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Do Countries Really Deviate from the Optimal Tax System?

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Abstract

One of the main goals of the literature on optimal tax systems is to reduce the gap between the highly stylized theory of optimal taxation and the practice of fiscal policy reform. Unfortunately, however, we know little about the extent to which the international experience follows the policy prescriptions derived from economic theory or how those policy prescriptions would change with economic development. Based on the standard theory of optimal tax systems, this paper predicts the possible effects of economic development on the optimal level and composition of tax revenue and empirically tests these predictions with yearly data on three tax instruments from countries at different stages of development. On average, as countries develop they are shown to collect more tax revenue and switch from regressive tax instruments, like the value added tax, to more progressive taxes that become more productive with development, like personal and corporate income taxes.

Keywords: optimal tax system, marginal cost of funds, tax administration, redistribution

JEL codes: H20, H21

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1. Introduction

This paper uses the standard theory of optimal tax systems to predict possible effects of economic development on the optimal level and composition of tax revenue, and tests empirically the predictions of the model with yearly data on total tax revenue and tax revenue collections from three tax instruments—the personal income tax (PIT), the corporate income tax (CIT), and the value added tax (VAT)—and from large samples of developed and developing countries.

Economists are generally skeptical about the connection between tax theory and tax policy. For instance, Sørensen (2007, p.383) and Boadway (2012, p.2) argue that the contribution of optimal tax theory to tax policy is important, but the former observes that to many applied economists optimal taxation theory is so "technical and abstract" that have "little policy relevance;" while the latter recognizes that the connection between the two is "not direct" and "subtle." In order to better inform tax policy decisions, the literature on optimal tax systems pays special attention to a number of variables that constrain tax policies in practice, like the costs of tax compliance, tax avoidance and evasion, and the costs of tax administration, collection and enforcement. [1] Arguably, however, little is known about how the level of development affects the optimal tax system and whether countries follow the prescriptions derived from the theory of optimal tax systems.

[1] Slemrod and Gillitzer (2014) offer a complete overview of the theory, which considers the administration and compliance costs of taxation, tax evasion, issues on auditing, tax remittance, and the use of tax policy instruments different from the tax rate, like the breadth of the tax base and enforcement effort.

Most of the academic discussion about how optimal tax theory should translate into policy reforms seems to be inspired by the U.S. system and other developed economies. [2] Developing countries, in contrast, have received much less attention, and it is not yet clear how the optimal tax system should be designed when, for instance, institutions are immature and the tax administration agency has little technical and financial capacity to collect taxes. As pointed out by Casanegra de Jantscher (1990), "in developing countries tax administration *is* tax policy" (emphasis in the original). Slemrod (1990), Mayshar (1991) and Alm (1996) highlighted the importance of the costs faced by taxpayers and the tax collection agency for the design of the tax system. Later the literature on optimal tax systems has incorporated these and other insights but, to the best of my knowledge, none has attempted to explore how economic development alters the optimal level and composition of tax revenue. Related contributions, consistent with the findings of this paper albeit not within the framework provided by the literature on optimal tax systems, are Gordon and Li (2009) and Huang and Rios (2016). [3] The former argue that governments rely on bank records in order to enforce tax compliance, and that in poorer countries firms are more likely going to evade taxes by shifting to the informal sector. The greater threat of financial disintermediation limits the ability of governments in poorer countries to collect taxes, resulting in a relatively low share of tax revenue over GDP. Similarly, Huang and Rios (2016) argue developing countries rely more on consumption taxes because they are more enforceable than non-linear income taxes.

[2] See, for instance, Diamond and Saez (2011) and Mankiw, Weinzierl and Yagan (2009) for discussions about the tax system in the United States, and the *Mirrlees'* (2011) *Review*, which focuses on the tax system of the United Kingdom and it is intended to serve as a model of an optimal tax system for open developed economies.

[3] Kenny and Winer (2006) also study the composition of tax revenue sources around the world. A key difference is that here the theoretical analysis is based on the theory of optimal tax systems, not on a political economy theory.

The model used in this paper is based on Slemrod and Yitzhaki's (1996) decomposition of the marginal cost of funds into a marginal efficiency cost of funds and the Feldstein's (1972) distributional characteristic. These two concepts summarize the efficiency and equity costs of marginal tax revenue, and thus allow to represent the tradeoffs between efficiency, equity and revenue yield, the three basic attributes that describe an optimal tax system (Alm 1996). In practice, provided that decision makers routinely face tradeoffs between efficiency, equity and revenue yield, we can expect the theory of optimal tax systems to have empirical relevance.

The theoretical analysis in this paper suggest that, as long as economic development facilitates tax enforcement and thus makes tax collection agencies more effective in collecting tax revenue, as countries grow they tend to use more those tax instruments that allow for greater tax progressivity, like the PIT and the CIT. This can happen because other potentially more regressive tax instruments, like the VAT, are relatively easier to enforce and thus more easily implemented by poorer countries. [4]

The empirical analysis concludes that the *practice* of tax policy around the world roughly follows the prescriptions derived from the literature on optimal tax systems. In average, countries around the world do seem to take into account the tradeoffs between efficiency, equity and revenue yield in their tax policy decisions. Less developed countries rely more on the VAT, which is relatively efficient in terms of its capacity to produce a significant amount of tax revenue (Keen and Lockwood 2010) but regressive. When countries reach higher levels of development they are able to improve efficiency in the collection of progressive taxes, like the

[4] The VAT is commonly assumed to be regressive; however, Jenkins, Jenkins and Kuo (2006) show that certain characteristics of the tax, like formal or practical exemption of goods consumed by poor households, can possibly make it progressive. The discussion in this paper is based on the most common assumption that the VAT is regressive, or at most that is adds very little progressivity to the system.

PIT and the CIT, and choose to rely more on them. As a result of efficiency improvements and lower equity costs, total tax revenue is also shown to increase with economic development. Overall, the findings support the conclusion that the theoretical model is empirically relevant, as it describes empirical trade-offs between efficiency, equity and revenue yield.

The rest of the paper is organized as follows. The next section develops the theoretical framework and derives the optimal conditions for the use of tax instruments. Section 3 presents four testable hypotheses derived from the theoretical model. Section 4 presents the empirical analysis. Section 5 concludes.

2. Model

The model developed in this section is based on Mayshar (1991), Shaw, Slemrod and Whiting (2010) and Slemrod and Gillitzer (2014) analyses of optimal taxation in the presence of costly tax administration. Some important modifications to their framework are made: All variables are defined in monetary terms and uncertainty is assumed away for simplicity; taxpayers can "safely" (without penalty or probability of getting caught) shelter a certain amount of taxes from the tax authorities. There are only two tax bases i, consumption c (e.g. VAT) and income y (e.g. PIT or CIT).

2.1 Individual Taxpayer's Decisions

A taxpayer maximizes a quasiconcave utility function $u(c, y, G)$, where G is total government expenditure on public goods. Utility increases in c and G, and decreases in y due to the effort made to earn income (i.e. labor). Net after tax income y^n is defined as

$$y^n = (1 - t_y)(y - s_y) + s_y - \sigma_y(s_y, D_y, Y) - m_y(y) , \qquad (1)$$

where t_y is the income tax rate, s_y is the amount of income sheltered from the tax authorities (tax avoidance and tax evasion), σ_y the cost of sheltering income, and m_y the cost of income tax compliance. [5] Sheltering costs are assumed to be an increasing function of the amount of income sheltered; tax collection efforts related with the income tax, D_y, which consists of government spending in tax administration, collection and enforcement of the tax; and average per capita income in the economy, Y, which is used as a proxy for technological and institutional development. Tax compliance costs are assumed to be a positive function of y, reflecting a higher spending associated with greater tax burdens and additional sources of income.

Consumption is subject to a tax rate t_c and the taxpayer is able to shelter part of their consumption spending s_c at a cost σ_c. Considering the case in which taxpayers face no tax compliance costs for the consumption tax, then

$$c = (1 - t_c)y^n + t_c s_c - \sigma_c(s_c, D_c, Y)\ , \qquad (2)$$

where the sheltering cost is assumed to be a positive function of s_c, D_c, and Y.

If the income available after taxes and costs is fully spent on consumption, the taxpayer problem is to choose y, s_y and s_c to maximize their utility. The first order conditions are

$$(y) \qquad (1 - t_c)\frac{\partial y^n}{\partial y}\frac{\partial u}{\partial c} + \frac{\partial u}{\partial y} = 0 \qquad (3.a)$$

$$(s_y) \qquad \frac{\partial \sigma_y}{\partial s_y} = t_y \qquad (3.b)$$

$$(s_c) \qquad \frac{\partial \sigma_c}{\partial s_c} = t_c \qquad (3.c)$$

[5] Slemrod and Gillitzer (2014) offer a complete overview of the theory, which considers the administration and compliance costs of taxation, tax evasion, issues on auditing, tax remittance, and the use of tax policy instruments different from the tax rate, like the breadth of the tax base and enforcement effort.
[5] See, for instance, Diamond and Saez (2011) and Mankiw, Weinzierl and Yagan (2009) for discussions about the tax system in the United States, and the *Mirrlees'* (2011) *Review*, which focuses on the tax system of the United Kingdom and it is intended to serve as a model of an optimal tax system for open developed economies.

For any interior solution, conditions (3.a-c) describe the optimal behavior of the individual in terms of tax rates, tax compliance costs and sheltering costs.

2.2 Government Decisions with Identical Taxpayers

Assume for a moment that taxpayers are homogeneous, such that a benevolent government chooses the tax rates t_y and t_c and the level of tax collection effort D_y and D_c in order to maximize a representative taxpayer's utility. The presence of the optimal tax collection effort decisions in the model is justified by the fact that countries rarely have the ability to collect the tax burdens that comply exactly with the tax code. In practice, taxpayers' tax compliance is deficient and the government has limited means to improve it.

Total tax collections must be enough to cover the revenue requirement G, which is initially assumed to be exogenous, plus the cost of tax administration. The Lagrange for this problem can be written as

$$L = u(c, y, G) + \lambda\left[-G + t_y\left(y - s_y\right) + t_c(y^n - s_c) - D_c - D_y\right]$$

Using (1), (2) and (3.a-c), the first order conditions for the optimal government choices of tax rates can be expressed as: [6]

$$(t_y) \qquad \frac{\lambda}{\frac{\partial u}{\partial c}} = \frac{(1-t_c)(y-s_y)}{(1-t_c)(y-s_y)+\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial t_y}-t_y\frac{\partial s_y^*}{\partial t_y}}\,, \qquad (4.a)$$

$$(t_c) \qquad \frac{\lambda}{\frac{\partial u}{\partial c}} = \frac{y^n-s_c}{y^n-s_c+\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial t_c}-t_c\frac{\partial s_c^*}{\partial t_c}}\,. \qquad (4.b)$$

The right hand side of these conditions correspond to the marginal efficiency cost of funds ($MECF$) associated to t_i , $i = y, c$, as defined by Mayshar and Yitzhaki (1995). The numerator

[6] Kenny and Winer (2006) also study the composition of tax revenue sources around the world. A key difference is that here the theoretical analysis is based on the theory of optimal tax systems, not on a political economy theory.

represents the marginal cost of taxation in terms of individual consumption forgone, and the denominator represents marginal tax revenue. As in Slemrod and Gillitzer (2014), marginal tax revenue is affected by sheltering responses to the tax rate. Other things equal, greater tax rates that increase the erosion of the tax base ($\partial y^*/\partial t_i < 0$ and $\partial s_i^*/\partial t_i > 0$) also increase the $MECF$. This scenario characterizes the typical positive relation between tax rate and the $MECF$.

Moreover, assuming that the two taxes are associated with variable tax collection costs, the first order conditions for the optimal choices of tax collection expenditures lead to:

$$(D_y) \quad \frac{\lambda}{\frac{\partial u}{\partial c}} = \frac{(1-t_c)\frac{\partial \sigma_y}{\partial D_y}}{\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial D_y}-t_y\frac{\partial s_y^*}{\partial D_y}-1-t_c\frac{\partial \sigma_y}{\partial D_y}}, \tag{4.c}$$

$$(D_c) \quad \frac{\lambda}{\frac{\partial u}{\partial c}} = \frac{\frac{\partial \sigma_c}{\partial D_c}}{\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial D_c}-t_c\frac{\partial s_c^*}{\partial D_c}-1}. \tag{4.d}$$

The right hand side of these conditions can be interpreted as the marginal efficiency cost of tax collection efforts.

