
 3. whether some taxpayers are required to submit e-invoices
 4. some taxpayers are required to maintain online cash registers
 5. the tax authority receives data from other government bodies
 6. there exists a common database across government bodies
 7. whether the tax authority uses AI to conduct risk assessments for any tax type
 8. whether the tax authority uses AI to detect evasion.
- c. The collection capacity index is calculated from the indicators listed below. The unstandardized index (sum) has mean 2.56 and standard deviation 1.16.
 1. taxpayers can file online for any tax type
 2. taxpayers can pay online for any tax type
 3. taxpayers can request an extension online for any tax type
 4. taxpayers can ask for a payment arrangement online for any tax type
- d. The “taxation technology” index used in Figure 2 is a summary index that includes all of the variables listed above. The unstandardized index (sum) has mean 10.49 and standard deviation 2.58.

Appendix Table 1: Taxation Technology and Tax-to-GDP

	Tax Revenues as a Share of GDP (2018)			
Index of Tax Technology	2.155*			
	(1.133)			
Index of Identification	1.679*			
	(0.858)			
Index of Detection	2.136**			
	(1.008)			
Index of Collection	0.033			
	(1.031)			
Country income group fixed effects	Yes	Yes	Yes	Yes
Countries	75	75	75	75

Notes: This tables displays the estimates of the relationship between tax revenues as a share of GDP and an indices of taxation technology for 74 individual countries. The tax revenues as a share of GDP measure is drawn from the International Survey on Revenue Administration (CIAT, IMF, IOTA, OECD 2022) using values for 2018. We fill in missing values for 7 out of 74 countries using UNU-WIDER (2022) data in 2018. The indices of taxation technology is computed from individual measures drawn from the OECD Inventory of Tax Technology Initiatives (ITTI) (2023) Global Survey on Digitalisation. The identification index is calculated from indicators for whether the tax authority requires taxpayers to have a digital ID, the digital ID is built on an existing system, a digital ID can be established using a unique identity number, using government issued documents, using biometric information, and whether there are online services for registration for any tax type (PIT, CIT, VAT). The detection index is calculated from indicators for whether the tax authority receives data on taxpayers, receives data from third parties, some taxpayers are required to submit e-invoices, some taxpayers are required to maintain online cash registers, the tax authority receives data from other government bodies, there exists a common database across government bodies, whether the tax authority uses AI to conduct risk assessments for any tax type, and whether the tax authority uses AI to detect evasion. The collection index is calculated from indicators for whether taxpayers can file online for any tax type, taxpayers can pay online for any tax type, taxpayers can request an extension online for any tax type, and whether taxpayers can ask for a payment arrangement online for any tax type. More information about the tax technology measures can be found at <https://www.oecd.org/tax/forum-on-tax-administration/tax-technology-tools-and-digital-solutions/>. All regressions include fixed effects for country income group. Standard errors in parentheses are robust.

Appendix II: Impacts of Tax Interventions

Below is the list of papers included in Figure 5. Details on the results included are provided in the online replication dataset.

Tax officials: incentives/deployment

Amodio, Francesco, Jieun Choi, Giacomo De Giorgi, and Aminur Rahman. "Bribes vs. taxes: Market structure and incentives." *Journal of Comparative Economics* 50, no. 2 (2022): 435-453.

Balan, Pablo, Augustin Bergeron, Gabriel Tourek, and Jonathan L. Weigel. "Local elites as state capacity: How city chiefs use local information to increase tax compliance in the democratic republic of the Congo." *American Economic Review* 112, no. 3 (2022): 762-797.

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Khan, Adnan Q., Asim I. Khwaja, and Benjamin A. Olken. "Tax farming redux: Experimental evidence on performance pay for tax collectors." *The Quarterly Journal of Economics* 131, no. 1 (2016): 219-271.

Ortega, Daniel, and Carlos Scartascini. "Don't blame the messenger. The delivery method of a message matters." *Journal of Economic Behavior & Organization* 170 (2020): 286-300.