Note that the expressions in the left hand side of equations (4.a)-(4.d) are identical. This implies that the MECF of all tax instruments, including tax rates as well as tax collection efforts, must be equalized under the optimal tax system.[7] Another implication is that, in order to obtain an optimal solution that requires the use of two or more tax instruments, then the MECF of these tax instruments must be increasing in the respective tax rates. Otherwise the solution would involve the use of only one tax instrument.

[7] The VAT is commonly assumed to be regressive; however, Jenkins, Jenkins and Kuo (2006) show that certain characteristics of the tax, like formal or practical exemption of goods consumed by poor households, can possibly make it progressive. The discussion in this paper is based on the most common assumption that the VAT is regressive, or at most that is adds very little progressivity to the system.

2.3 Government Decisions with Heterogeneous Taxpayers

Now consider the case of heterogeneous taxpayers, in which distributional concerns become relevant to the government. Assume that there are H taxpayers h with different levels of income y^h. The social welfare function is assumed to have the following form

$$W\{u^1(c^1, y^1, G), \dots, u^H(c^H, y^H, G)\} \,,$$

and the budget constraint is thus given by

$$G = \sum_{h=1}^{H} t_y\left(y^h - y^e - s_y^h\right) + t_c\left(y^{nh} - s_c^h\right) - D_c - D_y \,.$$

For simplicity, we focus on the optimal government decision about t_y; analogous results can be obtained for t_c, D_y and D_c. Denoting the Lagrange multiplier as μ, the first order condition for the optimal income tax rate is

$$(t_y) \quad \mu = \frac{\sum_{h=1}^{H} \frac{\partial W}{\partial u^h}\frac{\partial u^h}{\partial c^h}(1-t_c)\left(y^h - s_y^h\right)}{\sum_{h=1}^{H}(1-t_c)\left(y^h - s_y^h\right) + \left(\frac{t_y}{t_c} + \frac{\partial y^{hn}}{\partial y^h}\right) t_c \frac{\partial y^{h*}}{\partial t_y} - t_y \frac{\partial s_y^{h*}}{\partial t_y}} \,, \qquad (5.a)$$

In order to obtain the traditional measure of the marginal cost of funds we divide the two sides of this condition by the social valuation of marginal consumption, $\sum_{h=1}^{H} \frac{\partial W}{\partial u^h}\frac{\partial u^h}{\partial c^h}$, which is the same for all tax instruments. The marginal cost of funds of the income tax is

$$MCF_{t_y} = \frac{MSWC_{t_y}}{MR_{t_y}} \,; \qquad (5.b)$$

where $MSWC_{t_y}$ is the marginal social welfare cost of rising one additional dollar of taxes, and MR_{t_y} the marginal revenue obtained with a small change in t_y. Following Mayshar and Yitzhaki (1995), the marginal cost of funds is decomposed into the marginal efficiency cost of funds and the Feldstein's (1972) "distributional characteristic" (DC):

$$MCF_{t_y} = \frac{\frac{1}{H}\sum_{h=1}^{H}(1-t_c)(y^h-s_y^h)}{MR_{t_y}} \cdot \frac{MSWC_{t_y}}{\frac{1}{H}\sum_{h=1}^{H}(1-t_c)(y^h-s_y^h)} = MECF_{t_y} \cdot DC_{t_y}\ . \qquad (5.c)$$

The value of the distributional characteristic increases when the burden of the tax falls more (less) heavily on individuals whose utilities from consumption are more (less) valuable for society. If a relatively high weight is assigned to the utility of the poor and the tax is progressive, then the distributional characteristic can be expected to be lower than one and get closer to zero as the progressivity increases; otherwise, if the tax is regressive the distributional characteristic can be greater than one.

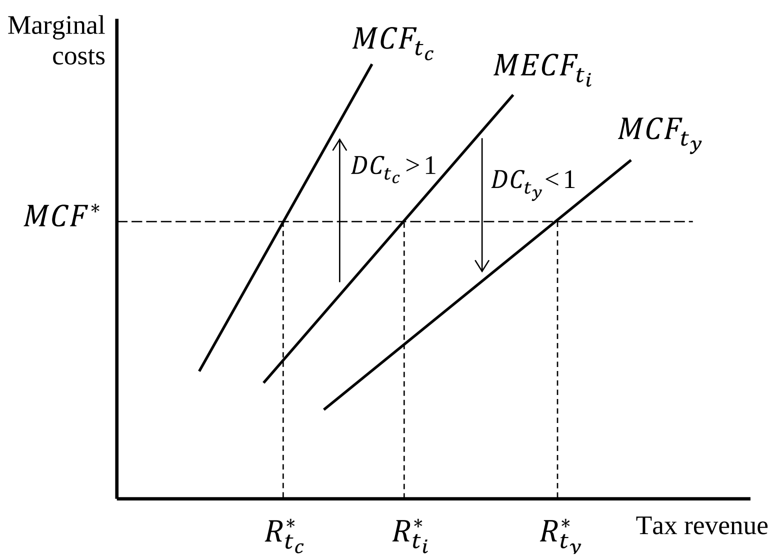
Note that the distributional characteristic depends on the distributional weights, which besides an idealized representation of societies preferences, could be interpreted –from a more positive (less normative) perspective– as the distributional preferences of the decision maker. Government authorities may have their own preferences for redistribution, which may be shaped by political economy considerations like their interest to increase the probability of reelection. This is important because it implies that the distributional characteristic does not necessarily depend on the actual income inequalities of a country.

An analogous expression of the marginal cost of funds can be obtained for the consumption tax rate, and it is also possible to obtain the marginal cost of tax collection efforts. Notwithstanding this fact, for the sake of simplicity the following discussion will focus especially on the marginal efficiency cost of funds and distributional characteristics associated with the tax rates t_c and t_y.

Figure 1 illustrates how the optimal tax mix is obtained under this model. The vertical axis represents marginal costs of tax revenue collection and the horizontal axis the amount of tax revenue R_{t_i} collected with each tax rate t_i. An internal solution with multiple tax instruments i requires the marginal cost of funds of all of them to be increasing in t_i. For a given value of the distributional characteristic, and assuming that R_{t_i} increases with t_i, this implies that the marginal efficiency cost of funds of each tax rate i, $MECF_{t_i}$, is also increasing in R_{t_i}.

An optimal tax system is characterized by the presence of a unique optimal marginal cost of funds MCF^* describing the marginal cost under each of the tax instruments used. Assume for simplicity that the optimal marginal cost of funds MCF^* has already been determined, and that the functions describing the marginal efficiency cost of funds of t_c and t_y are identical, and represented by $MECF_{t_i}$. In general, tax instruments that redistribute more in the decision maker's desired direction will be used more intensively. For instance, if the consumption of the poor is regarded as more relevant, and if an income tax increase is progressive while a consumption tax increase is regressive, then it should be the case that $DC_{t_c} > 1 > DC_{t_y}$, and thus also that, for any given amount of tax revenue, $MCF_{t_c} > MCF_{t_y}$. Under these assumptions a country would choose to rely more on the income tax, such that $R^*_{t_c} < R^*_{t_y}$.

Figure 1. Optimal Composition of Tax Revenue.



It is apparent that total tax revenue depends on the marginal cost of funds of the tax system, which in turn depends on the distributional effects and the efficiency of each tax instrument. As suggested by Alm (1996), therefore, the appropriate design of tax systems involves trade-offs between equity, efficiency and revenue yield.

3. Testable Hypotheses

Even though the behavioral responses to tax policy, the costs of tax compliance, tax shielding and tax administration are generally unknown and can vary considerably across countries, the model described in the previous section can be used to identify four testable hypotheses about the effect of tax rates and development on the level and composition of tax revenue:

Hypothesis 1: Decreasing marginal effect of tax rates on own tax revenue (positive slope of $\boldsymbol{MECF_{t_i}}$ function). A necessary condition for an internal solution with two or more tax instruments is that, for any given distributional characteristic, the marginal efficiency cost of funds of each t_i should increase with tax revenue R_{t_i}. This relationship is represented by the positive slope of $MECF_{t_i}$ in Figure 1; it implies that marginal tax revenue MR_{t_i} is decreasing in R_{t_i}, and that subsequent increases in the tax rate t_i will lead to a reduction in own marginal tax revenue MR_{t_i}. Evidence in support of hypothesis 1 would imply that this necessary condition for an internal solution is satisfied in practice, such that the model can validly be used to explain the size and composition of tax revenue.

Hypothesis 2: Positive effect of economic development on own marginal tax revenue (downward shift of each $\boldsymbol{MECF_{t_i}}$ function). Provided that economic development increases the size of the tax bases, and is accompanied with institutional and technological improvements that could possibly reduce tax collection costs and incentives for non-compliance, then it can be expected (although not with certainty) to increase marginal revenue at any given tax rate and for any tax instrument.

Economic development is typically accompanied with higher individual income, improved technology, and institutional development. Improved technology and institutional development can be expected to reduce the tax collection costs due to, for instance, a greater proportion of transactions and activities registered in the formal economy, more skilled personnel and efficiency gains available to the tax agency. The empirical section will provide some evidence for this assumption. For now, note that a technologically advanced tax collection agency may be better able to reduce tax compliance costs and the share of the tax base that is sheltered by the taxpayers. This is especially relevant for taxes that require a great deal of data collection and processing, like the income taxes. In Figure 1, the reduction of tax collection costs, tax compliance costs and tax avoidance can be represented by a downward shift of $MECF_{t_i}$.

Hypothesis 3: Positive effect of economic development on total tax revenue (reduction of $\boldsymbol{MCF^*}$). Provided that economic development helps to increase marginal tax revenue for some tax instruments (hypothesis 2), and assuming that the demand for public expenditure is exogenous and downward sloping, then economic development allows to reduce the optimal marginal cost of funds MCF^* at the national level and thus also to increase the optimal amount of *total* tax revenue. Moreover, in line with Casanegra de Jantscher (1990), less developed countries—which presumably have more limited information about tax bases, suffer from deficient (more expensive) technologies at the government and personal levels, and may even have weaker institutions—can be expected to have more room to increase tax revenues by making changes to administration, collection and enforcement efforts. The last point suggests that the effect of development on total revenue can be greater for less developed countries.

Similarly, the optimal amount of total tax revenue may also increase if economic development allows to better target taxpayers' income and thus reduce the value of the distributional characteristics. When economic development is accompanied with greater consumption for individuals of all income levels, then if the marginal utility of consumption is diminishing, the value of distributional characteristic will likely decrease for some tax instruments, leading to an increase in the optimal amount of total tax revenue. In addition, the value of the distributional characteristic of a tax increases if tax compliance costs are regressive and countries assign greater weights to the marginal utility of the poor. There is a growing literature concerned with the costs that taxation imposes on individual and corporate taxpayers. Estimates of tax compliance costs for the United States can be found in Fichtner and Feldman (2013). Coolidge (2012) provides a review of empirical findings about tax compliance costs for firms in developed and developing countries. Many of the conclusions of these studies are country specific, but some general findings are useful for this discussion. For instance, regressive tax compliance costs are a clear finding in both developed and developing countries, and regressivity seems to be worse in the latter. Evans (2008) concludes that compliance costs are generally significant, regressive and non-decreasing over time, and Barbone, Bird and Vazquez-Caro (2012) discuss additional evidence that support these conclusions. Based on tax compliance studies in South Africa, Yemen, Peru and Ukraine, Coolidge (2010) shows that compliance costs of firms are relatively fixed, representing minor burdens for large firms but very significant burdens for small firms. At the cross-country level, these findings suggest that development reduces the relative importance of tax compliance costs and thus tends to reduce the value of distributional characteristics of available instruments.

This hypothesis provides a complementary explanation to the wide array of existing theories about the size of government, most of which are focused on demand-side political economy considerations.[8]

Hypothesis 4: Effect of economic development on tax revenue composition. Provided that economic development helps to increase marginal tax revenue and to reduce the value of the distributional characteristic of some the tax instruments available, then greater levels of development will be associated with a more intensive use of those tax instruments.

In particular, the tax instruments whose marginal tax revenue increases with economic development will be identified by the empirical analysis of hypothesis 2.

Identifying the tax instruments whose distributional characteristics decrease with economic development is, unfortunately, not possible with the available data. To overcome this limitation, the empirical analysis proceeds under two assumptions. One is that direct taxes like the PIT and the CIT allow for higher degrees of progressivity, and that indirect taxes like the VAT are more regressive. The other assumption is that higher income inequalities are considered undesirable by the decision makers, such that they increase the value of the distributional characteristics. Based on these assumptions, the model predicts that as countries develop they will use the PIT and CIT more and move away from the VAT.

Even without advanced technologies and limited tax enforcement capacity, less developed countries can rely on the VAT to collect significant amounts of tax revenue. Indeed, the VAT has been referred to as a "money machine" due to its power to increase tax revenue collection (Keen

[8] The best known theory about the effects of development on government size is the so called Wagner's law, which states that the relative size of government increases with real GDP per capita due to the greater complexity of government functions and the luxurious nature of public goods and services. See Shelton (2007) and Funashima (2017) for evaluations of the Wagner's law and surveys of alternative theories of government size.

and Lockwood 2010), and it is well known that less developed countries rely more on this tax instrument in spite of its regressive effects (Huang and Rios 2016). When countries develop, however, the model suggests that they will partially replace the VAT with more progressive tax instruments.

4. Data and Empirical Analysis

This section provides empirical evidence supporting the hypotheses presented in the previous section. The data consists of two unbalanced panels. Database I, based mainly on the USAID Collecting Taxes database, provides more cross country information and covers up to 154 countries during the period 2008-2013. Database II, based on Vegh and Vuletin (2015) and IMF's World Revenue Longitudinal Data set (WoRLD), covers up to 140 countries during a longer period of time: 1990-2017. The subsamples used vary in terms of the number of countries and observations, which have been maximized as allowed by data availability but in some case some observations have been dropped to ensure comparability of results.[9]

4.1 Data Description

The empirical analysis focuses on three major sources of tax revenue, the personal income tax (PIT), the corporate income tax (CIT), and the value added tax (VAT). Tables 1A and 1B (see Appendix 4) present the summary statistics of the variables from Database I and Database II, respectively. The main independent variable is the (natural) *log of GDP per capita*, expressed in purchasing power parity (PPP) of 2011 US dollars, which is used to represent the level of development and the non-linear relationship effects that this variable is expected to have on the size and composition of tax revenue.[10] The (natural) *log of population* is included in all

[9] Appendix 2 contains the lists of countries considered in each database and the subsamples used in the different econometric specifications.
[10] Appendix 3 provides variable definitions and data sources.

regression to isolate scale effects not explicitly captured by the optimality conditions presented in Section 2. With few exceptions, other controls are excluded because they either severely reduce the number of observations or are highly correlated with *log of GDP per capita*. Although statistically costly, their exclusion has been necessary to ensure that *log of GDP per capita* can fully display its explanatory power in a complex analysis that consists of several regressions (11 different dependent variables, some evaluated with the two databases, and different income groups and econometric models) that need to be interpreted jointly. In this context, in order to control for common international trends and unobserved heterogeneity, all panel data regressions include year dummies (not shown) and either regional or country fixed effects.

The dependent variables in the analysis of hypotheses 1 and 2 are the marginal tax revenues of alternative tax instruments, represented here by changes in the productivity measures of the three tax instruments. The productivity of a tax instrument is defined as the average tax revenue collected (as percent of GDP) for each percent point of the tax rate.[11] For instance, *VAT productivity* is computed as total VAT collections as percent of GDP divided by the standard VAT rate. A reduction (increase) of average tax revenue per percentage point of the tax rate implies that marginal revenue is decreasing (increasing) in the tax rate. The data show that the average productivity of the PIT tends to increase with the level of development. For the CIT and the VAT low income countries display, in average, lower productivities, but there is no clear trend across income groups.

[11] This measure is also considered as a proxy for efficiency. For instance, Aizenmana and Jinjara (2008) use it as a proxy for the efficiency of the VAT. This interpretation is consistent with the definition of the marginal efficiency cost of funds in expressions (4.a-b) and (5.b-c).

[14] Regressions (1.a-b) are sensitive to the inclusion of the interaction term between GDP per capita and the low income dummy. If this variable is excluded, the coefficient of the *growth rate of GDP per capita* becomes significant at the 5% level.

Important control variables used to test hypotheses 1 and 2 are the tax rates (maximum or standard) of the PIT, CIT and VAT, which do not appear to vary systematically across income groups.

The dependent variables used to analyze hypotheses 3 and 4 are total tax revenue as a percent of the GDP; tax revenue collected by the PIT, CIT and VAT as percentages of total tax revenue (only in Database I), and as percentages of de GDP. Again, only the PIT appears to have a clear tendency to increase as a percentage of both total tax revenue and the GDP when the level of development goes up.

Additional controls included in Database I are *tax administration costs*, defined as total costs of administering the tax system as a percent of tax revenue; *large taxpayer unit*, a dummy that takes the value of 1 if the country has an agency specialized in large taxpayers, and 0 otherwise; *SARA*, a dummy that takes the value of 1 if the country has a semi-autonomous revenue agency, and 0 otherwise; and the *Gini coefficient*, which is defined between 0 and 100 and increases with the extent of income inequalities.

4.2 Analysis of Hypotheses 1 and 2

We first focus on the regression results pertaining hypotheses 1 and 2. The dependent variables are given by the tax productivity measures, which are used as proxies of marginal tax revenue. Tables 2A and 2B show the results obtained with Database I, while Table 2C presents the results obtained with Database II (see Appendix 4). In general, we are not interested only on statistically significant results; no statistical significance can be equally informative.

The regressions in Table 2A are based on the Random-Effects Generalized Least Squared model. Given that the time period is relatively short, within country variations of tax policy instruments and the level of development are small and statistically weak. The Random-Effects model allows to exploit the cross-country variation of these variables. Regional dummies are added to partially control for unobserved fixed effects. Standard errors of all regressions are robust to cross-sectional heteroskedasticity and clustered by country, thus also robust to within-panel serial correlation. Each econometric specification is evaluated with the full set of observations available, as well as with the alternative income groups.

The effects of tax rates on tax productivity are consistent with hypothesis 1. An increase in the maximum PIT rate has a negative and significant effect on PIT productivity in the full sample (regression 1) and within income groups (regressions 2-4), implying that marginal revenue of the PIT decreases with the tax rate. Similar results are found for the CIT and VAT (regressions 5-12), although the negative effects of the CIT are not obtained for high income countries (regression 8). These results are consistent with upward sloping $MECF$ functions for the three tax instruments.

Economic development, represented by the *log of GDP per capita*, has a positive effect on the productivity of the PIT and CIT in the full sample regressions (1 and 5), supporting hypothesis 2 for these two tax instruments. For the PIT the effect is significant at the 5% level and for the CIT at the 1% level. However, for the VAT the relationship is not statistically significant. The effects within income-groups vary widely across tax instruments. For the PIT, a positive and significant effect of development is verified only within the high income group (regression 4), suggesting that as development increases within this group there is a significant shift downward of its $MECF$ function. For the CIT, a similar shift is verified only among low income countries (regression 6). For the VAT, development has the opposite effect among middle and high income countries (regressions 11 and 12).

Table 2B presents the regression results obtained under the Dynamic panel data model System GMM (Generalized Method of Moments). This model is appropriate for panel data with few (less than 10) periods and a large number of countries in which fixed effects can be of importance. The inclusion of autocorrelation terms (coefficients not shown) and the instruments' requirements lead to a reduction in the number of observations. Nevertheless, the previous results are mostly confirmed. Tax rates appear to have negative marginal effects on their respective productivity measures. Interestingly, and similar to what was obtained in Table 2A, regression (9), the CIT rate appears to have a negative effect on VAT productivity, suggesting that higher CIT rates may be eroding the tax base of the VAT. Regarding hypothesis 2, the level of development has a positive effect on the productivity of the PIT and CIT. An additional control variable, defined as the level of development only for low and lower-middle countries (and 0 otherwise), is included to capture possible differences in the effect of development on marginal tax revenue between lower and higher income countries. The coefficient of this variable is significant only in regression (2), and shows that the effect of development on marginal tax revenue of the CIT is higher in lower income countries.

Table 2C presents the results obtained with Database II. A longer period of up to 28 years provides greater within-country variation, allowing for more meaningful estimates of causal within-country effects under the Fixed-Effects model. These regressions include autoregressive terms to control for serial autocorrelation. In addition, in regressions (1)-(3) the *log of GDP per capita*, which possesses a unit root, is replaced by its first difference, which is stationary. The first difference in the natural logarithm is approximately equal to the growth rate of a variable. In order to make sure that this conceptual change does not distort the interpretation of the results, regressions (4)-(6) consider instead the difference of the quadratic function of the *GDP per* *capita*. The results under the two specifications are largely consistent. Again, hypothesis 1 is strongly confirmed and hypothesis 2 is confirmed only partially. After controlling for possible different effects of development in low and lower-middle income countries, the '*growth rate' of GDP per capita* appears to have a negative effect on the marginal tax revenue of the PIT. This result is unexpected, and it may be related with the greater ability of higher income individuals to avoid or evade the PIT. In the case of the CIT, hypothesis 2 is confirmed regardless the level of development, but there is no evidence suggesting that the level of development affects the productivity of the VAT. The latter result, which is largely consistent across Tables 2A, 2B and 2C, suggests that less developed countries may face no systematic disadvantage in the collection of the VAT.

Another interesting result is the positive cross base effects between the PIT and the CIT. The PIT rate has a positive effect on CIT productivity and the CIT rate has a positive effect on PIT productivity. This may be explained by optimizing behavior of taxpayers, who faced with one higher tax rate may try to switch to another income source, increasing the tax base and the productivity of the latter. It is important to acknowledge that differences with respect to the previous results may be influenced by both the longer time period and the smaller sample of countries.

As discussed, positive effects of development on tax productivity can be partially explained by administration cost savings due to technological and institutional improvements. Table 3 (see Appendix 4) provides evidence about the effect of development on tax administration costs, measured as a percent of tax revenue. Unfortunately, the number of observations available is not large and less developed countries are underrepresented; thus the results obtained are far from conclusive. Regressions (1)-(3) present Random-Effects coefficients obtained with the full sample and two income groups; regional dummies are omitted because they render the variables of interest irrelevant. Regressions (4) and (5) present Dynamic System GMM coefficients for the full sample of countries, without and with regional controls, respectively. The share of tax revenue used to cover tax administration costs is shown to decrease as the level of development goes up. This effect is observed in the full sample regressions (1), (4) and (5), as well as the low and low-middle income group in regression (2). The evidence about the relevance of the other controls is not robust. Only for the low and low-middle income group the presence of a large taxpayer unit helps to reduce administration costs. The presence of semi-autonomous tax collection agency appear to be relevant to explain administration costs only in the dynamic model. Development and the other controls have very little explanatory power among high and upper-middle income countries, as suggested by regression (3).

In general, the results in Table 3 suggest that development does lead to lower administration costs, especially in less developed countries. This may be one reason behind the positive effect of development on tax productivity obtained in support of hypothesis 2 for the PIT (under some specifications) and the CIT.

4.3 Analysis of Hypotheses 3 and 4

Tables 4A and 4B (see Appendix 4) present the regressions testing hypotheses 3 and 4, using Database I. Table 4A presents a simple cross-country analysis intended to compare tax policy choices made at different level of development, but not necessarily implemented timely in response to economic growth. In order to minimize the influence of short-term business-cycle effects, all variables are defined as averages for the period 2008-2013. This analysis is based on Database I because it provides information for a greater number of countries; however, similar results are obtained with Database II and alternative time periods (not presented).