Weigel, Jonathan L. "The participation dividend of taxation: How citizens in Congo engage more with the state when it tries to tax them." *The Quarterly Journal of Economics* 135, no. 4 (2020): 1849-1903.

Identification

Jouste, Maria, Milly I. Nalukwago, and Ronald Waiswa. "Do tax administrative interventions targeted at small businesses improve tax compliance and revenue collection?." *Evidence from Ugandan Administrative Tax Data.* (2021).

Okunogbe, Oyebola. "Becoming legible to the state : The role of identification and collection capacity in taxation." *World Bank Policy Research Working Paper 9852*, (2021)

Detection/third-party info

Ali, Merima, Abdulaziz B. Shifa, Abebe Shimeles, and Firew Woldeyes. "Building fiscal capacity in developing countries: Evidence on the role of information technology." *National Tax Journal* 74, no. 3 (2021): 591-620.

Bellon, Matthieu, Era Dabla-Norris, Salma Khalid, and Frederico Lima. "Digitalization to improve tax compliance: Evidence from VAT e-Invoicing in Peru." *Journal of Public Economics* 210 (2022): 104661.

Brockmeyer, Anne, Spencer Smith, Marco Hernandez, and Stewart Kettle. "Casting a wider tax net: Experimental evidence from Costa Rica." *American Economic Journal: Economic Policy* 11, no. 3 (2019): 55-87.

Carrillo, Paul, Dina Pomeranz, and Monica Singhal. "Dodging the taxman: Firm misreporting and limits to tax enforcement." *American Economic Journal: Applied Economics* 9, no. 2 (2017): 144-164.

Eissa, Nada, Andrew Zeitlin, Saahil Karpe, and Sally Murray. "Incidence and impact of electronic billing machines for VAT in Rwanda." *International Growth Centre Report* (2014).

Fan, Haichao, Yu Liu, Nancy Qian, and Jaya Wen. "Computerizing VAT invoices in China." No. w24414. *National Bureau of Economic Research*, 2018.

Londoño-Vélez, Juliana, and Javier Ávila-Mahecha. "Can wealth taxation work in developing countries? Quasi-experimental evidence from Colombia." In *Annual Congress of the IIPF*. 2018.

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Mittal, Shekhar, and Aprajit Mahajan. "VAT in emerging economies: Does third party verification matter?" *Available at SSRN 3029963* (2017).

Naritomi, Joana. "Consumers as tax auditors." *American Economic Review* 109, no. 9 (2019): 3031-3072.

Shah, Jawad. "Using computerized information to enforce VAT: Evidence from Pakistan." *Available at SSRN 4569607* (2020).

Collection: facilitation

Das, Satadru, Lucie Gadenne, Tushar Nandi, and Ross Warwick. "Does going cashless make you tax-rich? Evidence from India's demonetization experiment." *Journal of Public Economics* 224 (2023): 104907. <https://doi.org/10.1016/j.jpubeco.2023.104907>

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Collection: enforcement/sanctions

Aparicio, Gabriela, Paul E. Carrillo, and M. Shahe Emran. "Taxes, prisons, and CFOs: The effects of increased punishment on corporate tax compliance in Ecuador." *Available at SSRN 1808945* (2011).

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Holz, Justin E., John A. List, Alejandro Zentner, Marvin Cardoza, and Joaquin E. Zentner. "The \$100 million nudge: Increasing tax compliance of firms using a natural field experiment." *Journal of Public Economics* 218 (2023): 104779.

López-Luzuriaga, Andrea, and Carlos Scartascini. "Compliance spillovers across taxes: The role of penalties and detection." *Journal of Economic Behavior & Organization* 164 (2019): 518-534.

Mascagni, Giulia, and Christopher Nell. "Tax compliance in Rwanda: Evidence from a message field experiment." *Economic Development and Cultural Change* 70, no. 2 (2022): 587-623.

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