The results provide strong evidence in support of hypothesis 3. Regressions (1.a-b) and (5.a-b) show that the level of development has a positive and significant effect on total tax revenue. This result is robust to the functional form used (log or quadratic), and the inclusion of regional effects. The conclusion of a positive effect of development is reinforced by the importance of regional effects, shown to be significant and mostly negative with respect to the base group, Western Europe, which consists only of high income countries.

In particular, regressions (5.a-b) attempt to capture the role of the distributional components. If it is true that development allows countries to better target the preferred income distribution with progressive tax instruments and move away from regressive taxes, then the resultant lower value of distributional components would increase the optimal amount of total tax revenue. In this context, greater inequalities leading to a greater switch toward progressive tax instruments would have a positive effect on total tax revenue. This is the result obtained in regression (5.a), significant at the 10% level. The coefficient of the interaction term between development and the *Gini coefficient* is negative, suggesting that the value of the distributional characteristic decreases more slowly, or maybe that the need for redistribution is smaller, at higher levels of development.

The other regressions in Table 4A focus on tax revenue composition. According to hypothesis 4, economic development allows countries to substitute away from the VAT, and increase tax revenue collections from the PIT and CIT (as a percentage of total tax revenue). These predictions are soundly confirmed for the case of the PIT, but not for the CIT, and only partially for the VAT. The significant negative effect of development on relative VAT collections is robust to the use of different non-linear functional forms and regional effects (4.a-b), but not to the inclusion of the *Gini coefficient* (8.a-b).

Table 4B presents a panel analysis based on Database I. Again, the models used are Random-Effects GLS and Dynamic System GMM. In line with hypothesis 3, regressions (1) and (5) show that economic development has a positive effect on the share of tax revenue over GDP. This conclusion is also reinforced by the sign and significance of the regional dummies. In both regressions all the coefficients of regional dummies have a negative sign and are significant at least at the 5% level. Since the base group, Western Europe, consists of high income countries, the negative sign means in several cases that countries with lower levels of development have a lower share of tax revenue over GDP.

The effects of economic development on revenue composition, this time defined with respect to the GDP instead of total tax revenue (to be able to associate the results with those in Tables 2A and 2B), are estimated by the regressions (2)-(4) and (6)-(8). The *log of GDP per capita* has a positive and significant effect, at the 5% level, on the PIT share only under the Dynamic System GMM model in regression (6); however, both regressions (2) and (6) show negative signs and significance of the regional controls, suggesting that development does have a positive effect of on the relative use of the PIT. For the case of the CIT, development has a more robust positive effect; and for the case of the VAT development is shown to have no discernible effect on its relative importance.

Importantly, note that the last results are consistent with the results obtained in Tables 2A and 2B: The effect of development on the shares of the three tax instruments is positively related to its effects on their productivity. This means that, as countries develop, they appear to increase more the use of those tax instruments that become more productive. This conclusion provides evidence in support not only of hypothesis 4, but also of the framework described in section 2, in which tax productivity and tax composition are shown to be simultaneously determined.

Table 4C (see Appendix 4) presents the results obtained with Database II and the Fixed-Effects model. Regressions (1)-(5) use data from all countries and regressions (6)-(10) from low and lower-middle income countries. The growth of per capita GDP appears to have a positive effect on total tax revenue, providing additional support for hypothesis 3, but significant effects are only obtained in regressions (2.a-b) and (7.a-b), where the sample is restricted (for comparability purposes) to those observations also available for the PIT and CIT cases.

Hypothesis 4, focused on the effects of economic development on revenue composition, is evaluated by regressions (3)-(5) and (8)-(10). The *growth rate of GDP per capita* has a clear positive and significant effect only on the CIT share, although the effect appears to be smaller for low income countries. The share of the PIT does not increase with the *growth rate of GDP per capita*, implying that in average countries did not take advantage of the potential progressivity of this tax during the period 1990-2017. Finally, and consistent with the results from Table 4B, the VAT share does not appear to change with economic development.

Overall, the empirical results partially confirm hypotheses 3 and 4. Total tax revenue is shown to increase in most specifications with the level of development, while the choice of specific tax instruments is very consistent with the effects of development on their tax productivities.

5. Conclusions

The theory of optimal tax systems incorporates key constraints to the tax policy decisions, including tax avoidance and evasion, the costs of tax compliance, and the costs of tax administration, collection and enforcement. The inclusion of these variables allows to add practical relevance to the discussion of the optimal tax problem, and to explicitly describe the tradeoffs between efficiency, equity and revenue yield. However, to date there have been no attempts to verify if the theory can be used describe actual tax policy decisions, and how economic development affects the optimal tax system.

This paper analyzes the optimal conditions for the implementation of an optimal tax system, and contributes with four empirical results. First, the productivity of the three tax instruments analyzed decreases with the tax rate. This finding confirms the theoretical prediction about the positive slope of the marginal cost of funds of tax revenue sources. The paper also reaches three conclusions about the effects of development on the optimal tax system. First, economic development leads to efficiency gains in the collection of the personal income tax and the corporate income tax, but not in the collection of the value added tax. Second, these efficiency gains seem to reduce the overall marginal cost of funds of the system, leading to an increase in the optimal level of public expenditure and thus also to greater tax revenue collections. Third, optimal tax revenue composition depends on efficiency and equity considerations that vary with the level of development. Less developed countries rely more on the VAT in spite of its regressive effects, because it offers a great tax revenue potential that does not depend on the level of development. In contrast, higher income countries rely more on the PIT, likely because it allows for greater tax progressivity. Finally, increases in GDP per capita appear to increase both the productivity and the use of the CIT regardless the level of development.

The theory of optimal tax systems is shown to be remarkably effective in describing and predicting the level and composition of tax revenue across countries at different levels of development. The analysis presented in this paper provides empirical support to this theory, which is shown to have applications not previously exploited in the literature. However, much remains to be done in order to advance our understanding of optimal tax systems and the empirical validity of this theory. For instance, the formulation of the hypotheses presented in this paper largely consisted of verbal arguments based on findings of the literature. A more rigorous derivation based, for instance, in comparative static analysis, may shed light on additional relevant determinants and functional relationships. The empirical analysis presented in this paper could also be improved significantly with the use of a large and balanced panel database. This may facilitate the inclusion of additional controls, which would help understanding the channels through which economic development affects the level and composition of tax revenue. Finally, the paper focuses exclusively on the optimal tax system, but it does not explore the conditions that may induce countries to deviate from it. A careful consideration of these conditions may lead to a number of relevant empirical questions.

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Appendix 1.A. Derivation of (4.a)-(4.d)

The first order condition for t_y is

$$\left[(1-t_c)\frac{\partial y^{n*}}{\partial t_y}\right]\frac{\partial u}{\partial c}+\frac{\partial u}{\partial y}\frac{\partial y^*}{t_y}+\lambda\left[y-s_y+t_y\left(\frac{\partial y^*}{\partial t_y}-\frac{\partial s_y^*}{\partial t_y}\right)+t_c\frac{\partial y^{n*}}{\partial t_y}\right]=0\ , \qquad \text{(A.1)}$$

where, based on (1) and using (3.b), $\frac{\partial y^{n*}}{\partial t_y}=-(y-s_y)+\frac{\partial y^n}{\partial y}\frac{\partial y^*}{\partial t_y}$.

Using also (3.a), condition (A.1) can be reduced to

$$-(1-t_c)(y-s_y)\frac{\partial u}{\partial c}+\lambda\left[(1-t_c)(y-s_y)+\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial t_y}-t_y\frac{\partial s_y^*}{\partial t_y}\right]=0.$$

Rearranging, $\frac{\lambda}{\frac{\partial u}{\partial c}}=\frac{(1-t_c)(y-s_y)}{(1-t_c)(y-s_y)+\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial t_y}-t_y\frac{\partial s_y^*}{\partial t_y}}$, which is equal to (4.a).

Similarly, the first order condition for t_c is

$$\left[-y^n+s_c+(1-t_c)\frac{\partial y^{n*}}{\partial t_c}\right]\frac{\partial u}{\partial c}+\frac{\partial u}{\partial y}\frac{\partial y^*}{t_c}+\lambda\left\{y^n-s_c+t_y\frac{\partial y^*}{\partial t_c}+t_c\left(\frac{\partial y^{n*}}{\partial t_c}-\frac{\partial s_c^*}{\partial t_c}\right)\right\}=0\ .$$

Using (3.a) and (3.c) this expression can be reduced to

$$-(y^n-s_c)\frac{\partial u}{\partial c}+\lambda\left[y^n-s_c-t_c\frac{\partial s_c^*}{\partial t_c}+\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial t_c}\right]=0\ \text{, and}$$

$$\frac{\lambda}{\frac{\partial u}{\partial c}}=\frac{y^n-s_c}{y^n-s_c+\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial t_c}-t_c\frac{\partial s_c^*}{\partial t_c}}\text{, which is equal to (4.b).}$$

The first order condition for the optimal choice of D_y is

$$(1-t_c)\frac{\partial y^{n*}}{\partial D_y}\frac{\partial u}{\partial c}+\frac{\partial u}{\partial y}\frac{\partial y^*}{D_y}+\lambda\left[t_y\left(\frac{\partial y^*}{\partial D_y}-\frac{\partial s_y^*}{\partial D_y}\right)+t_c\frac{\partial y^{n*}}{\partial D_y}-1\right]=0\ , \qquad \text{(A.2)}$$

where $\frac{\partial y^{n*}}{\partial D_y}=\frac{\partial y^n}{\partial y}\frac{\partial y^*}{\partial D_y}-\frac{\partial \sigma_y}{\partial D_y}$. Using (3.a), (A.2) can be reduced to

$$\frac{\lambda}{\frac{\partial u}{\partial c}}=\frac{(1-t_c)\frac{\partial \sigma_y}{\partial D_y}}{\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial D_y}-t_y\frac{\partial s_y^*}{\partial D_y}-1-t_c\frac{\partial \sigma_y}{\partial D_y}}\text{, which is equal to (4.c).}$$

Finally, the first order condition for D_c is

$$\left[(1-t_c)\frac{\partial y^n}{\partial D_c}-\frac{\partial \sigma_c}{\partial D_c}\right]\frac{\partial u}{\partial c}+\frac{\partial u}{\partial y}\frac{\partial y^*}{D_c}+\lambda\left[t_y\frac{\partial y^*}{\partial D_c}+t_c\left(\frac{\partial y^{n*}}{\partial D_c}-\frac{\partial s_c^*}{\partial D_c}\right)-1\right]=0\ .$$

Using (3.a) this can be reduced to $\frac{\lambda}{\frac{\partial u}{\partial c}}=\frac{\frac{\partial \sigma_c}{\partial D_c}}{\left(\frac{t_y}{t_c}+\frac{\partial y^n}{\partial y}\right)t_c\frac{\partial y^*}{\partial D_c}-t_c\frac{\partial s_c^*}{\partial D_c}-1}$, which is equal to (4.d).

Appendix 1.B. Derivation of (5.a)

Incorporating the exempted level of income (1) must be redefined for each taxpayer h as

$$y^{nh} = (1 - t_y)y^h + t_y s_y^h - \sigma_y(s_y^h, D_y, Y) - m_y(y^h) \; .$$

Using (3.b), the effect of t_y on net after tax income is

$$\frac{\partial y^{nh*}}{\partial t_y} = -(y^h - s_y^h) + \frac{\partial y^{hn}}{\partial y^h}\frac{\partial y^*}{\partial t_y} \; . \qquad \text{(A.3)}$$

Considering these equalities as well as the problem described by (5) and (6), the first order condition for t_y is

$$(t_y) \quad \sum_{h=1}^{H} \frac{\partial W}{\partial u^h}\left\{\left[(1 - t_c)\frac{\partial y^{nh*}}{\partial t_y}\right]\frac{\partial u^h}{\partial c^h} + \frac{\partial y^{h*}}{t_y}\frac{\partial u^h}{\partial y^h}\right\}$$

$$+\mu\left\{\sum_{h=1}^{H}(y^h - s_y^h) + t_y\left(\frac{\partial y^{h*}}{\partial t_y} - \frac{\partial s_y^{h*}}{\partial t_y}\right) + t_c\frac{\partial y^{nh*}}{\partial t_y}\right\} = 0 \; .$$

Using (A.3) and (3.a), the last condition can be rewritten as

$$\sum_{h=1}^{H} \frac{\partial W}{\partial u^h}\left[-(1 - t_c)(y^h - s_y^h)\frac{\partial u^h}{\partial c^h}\right]$$

$$+\mu\left\{\sum_{h=1}^{H}(1 - t_c)(y^h - s_y^h) - t_y\frac{\partial s_y^{h*}}{\partial t_y} + t_c\left(\frac{t_y}{t_c} + \frac{\partial y^{hn}}{\partial y^h}\right)\frac{\partial y^{h*}}{\partial t_y}\right\} = 0 \; ;$$

$$\mu = \frac{\sum_{h=1}^{H}\frac{\partial W}{\partial u^h}\frac{\partial u^h}{\partial c^h}(1-t_c)(y^h - s_y^h)}{\sum_{h=1}^{H}(1-t_c)(y^h - s_y^h) + \left(\frac{t_y}{t_c} + \frac{\partial y^{hn}}{\partial y^h}\right)t_c\frac{\partial y^{h*}}{\partial t_y} - t_y\frac{\partial s_y^{h*}}{\partial t_y}}$$, which is equal to (5.a).

Appendix 2. Lists of Countries

Symbols & region codes:

* **Tables 2A** and **2B**
\+ **Table 2C**
^ **Table 3**
/ **Table 4A** or ł if also in regs. **(5)-(8)**
† **Table 4B**
‡ **Table 4C**
Reg. (1) of **Table 4C** includes *all* countries

RC **Region Codes**
1: East Asia & Pacific
2: Cent.Europe & Cent.Asia
3: Lat.America & Carib.
4: Mid.East & North Africa
5: South Asia
6: Sub-Saharan Africa
7: Western Europe (**base**)
8: United States & Canada

Low income

	RC	country						
1	5	Bangladesh	*		^	ł	†	‡
2	6	Benin	*			ł	†	‡
3	6	Burkina Faso	*			ł	†	‡
4	6	Burundi				ł	†	‡
5	1	Cambodia	*			ł	†	‡
6	6	Central Af. Rep.	*			ł	†	‡
7	6	Chad	*			ł	†	
8	6	Comoros						
9	6	Congo, D. Rep.						‡
10	6	Cote d'Ivoire	*			ł	†	‡
11	6	Ethiopia	*	+		ł	†	‡
12	6	Gambia, The	*			/	†	‡
13	6	Ghana	*	+		/	†	‡
14	6	Guinea						‡
15	6	Guinea-Bissau					†	
16	3	Haiti	*			ł	†	
17	5	India	*		^	ł	†	‡
18	6	Kenya	*	+		ł	†	‡
19	2	Kyrgyz Rep.	*			ł	†	‡
20	1	Lao PDR	*			ł	†	
21	6	Liberia	*			ł	†	‡
22	6	Madagascar	*			ł	†	‡
23	6	Malawi	*			ł	†	‡
24	6	Mali	*			ł	†	‡
25	6	Mauritania	*			ł	†	
26	1	Mongolia	*		^	ł	†	‡
27	6	Mozambique	*		^	ł	†	‡
28	5	Nepal	*			ł	†	‡
29	6	Niger	*			ł	†	‡
30	6	Nigeria	*			ł	†	
31	5	Pakistan	*			ł	†	‡
32	6	Rwanda	*		^	ł	†	‡
33	6	Senegal	*			ł	†	‡
34	6	Sierra Leone	*			ł	†	‡
35	6	Sao Tome & Pr.						
36	6	Sudan				ł	†	‡
37	2	Tajikistan	*			ł	†	‡
38	6	Tanzania	*	+		ł	†	‡
39	6	Togo	*			ł	†	‡
40	6	Uganda	*		^	ł	†	‡
41	2	Uzbekistan	*			/	†	
42	1	Vietnam	*		^	ł	†	‡
43	4	West Bank Gaza	*				†	
44	4	Yemen, Rep.	*			/	†	‡
45	6	Zambia	*	+		ł	†	‡
46	6	Zimbabwe	*		^	ł	†	‡
Sum:		46	39	5	8	40	42	36

Lower-middle income

RC	country						
2	Albania	*		^	ł	†	‡
4	Algeria	*			/	†	
6	Angola						‡
2	Armenia	*			ł	†	‡
2	Azerbaijan	*	+		ł	†	‡
2	Belarus	*			ł	†	‡
5	Bhutan			^	ł	†	‡
3	Bolivia	*	+				‡
2	Bosnia Herz.	*		^	ł	†	‡
6	Cameroon	*			ł	†	‡
6	Cape Verde	*			ł	†	‡
1	China	*	+		ł	†	‡
3	Colombia	*	+	^	ł	†	‡
6	Congo, Rep.	*			ł	†	‡
4	Djibouti				ł		
3	Dom. Republic	*	+		ł	†	‡
3	Ecuador	*			ł	†	
4	Egypt	*			ł	†	‡
3	El Salvador	*	+	^	ł	†	‡
1	Fiji	*	+	^	ł	†	‡
2	Georgia	*	+		ł	†	‡
3	Guatemala	*		^	ł	†	‡
3	Honduras	*	+	^	ł	†	‡
1	Indonesia	*		^	ł	†	‡
4	Iran, Is. Rep.	*	+		ł	†	‡
3	Jamaica	*	+		/	†	‡
4	Jordan	*		^	ł	†	‡
6	Lesotho	*			ł	†	‡
2	Macedonia	*			ł	†	‡
5	Maldives				ł	†	
2	Moldova	*		^	ł	†	‡
4	Morocco	*			ł	†	‡
6	Namibia	*	+		ł	†	‡
3	Nicaragua	*			ł	†	
3	Paraguay	*	+		ł	†	‡
3	Peru	*	+	^	ł	†	‡
1	Philippines	*	+	^	ł	†	‡
5	Sri Lanka	*		^	ł	†	‡
3	Suriname	*			/	†	‡
6	Swaziland	*			ł	†	‡
4	Syrian Ar. Rep.				ł		
1	Thailand	*	+	^	ł	†	‡
4	Tunisia	*			ł	†	‡
2	Turkmenistan						
2	Ukraine	*			ł	†	‡
	45	39	16	15	42	40	38

Upper-middle income

RC	country						
3	Argentina	*	+	^	ł	†	‡
3	Belize	*			/	†	‡
6	Botswana	*		^	ł	†	‡
3	Brazil	*		^	ł	†	‡
2	Bulgaria	*	+	^	ł	†	‡
3	Chile	*	+	^	ł	†	‡
3	Costa Rica	*	+		ł	†	‡
2	Croatia	*		^	ł	†	‡
3	Dominica	*			/	†	‡
6	Equat. Guinea	*			/	†	‡
6	Gabon						
3	Grenada	*			/	†	‡
2	Hungary	*	+	^	ł	†	‡
2	Kazakhstan	*			ł	†	‡
2	Latvia	*	+	^	ł	†	‡
4	Lebanon	*			/	†	
2	Lithuania	*	+	^	ł	†	‡
1	Malaysia	*		^	ł	†	‡
6	Mauritius	*	+	^	ł	†	‡
3	Mexico	*	+	^	ł	†	‡
2	Montenegro	*			ł	†	
3	Panama	*			ł	†	‡
2	Poland	*		^	ł	†	‡
2	Romania	*	+	^	ł	†	‡
2	Russian Fed.	*	+	^	ł	†	‡
2	Serbia	*			ł	†	‡
6	Seychelles	*			ł	†	‡
2	Slovak Republic	*		^	ł	†	‡
6	South Africa	*	+	^	ł	†	‡
3	St.Kitts & Nevis				/	†	‡
3	St. Lucia	*			/	†	‡
3	St. Vinc. & Gre.	*			/	†	‡
2	Turkey	*	+	^	ł	†	‡
3	Uruguay	*	+	^	ł	†	‡
3	Venezuela, RB				ł	†	
	35	32	14	19	34	34	31

High income

RC	country						
3	Ant. & Barbuda	*			/	†	‡
1	Australia	*	+	^	ł	†	‡
7	Austria	*	+	^	ł	†	‡
3	Bahamas, The					†	
3	Barbados	*	+		ł	†	‡
7	Belgium	*	+	^	ł	†	‡
8	Canada	*	+	^	ł	†	‡
4	Cyprus	*		^	ł	†	‡
7	Czech Republic	*	+	^	ł	†	‡
7	Denmark	*	+	^	ł	†	‡
2	Estonia	*		^	ł	†	‡
7	Finland	*	+	^	ł	†	‡
7	France	*	+	^	ł	†	‡
7	Germany	*	+	^	ł	†	‡
7	Greece	*	+	^	ł	†	‡
1	Hong Kong (Ch)				ł	†	‡
7	Iceland	*		^	ł	†	‡
7	Ireland	*		^	ł	†	‡
4	Israel	*			ł	†	‡
7	Italy	*	+	^	ł	†	‡
1	Japan	*	+	^	ł	†	‡
1	Korea, Rep.	*	+	^	ł	†	‡
4	Kuwait						
7	Luxembourg	*	+	^	ł	†	‡
7	Malta	*	+	^	ł	†	‡
7	Netherlands	*		^	ł	†	‡
1	New Zealand	*	+	^	ł	†	‡
7	Norway	*	+	^	ł	†	‡
7	Portugal	*	+	^	ł	†	‡
4	Qatar						
1	Singapore	*		^	ł	†	‡
2	Slovenia	*		^	ł	†	‡
7	Spain	*	+	^	ł	†	‡
7	Sweden	*	+	^	ł	†	‡
7	Switzerland	*	+	^	ł	†	‡
1	Taiwan, China	*			ł	†	
3	Trin. & Tobago	*			/	†	‡
4	U.Arab Emir.					†	
7	United Kingdom	*	+	^	ł	†	‡
8	United States			^	ł	†	‡
	40	34	23	30	36	38	35

Appendix 3. Variable Definitions and Sources

Variable	Definition	Source
Real GDP	Output-side real GDP at chained PPPs (in mil. 2011 US$)	Penn World Table, version 9.0 (Feenstra et al. 2015)
Population	Population (in millions).	Penn World Table, version 9.0 (Feenstra et al. 2015)
PIT Productivity	Database I: Actual personal income tax revenue as a percent of GDP divided by the *average* PIT rate. The average PIT rate is a weighted average of the lowest and highest marginal PIT rates, with weights equal to the levels of income at which these rates begin to apply. Database II: Actual PIT revenue as a percent of GDP divided by the *maximum* PIT rate.	USAID Collecting Taxes Computed with data from Vegh & Vuletin (2015) and IMF's WoRLD
CIT Productivity	It represents how well the corporate income tax produces revenue, given the prevailing tax rate. It is obtained by dividing the ratio of total CIT revenues to GDP by the general CIT rate.	Database I: USAID Collecting Taxes Database II: Computed with data from Vegh & Vuletin (2015) and IMF's WoRLD
VAT Productivity	VAT receipts as % of GDP divided by the standard VAT rate.	Database I: USAID Collecting Taxes Database II: Computed with data from Vegh & Vuletin (2015) and IMF's WoRLD
PIT Maximum Rate	Highest tax rate applied under the PIT system on income above level at which the PIT begin to apply.	Database I: USAID Collecting Taxes Database II: Vegh & Vuletin (2015)
CIT Rate	Rate of the corporate income tax. In most countries, only one CIT rate is applied to corporate profits. In addition, in most countries, owners of sole proprietorships or unincorporated partnerships pay personal income taxes and not corporate income taxes.	Database I: USAID Collecting Taxes Database II: Vegh & Vuletin (2015)
VAT Rate	General rate at which most goods and services are taxed under the value added tax. Most countries have a variety of reduced rates for certain basic goods, such as basic foodstuffs, and have a zero rate on exported goods.	Database I: USAID Collecting Taxes Database II: Vegh & Vuletin (2015)
Tax Revenue share of GDP	It is total tax revenues, including both domestic taxes and customs duties, as percent of GDP.	Database I: USAID Collecting Taxes Database II: IMF's WoRLD
PIT share of GDP	It is the level of PIT collections as percent of GDP.	Database I: USAID Collecting Taxes Database II: IMF's WoRLD
CIT share of GDP	It is the level of CIT collections as percent of GDP.	Database I: USAID Collecting Taxes Database II: IMF's WoRLD
VAT share of GDP	It is the level of net VAT collections as a percent of GDP. Values are net unless otherwise indicated.	Database I: USAID Collecting Taxes Database II: IMF's WoRLD
PIT share of Tax Revenue	Computed as the ratio of PIT share of GDP over Tax Revenue share of GDP, multiplied by 100.	Database I: Own calculations using USAID Collecting Taxes data
PIT share of Tax Revenue	Computed as the ratio of CIT share of GDP over Tax Revenue share of GDP, multiplied by 100.	Database I: Own calculations using USAID Collecting Taxes data
VAT share of Tax Revenue	Computed as the ratio of VAT share of GDP over Tax Revenue share of GDP, multiplied by 100.	Database I: Own calculations using USAID Collecting Taxes data
Gini coefficient	Measure of income inequality, computed as the ratio of the area between the line of equality (connecting the point denoting 0% of the cumulative share of population in the horizontal axis with the point of 100% of the cumulative share of income in the vertical axis) and the Lorenz curve, over the area below the line of equality. A Gini coefficient equal to 0 (100) represents perfect equality (inequality).	Database I: World Income Inequality Database - WIID3.4
Administration Costs (% of tax revenue)	Cost of administering the tax system divided by total revenues collected by the tax administration, expressed in percentage points.	Database I: USAID Collecting Taxes
SARA	"1" if country has a semi-autonomous revenue agency (SARA). "0" otherwise.	Database I: USAID Collecting Taxes
Large Taxpayer Unit	"1" means that the tax administrations has a division tending solely to the largest taxpayers. "0" means that the tax administration does not have such a division.	Database I: USAID Collecting Taxes

Appendix 4. Tables Empirical Analysis

Table 1A. Summary Statistics Database I (2008-2013)

Income group:		**Full sample**					**Low**		**Lower-middle**		**Upper-middle**		**High**	
	Tables	**Obs. (countries)**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs. (countries)**	**Mean**	**Obs. (countries)**	**Mean**	**Obs. (countries)**	**Mean**	**Obs. (countries)**	**Mean**
GDP per capita (PPP)	all below	749 (154)	17,213	16,393	508	91,817	196 (42)	2,458	190 (40)	8,764	168 (34)	17,388	195 (38)	40,125
Population (millions)	all below	749 (154)	40.0	146.1	0.1	1,362.5	196 (42)	47.2	190 (40)	63.5	168 (34)	24.7	195 (38)	23.1
PIT Productivity	2A,2B	714 (144)	15.4	15.4	0.0	193.4	183 (39)	9.6	177 (39)	11.7	162 (32)	15.7	192 (34)	24.2
CIT Productivity	2A,2B	714 (144)	13.6	12.1	0.0	86.0	183 (39)	8.5	177 (39)	15.4	162 (32)	13.9	192 (34)	16.5
VAT Productivity	2A,2B	714 (144)	39.1	15.8	0.1	100.5	183 (39)	31.0	177 (39)	43.1	162 (32)	42.4	192 (34)	40.3
PIT Maximum Rate	2A,2B	714 (144)	31.1	11.9	0.0	63.0	183 (39)	31.9	177 (39)	29.2	162 (32)	24.9	192 (34)	37.2
CIT Rate	2A,2B	714 (144)	25.1	7.7	0.0	60.0	183 (39)	28.6	177 (39)	25.1	162 (32)	22.1	192 (34)	24.3
VAT Rate	2A,2B	714 (144)	16.3	4.6	1.5	27.0	183 (39)	15.9	177 (39)	15.5	162 (32)	16.7	192 (34)	17.0
Tax Adm. Costs (% of *R*)	3	362 (72)	1.3	1.1	0.1	7.4	31 (8)	3.13	73 (15)	1.37	96 (19)	1.15	162 (30)	1.10
SARA	3	362 (72)	0.4	0.5	0.0	1.0	31 (8)	0.61	73 (15)	0.36	96 (19)	0.59	162 (30)	0.37
Large Taxpayer Unit	3	362 (72)	0.9	0.4	0.0	1.0	31 (8)	0.68	73 (15)	0.93	96 (19)	0.95	162 (30)	0.80
PIT share of Tax Revenue (%)	4A	152 (152)	20.2	12.6	0.0	86.4	40 (40)	16.6	42 (42)	17.8	34 (34)	15.6	36 (36)	31.4
CIT share of Tax Revenue (%)	4A	152 (152)	18.0	13.2	0.0	81.4	40 (40)	16.6	42 (42)	21.3	34 (34)	17.5	36 (36)	16.1
VAT share of Tax Revenue (%)	4A	152 (152)	19.5	7.1	7.7	44.7	40 (40)	14.5	42 (42)	18.1	34 (34)	21.2	36 (36)	25.2
Gini coefficient	4A	135 (135)	38.7	9.1	23.5	64.8	36 (36)	39.9	39 (39)	42.3	26 (26)	40.6	34 (34)	31.6
Tax Revenue (% of GDP)	4B	749 (154)	20.0	8.3	4.0	55.2	196 (42)	14.8	190 (40)	18.4	168 (34)	20.8	195 (38)	26.0
PIT share of GDP (%)	4B	749 (154)	4.2	3.8	0.0	25.8	196 (42)	2.5	190 (40)	2.8	168 (34)	3.3	195 (38)	7.9
CIT share of GDP (%)	4B	749 (154)	3.1	2.7	0.0	21.5	196 (42)	2.2	190 (40)	3.4	168 (34)	3.2	195 (38)	3.7
VAT share of GDP (%)	4B	749 (154)	6.2	2.9	0.0	15.3	196 (42)	4.7	190 (40)	6.5	168 (34)	7.0	195 (38)	6.5

Table 1B. Summary Statistics Database II (1990-2017)

Income group:		Full sample					Low		Lower-middle		Upper-middle		High	
	Tables	Obs. (countries)	Mean	Std. Dev.	Min	Max	Obs. (countries)	Mean	Obs. (countries)	Mean	Obs. (countries)	Mean	Obs. (countries)	Mean
GDP per capita (PPP)	all below	2,547 (140)	17,201	15,605	477	99,477	424 (36)	2,047	678 (38)	6,829	584 (31)	14,258	861 (35)	34,828
Population (millions)	all below	2,547 (140)	48.1	159.9	0.0	1,403.5	424 (36)	96.2	678 (38)	58.8	584 (31)	28.1	861 (35)	29.6
PIT Productivity	2C	1,184 (58)	16.8	12.2	0.1	77.5	53 (5)	8.1	262 (16)	8.3	271 (14)	13.9	598 (23)	22.6
CIT Productivity	2C	1,184 (58)	11.5	6.4	0.0	45.0	53 (5)	6.5	262 (16)	11.7	271 (14)	11.5	598 (23)	11.8
VAT Productivity	2C	1,184 (58)	37.7	11.6	0.0	89.1	53 (5)	22.1	262 (16)	39.1	271 (14)	35.3	598 (23)	39.6
PIT Maximum Rate	2C	1,184 (58)	36.4	12.1	10.0	68.0	53 (5)	31.0	262 (16)	28.5	271 (14)	30.2	598 (23)	43.2
CIT Rate	2C	1,184 (58)	28.3	7.6	8.5	58.2	53 (5)	30.4	262 (16)	27.6	271 (14)	23.8	598 (23)	30.6
VAT Rate	2C	1,184 (58)	16.7	5.0	3.0	27.0	53 (5)	15.5	262 (16)	14.0	271 (14)	18.9	598 (23)	17.1
Tax Revenue (% of GDP)	4C	2,547 (140)	19.9	7.6	0.6	53.3	424 (36)	12.5	678 (38)	17.7	584 (31)	19.5	861 (35)	25.4
PIT share of GDP (%)	4C	2,547 (140)	4.4	4.3	0.0	26.3	424 (36)	1.5	678 (38)	2.1	584 (31)	3.0	861 (35)	8.5
CIT share of GDP (%)	4C	2,547 (140)	2.9	2.1	0.1	20.8	424 (36)	1.9	678 (38)	3.0	584 (31)	2.9	861 (35)	3.4
VAT share of GDP (%)	4C	1,915 (121)	6.2	2.4	0.0	18.9	225 (28)	4.2	473 (33)	5.9	443 (29)	6.7	774 (31)	6.6

Table 2A. Effects of Tax Rates and Development on Marginal Tax Revenue; Random-Effects GLS (Database I)

Dependent variable:	PIT Productivity				CIT Productivity				VAT Productivity			
Income level:	Full sample	Low	Middle	High	Full sample	Low	Middle	High	Full sample	Low	Middle	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
PIT maximum rate	-0.40**	-0.32***	-0.23*	-0.69**	0.00	0.11	0.14	-0.12*	-0.01	-0.32	0.04	0.14
	(0.16)	(0.09)	(0.12)	(0.29)	(0.06)	(0.08)	(0.14)	(0.07)	(0.08)	(0.23)	(0.16)	(0.11)
CIT rate	0.08	0.11	0.12	0.38	-0.49**	-0.18**	-0.68**	-0.01	-0.25*	-0.16	-0.30	-0.15
	(0.14)	(0.13)	(0.16)	(0.30)	(0.24)	(0.09)	(0.34)	(0.12)	(0.14)	(0.24)	(0.25)	(0.16)
VAT rate	0.08	0.25	-0.37	1.05	-0.09	-0.07	-0.35	-0.31	-1.03***	-1.14**	-1.14**	-0.61*
	(0.28)	(0.29)	(0.24)	(0.91)	(0.16)	(0.20)	(0.25)	(0.43)	(0.30)	(0.51)	(0.55)	(0.35)
Log of GDP per capita	3.14**	3.62	-1.95	21.31**	3.65***	4.48**	1.39	8.33	-0.83	0.81	-5.93*	-11.77**
	(1.30)	(2.77)	(2.09)	(9.00)	(0.97)	(1.80)	(2.08)	(7.41)	(1.86)	(5.41)	(3.29)	(4.78)
Log of population	-0.20	-0.99	0.67	0.31	-0.23	1.27	0.37	-0.68	-2.99***	-2.03	-3.42***	-2.48***
	(0.44)	(0.84)	(0.52)	(1.31)	(0.40)	(0.96)	(0.42)	(1.44)	(0.69)	(2.42)	(1.10)	(0.74)
East Asia & Pacific	-11.28**	4.08	26.74	4.02	6.00**	-38.72**	5.42	-2.24	-0.93	100.00*	7.71	3.16
	(5.29)	(20.94)	(20.06)	(14.09)	(2.91)	(19.14)	(3.29)	(4.11)	(5.66)	(54.50)	(7.89)	(4.38)
Central Europe & Central Asia	-9.85**	7.38	42.49**	-5.16	-0.35	-43.69**	1.23	-4.50	3.09	101.20*	14.05*	-3.19
	(4.61)	(19.51)	(20.03)	(5.91)	(3.23)	(18.46)	(7.06)	(5.51)	(3.77)	(56.15)	(7.92)	(3.70)
Latin America & Caribbean	-16.96***	4.12	28.19	11.99	4.03	-47.31**	2.03	18.61	-0.75	92.89*	8.48**	-9.05
	(4.09)	(19.27)	(19.19)	(9.99)	(3.98)	(18.55)	(2.49)	(20.60)	(3.98)	(53.15)	(3.45)	(10.35)
Middle East & North Africa	-15.03***	1.31	28.79	2.31	8.80*	-53.03***	8.20	18.65	1.01	92.53*	8.09	13.73***
	(4.46)	(21.20)	(19.65)	(7.57)	(5.06)	(19.07)	(5.99)	(13.39)	(5.27)	(55.82)	(4.99)	(4.17)
South Asia	-16.78***	1.91	24.40	--	4.66	-48.74**	0.00	--	-14.64**	82.84	0.00	--
	(5.05)	(20.36)	(18.92)	--	(3.68)	(20.63)	(0.00)	--	(6.44)	(58.09)	(0.00)	--
Sub-Saharan Africa	-9.17*	6.85	35.93*	--	7.96**	-44.67**	9.76***	--	-10.84*	95.33*	-1.08	--
	(4.79)	(19.67)	(19.24)	--	(3.34)	(19.06)	(3.22)	--	(6.23)	(56.60)	(5.94)	--
Canada	8.84*	--	--	20.06	-3.68	--	--	-7.45	-6.43	--	--	0.59
	(5.17)	--	--	(15.75)	(2.54)	--	--	(5.44)	(4.75)	--	--	(4.92)
Constant	14.69	0.00	0.00	-196.27*	-6.03	0.00	11.28	-51.40	122.25***	0.00	168.23***	214.07***
	(14.51)	(0.00)	(0.00)	(102.39)	(12.88)	(0.00)	(19.83)	(100.25)	(24.18)	(0.00)	(30.84)	(62.42)
Joint signif. tax rates, GDP & pop.												
Chi2	11.01	18.72	9.08	11.91	25.83	19.26	6.15	17.15	50.81	14.71	38.70	12.70
Prob > chi2	0.0512	0.0022	0.1059	0.0361	0.0001	0.0017	0.2922	0.0042	0.0000	0.0117	0.0000	0.0263
R-squared within	0.1409	0.2444	0.0857	0.2449	0.0624	0.0359	0.1379	0.0387	0.0485	0.2291	0.0496	0.0441
R-squared between	0.4111	0.4656	0.3971	0.3292	0.2445	0.5338	0.1769	0.3569	0.3623	0.3497	0.3346	0.6036
R-squared overall	0.3143	0.3865	0.2879	0.3217	0.1951	0.3928	0.1602	0.4436	0.2879	0.3768	0.2190	0.4132
Observations	714	183	339	192	714	183	339	192	714	183	339	192
Number of countries	144	39	71	34	144	39	71	34	144	39	71	34

Robust standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All regressions include year dummies (not shown).

Table 2B. Effects of Tax Rates and Development on Marginal Tax Revenue; Dynamic Panel, One-Step System GMM (Database I)

Dependent variable:	PIT Productivity	CIT Productivity	VAT Productivity
	(1)	(2)	(3)
PIT maximum rate	**-0.33*** **	0.03	0.02
	(0.10)	(0.05)	(0.07)
CIT rate	0.13	**-0.41*** **	-0.22**
	(0.15)	(0.14)	(0.11)
VAT rate	0.22	-0.12	**-0.51** **
	(0.33)	(0.12)	(0.20)
Log GDP per capita	**1.83** **	**2.45*** **	**-1.08**
	(0.79)	(0.82)	(1.39)
Log GDP p.c. if low or lower-mid.inc.	**-0.07**	**0.35** **	**0.01**
	(0.13)	(0.15)	(0.23)
Log of population	0.06	-0.08	-1.55***
	(0.27)	(0.23)	(0.44)
East Asia & Pacific	-3.63	1.74	2.12
	(4.05)	(1.69)	(3.22)
Central Europe & Central Asia	-7.40**	-1.22	0.74
	(3.13)	(1.49)	(2.37)
Latin America & the Caribbean	-6.61**	3.00	0.35
	(3.26)	(2.11)	(2.37)
Middle East & North Africa	-4.83	4.92*	1.86
	(3.44)	(2.83)	(3.08)
South Asia	-6.90*	2.68	-8.87**
	(3.60)	(2.02)	(3.63)
Sub-Saharan Africa	-2.56	5.07**	-6.35
	(2.96)	(2.02)	(4.00)
Canada	4.37	-1.33	2.81
	(5.76)	(2.16)	(3.13)
Constant	-2.10	2.80	78.12***
	(11.41)	(7.85)	(16.36)
F test	754.24	23.44	27.84
P-value	0.000	0.000	0.000
Arellano-Bond AR(1) test (Pr > z)	-3.17 (0.002)	-3.06 (0.002)	-4.41 (0.000)
Arellano-Bond AR(2) test (Pr > z)	0.86 (0.391)	2.73 (0.006)	1.84 (0.066)
Observations	579	588	585
Number of countries	139	140	136
Number of instruments	29	29	29

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
All regressions include year dummies and an autoregressive term (not shown).

Table 2C. Effects of Tax Rates and Development on Marginal Tax Revenue; Fixed-Effects (Database II)

Dependent variable:	**PIT Productivity**	**CIT Productivity**	**VAT Productivity**	**PIT Productivity**	**CIT Productivity**	**VAT Productivity**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
PIT maximum rate	**-0.183*** **	0.070***	-0.017	**-0.184*** **	0.074***	-0.015
	(0.034)	(0.022)	(0.028)	(0.034)	(0.023)	(0.027)
CIT rate	0.034**	**-0.122*** **	-0.034	0.036**	**-0.129*** **	-0.031
	(0.016)	(0.029)	(0.043)	(0.017)	(0.028)	(0.042)
VAT rate	0.042	0.022	**-0.604*** **	0.042	0.024	**-0.597*** **
	(0.071)	(0.075)	(0.142)	(0.069)	(0.072)	(0.138)
Growth GDP per capita	**-5.716** **	**14.796** **	**1.383**	--	--	--
	(2.563)	(5.810)	(3.854)	--	--	--
Growth GDP pc if low or lower-mid.inc.	**6.925** **	**-7.532**	**-1.047**	--	--	--
	(2.737)	(7.608)	(11.527)	--	--	--
Growth GDP pc if low income	**-3.176**	**-5.646**	**20.336**	--	--	--
	(2.444)	(5.315)	(14.502)	--	--	--
First diff. GDP pc (in thousands)	--	--	--	**-0.360** **	**1.296*** **	**0.176**
	--	--	--	(0.159)	(0.328)	(0.254)
First diff. GDP pc squared	--	--	--	**0.001**	**-0.008** **	**-0.004***
	--	--	--	(0.001)	(0.004)	(0.002)
First diff. GDP pc if low or lower-mid.inc.	--	--	--	**0.538*** **	**-0.090**	**-0.858**
	--	--	--	(0.194)	(0.451)	(0.911)
First diff. GDP pc if low income	--	--	--	**-1.593*** **	**0.151**	**8.764*** **
	--	--	--	(0.469)	(0.860)	(2.451)
Log of population	1.375	3.020	4.735**	1.078	3.863**	4.326*
	(1.909)	(1.965)	(2.200)	(1.796)	(1.909)	(2.191)
Constant	-14.318	-45.708	-53.333	-9.340	-59.702*	-46.655
	(31.217)	(32.142)	(35.110)	(29.409)	(31.322)	(34.977)
F	1,086.4	220.88	47.980	1,469.4	236.07	41.290
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared within	0.9220	0. 7388	0.6639	0.9226	0.7471	0.6676
R-squared between	0.9224	0. 2410	0.3242	0.9405	0.1256	0.3811
R-squared overall	0.9175	0. 3540	0.3766	0.9302	0.2264	0.4224
Observations	1,138	1,143	1,126	1,138	1,143	1,126
Number of countries	58	58	58	58	58	58

Robust standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include year dummies and an autoregressive term (not shown).

Table 3. Determinants of Tax Collection Costs (Database I)

Dependent variable:	**Tax collection costs (% of tax revenue)**				
	Random-Effects GLS regressions			**Dynamic panel-data estimation (One-step System GMM)**	
Income level:	**Full sample**	**Low and Lower-middle**	**High and Upper-middle**	**Full sample**	**Full sample**
	(1)	**(2)**	**(3)**	**(4)**	**(4)**
Log of GDP per capita	**-0.54*****	**-1.27*****	**-0.08**	**-0.05****	**-0.09*****
	(0.20)	(0.26)	(0.20)	(0.02)	(0.03)
Log of population	-0.13**	-0.17*	-0.09	0.01	-0.01
	(0.06)	(0.10)	(0.07)	(0.01)	(0.01)
Semi-autonomous agency (dummy)	0.06	0.17	0.00	0.06**	0.06*
	(0.05)	(0.26)	(0.06)	(0.03)	(0.03)
Large taxpayer unit (dummy)	-0.26	-1.90*	-0.05	0.03	-0.00
	(0.24)	(1.15)	(0.17)	(0.05)	(0.04)
Constant	8.82***	17.30***	3.45**	0.39	1.17**
	(2.28)	(3.02)	(1.74)	(0.53)	(0.56)
Wald chi2	26.07	63.21	12.11	3,514.91	6,470.95
Prob > chi2	0.0020	0.0000	0.2072	0.0000	0.0000
Arellano-Bond AR(1) test (Pr > z)	--	--	--	-2.51 (0.012)	-2.48 (0.013)
Arellano-Bond AR(2) test (Pr > z)	--	--	--	2.02 (0.044)	2.03 (0.042)
R2 within	0.0022	0.0448	0.0232	--	--
R2 between	0.3069	0.6968	0.0687	--	--
R2 overall	0.3054	0.6284	0.0637	--	--
Observations	362	104	258	290	290
Number of countries	72	23	49	62	62
Number of instruments	--	--	--	16	23

Robust standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include year dummies (not shown).
Regressions (4) and (5) include autoregressive terms, and the latter also includes regional dummies (not shown).

Table 4A. Effect of Development on Total Tax Revenue and Tax Revenue Composition (Cross-Country Analysis; Database I)

Dependent variable:	**TAX share of GDP**	**PIT share of Tax Revenue**	**CIT share of Tax Revenue**	**VAT share of Tax Revenue**	**TAX share of GDP**	**PIT share of Tax Revenue**	**CIT share of Tax Revenue**	**VAT share of Tax Revenue**
	(1.a)	**(2.a)**	**(3.a)**	**(4.a)**	**(5.a)**	**(6.a)**	**(7.a)**	**(8.a)**
Log GDP per capita	**2.742*** **	**3.535*** **	**0.827**	**-2.005** **	**7.245*** **	**16.971*** **	**3.850**	**-7.639**
	(0.440)	(0.860)	(0.834)	(0.874)	(2.366)	(3.781)	(5.921)	(4.726)
Gini coefficient	--	--	--	--	**1.029***	**3.064*** **	**0.619**	**-0.673**
	--	--	--	--	(0.583)	(0.905)	(1.659)	(1.022)
Interaction term (Log GDP pc × Gini)	--	--	--	--	**-0.131** **	**-0.332*** **	**-0.029**	**0.054**
	--	--	--	--	(0.063)	(0.096)	(0.174)	(0.109)
Log of population	-1.117***	1.381***	0.673	-0.646	-1.177***	1.362**	1.289**	-1.743**
	(0.212)	(0.486)	(0.541)	(0.614)	(0.279)	(0.603)	(0.552)	(0.721)
Constant	12.312**	-34.129***	-0.319	59.430***	-21.718	-160.586***	-55.961	142.251***
	(5.656)	(12.723)	(10.916)	(14.246)	(22.973)	(39.301)	(58.151)	(50.393)
Observations (number of countries)	152	152	152	152	135	135	135	135
R-squared	0.329	0.135	0.013	0.038	0.423	0.199	0.132	0.176
	(1.b)	(2.b)	(3.b)	(4.b)	(5.b)	(6.b)	(7.b)	(8.b)
GDP pc (in thousands)	**0.268** **	**0.289***	**0.384**	**-0.487*** **	**0.732*** **	**1.130*** **	**0.288**	**-0.630**
	(0.104)	(0.173)	(0.327)	(0.180)	(0.178)	(0.327)	(0.376)	(0.398)
GDP pc (in thousands) squared	**-0.004*** **	**-0.002**	**-0.002**	**0.003***	**-0.005*** **	**-0.005** **	**0.000**	**0.005** **
	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Gini coefficient	--	--	--	--	**0.168**	**0.461** **	**0.357**	**-0.326**
	--	--	--	--	(0.112)	(0.187)	(0.247)	(0.236)
Interaction term (GDP pc × Gini)	--	--	--	--	**-0.010** **	**-0.015** **	**-0.004**	**-0.003**
	--	--	--	--	(0.004)	(0.007)	(0.010)	(0.008)
Log of population	-1.183***	0.663	0.646	0.037	-1.033***	0.636	0.807	-1.080*
	(0.223)	(0.474)	(0.518)	(0.603)	(0.278)	(0.567)	(0.617)	(0.631)
East Asia & Pacific	-8.486***	-4.757	17.092***	-10.097***	-5.606**	-3.067	10.230***	-2.506
	(2.342)	(3.909)	(4.479)	(2.966)	(2.511)	(5.034)	(3.397)	(3.259)
Central Europe & Central Asia	-4.525**	-10.994***	5.740	4.069	-1.631	-7.684**	0.776	6.411*
	(2.220)	(3.018)	(4.442)	(3.170)	(2.159)	(3.433)	(3.368)	(3.395)
Latin America & the Caribbean	-8.727***	-8.990**	14.942***	-1.387	-7.628***	-8.290	4.280	7.464
	(2.389)	(3.852)	(5.397)	(3.604)	(2.675)	(5.056)	(4.428)	(4.725)
Middle East & North Africa	-8.047***	-0.252	23.486***	-9.855*	-3.705	0.083	14.574***	-6.358
	(2.791)	(5.519)	(8.058)	(5.535)	(2.788)	(5.594)	(5.179)	(5.950)
South Asia	-12.886***	-11.898**	18.238**	-15.431**	-9.547***	-9.463	8.160	-8.822
	(2.722)	(4.916)	(8.288)	(7.617)	(2.560)	(5.744)	(6.269)	(7.089)
Sub-Saharan Africa	-8.024***	-5.433	15.066*	-10.040**	-4.676*	-5.209	0.172	-0.626
	(2.933)	(4.476)	(7.953)	(4.307)	(2.654)	(5.287)	(4.597)	(5.102)
United States & Canada	-9.766***	33.606**	1.321	-17.115***	-8.648**	34.643**	0.320	-10.782**
	(3.721)	(15.381)	(4.793)	(6.459)	(4.265)	(15.336)	(5.551)	(4.655)
Constant	42.655***	11.507	-9.668	41.376***	29.711***	-12.895	-18.278	75.148***
	(4.657)	(9.157)	(10.386)	(11.476)	(7.014)	(12.610)	(15.660)	(15.911)
Observations (number of countries)	152	152	152	152	135	135	135	135
R-squared	0.492	0.408	0.197	0.268	0.546	0.466	0.285	0.405

All variables in period (2008-2013) averages. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4B. Effect of Development on Total Tax Revenue and Tax Revenue Composition (Database I)

Model:	**Random-Effects GLS regression**				**Dynamic panel-data estimation (One-step System GMM)**			
Dependent variable:	**TAX share of GDP**	**PIT share of GDP**	**CIT share of GDP**	**VAT share of GDP**	**TAX share of GDP**	**PIT share of GDP**	**CIT share of GDP**	**VAT share of GDP**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Log GDP per capita	**1.38****	**0.47**	**0.91*****	**-0.43**	**1.06***	**0.43****	**0.44****	**-0.27**
	(0.69)	(0.32)	(0.25)	(0.34)	(0.64)	(0.21)	(0.22)	(0.23)
Log GDP p.c. if low or lower-mid.inc.	**-0.14**	**-0.12****	**0.04**	**-0.01**	**-0.10**	**-0.05**	**0.05****	**-0.01**
	(0.12)	(0.06)	(0.05)	(0.06)	(0.10)	(0.04)	(0.02)	(0.04)
Log of population	-0.79***	0.02	-0.01	-0.29**	-0.67***	0.05	0.00	-0.24**
	(0.21)	(0.09)	(0.09)	(0.12)	(0.18)	(0.06)	(0.04)	(0.09)
East Asia & Pacific	-7.87***	-3.37***	1.55**	-3.21***	-6.12***	-1.77**	0.54	-1.68***
	(2.19)	(1.25)	(0.71)	(0.72)	(1.88)	(0.77)	(0.39)	(0.57)
Central Europe & Central Asia	-3.74**	-4.35***	-0.05	0.78	-3.66**	-2.62***	-0.00	0.46
	(1.82)	(0.78)	(0.60)	(0.63)	(1.54)	(0.71)	(0.16)	(0.41)
Latin America & the Caribbean	-8.23***	-5.13***	0.86	-2.07***	-6.40***	-2.56***	0.46	-0.96*
	(1.91)	(0.88)	(0.91)	(0.70)	(1.67)	(0.99)	(0.38)	(0.50)
Middle East & North Africa	-6.33***	-4.31***	1.31	-2.14**	-4.93**	-1.83**	1.03***	-0.82
	(2.42)	(1.02)	(0.97)	(1.07)	(2.01)	(0.86)	(0.39)	(0.61)
South Asia	-12.65***	-5.48***	0.48	-5.40***	-10.10***	-2.85***	0.35	-2.80***
	(2.23)	(1.02)	(0.97)	(1.02)	(2.04)	(0.92)	(0.31)	(0.67)
Sub-Saharan Africa	-6.99***	-3.37***	1.62*	-3.56***	-5.61**	-1.49*	0.87*	-2.16***
	(2.56)	(1.20)	(0.89)	(1.01)	(2.29)	(0.80)	(0.45)	(0.76)
United States & Canada	-9.86**	1.25	-0.97*	-5.31***	-9.43***	1.23**	0.10	-2.86***
	(4.30)	(1.19)	(0.51)	(0.69)	(2.72)	(0.63)	(0.23)	(0.58)
Constant	21.51***	1.80	-5.25*	16.35***	18.96***	-0.94	-2.29*	11.46***
	(7.92)	(3.50)	(2.97)	(3.82)	(6.98)	(2.12)	(1.35)	(3.08)
Joint significance test chi2 or F	209.17	212.02	48.75	213.55	325.72	886.44	452.80	1,777.60
P-value	0.0000	0.0000	0.0000	0.0000	0.000	0.000	0.000	0.000
Arellano-Bond AR(1) test (Pr > z)	--	--	--	--	-5.48(0.000)	-3.45(0.001)	-2.23(0.026)	-4.06(0.000)
Arellano-Bond AR(2) test (Pr > z)	--	--	--	--	-0.17(0.867)	2.14(0.032)	1.38(0.169)	1.90(0.057)
R-squared within	0.0563	0.1407	0.0018	0.0120	--	--	--	--
R-squared between	0.4738	0.4805	0.1520	0.3903	--	--	--	--
R-squared overall	0.3668	0.3973	0.1374	0.3328	--	--	--	--
Observations	749	749	749	749	637	610	610	603
Number of countries	154	154	154	154	149	146	145	141
Number of instruments	--	--	--	--	26	26	26	26

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
All regressions include year dummies (not shown). Regressions (5)-(8) include autoregressive terms (not shown).

Table 4C. Effect of Development on Total Tax Revenue and Tax Revenue Composition; Fixed-Effects (Database II)

Income group:	**Full sample**					**Low and middle-low**				
Dependent variable:	**TAX share of GDP**	**TAX share of GDP**	**PIT share of GDP**	**CIT share of GDP**	**VAT share of GDP**	**TAX share of GDP**	**TAX share of GDP**	**PIT share of GDP**	**CIT share of GDP**	**VAT share of GDP**
	(1.a)	**(2.a)**	**(3.a)**	**(4.a)**	**(5.a)**	**(6.a)**	**(7.a)**	**(8.a)**	**(9.a)**	**(10.a)**
Growth rate of GDP per capita	**2.470**	**4.595****	**-0.239**	**2.136*****	**-0.397**	**6.688****	**9.240****	**-0.786*****	**2.187****	**-1.043**
	(1.512)	(2.187)	(0.268)	(0.667)	(0.407)	(2.667)	(4.267)	(0.277)	(0.942)	(0.674)
Growth rate of GDP pc if low income	**1.080**	**-2.266**	**0.089**	**-1.793****	**2.131**	**-3.156**	**-7.223***	**0.524**	**-1.955****	**2.350**
	(1.893)	(2.322)	(0.361)	(0.765)	(1.344)	(2.910)	(4.285)	(0.355)	(0.962)	(1.589)
Log of population	-0.150	-0.672	0.193	-0.046	0.234	-0.906	-3.176***	-0.306	-0.948	0.621
	(0.389)	(0.668)	(0.220)	(0.377)	(0.293)	(0.693)	(1.128)	(0.302)	(0.805)	(0.659)
Constant	6.975	15.974	-2.281	1.592	-1.616	18.646	57.692***	5.477	16.616	-7.935
	(6.323)	(10.389)	(3.515)	(6.061)	(4.692)	(11.390)	(18.748)	(5.000)	(13.362)	(10.959)
F	130.47	54.13	188.76	106.61	37.81	153.25	40.28	167.64	101.08	--
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	--
R-squared within	0.6505	0.6386	0.7379	0.6384	0.6258	0.7015	0.6503	0.7496	0.5913	0.6518
R-squared between	0.9964	0.9509	0.9853	0.9674	0.9184	0.9293	0.6162	0.8679	0.2942	0.7591
R-squared overall	0.9550	0.9239	0.9782	0.8770	0.8825	0.8860	0.5878	0.8539	0.3487	0.6622
Observations	4,057	2,547	2,547	2,547	1,869	2,129	1,102	1,102	1,102	673
Number of countries	166	140	140	140	119	91	74	74	74	59
	(1.b)	(2.b)	(3.b)	(4.b)	(5.b)	(6.b)	(7.b)	(8.b)	(9.b)	(10.b)
First diff. GDP pc (in thousands)	**0.109**	**0.298****	**-0.001**	**0.190****	**0.003**	**2.154****	**3.143****	**-0.181***	**0.888****	**0.039**
	(0.069)	(0.132)	(0.031)	(0.076)	(0.034)	(0.887)	(1.364)	(0.097)	(0.363)	(0.212)
First diff. GDP pc (in thousands) squared	**-0.001****	**-0.003****	**-0.000**	**-0.001**	**-0.000**	**-0.062***	**-0.119****	**0.004**	**-0.028****	**-0.009**
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.031)	(0.048)	(0.003)	(0.012)	(0.008)
First diff. GDP pc if low income	**0.642**	**0.408**	**-0.010**	**-0.124**	**0.962*****	**-0.958**	**-1.553**	**0.074**	**-0.652****	**0.931****
	(0.541)	(0.387)	(0.086)	(0.186)	(0.261)	(0.837)	(0.957)	(0.103)	(0.269)	(0.367)
Log of population	-0.149	-0.658	0.173	0.004	0.162	-0.715	-3.412***	-0.344	-0.949	0.372
	(0.356)	(0.682)	(0.220)	(0.380)	(0.290)	(0.714)	(1.178)	(0.303)	(0.805)	(0.660)
Constant	6.987	15.883	-1.949	0.776	-0.439	15.589	61.817***	6.117	16.640	-3.818
	(5.760)	(10.643)	(3.510)	(6.114)	(4.661)	(11.729)	(19.640)	(5.021)	(13.354)	(10.953)
F	131.25	48.97	192.64	130.64	40.87	154.05	43.78	142.20	92.63	--
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	--
R-squared within	0.6465	0.6344	0.7387	0.6389	0.6310	0.6995	0.6519	0.7496	0.5960	0.6593
R-squared between	0.9964	0.9522	0.9878	0.9729	0.9487	0.9520	0.5893	0.8445	0.2931	0.9067
R-squared overall	0.9547	0.9250	0.9801	0.8803	0.9116	0.9033	0.5605	0.8345	0.3485	0.8250
Observations	4,057	2,547	2,547	2,547	1,869	2,129	1,102	1,102	1,102	673
Number of countries	166	140	140	140	119	91	74	74	74	59

Robust standard errors, clustered by country, in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include year dummies and an autoregressive term (not shown).