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The capacity
of governments to raise
taxes

Oguzhan Akgun,
David Bartolini,
Boris Cournède

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Abstract/Résumé

The capacity of governments to raise taxes

This paper investigates the factors that shape governments' capacity to collect revenue. To do so, it analyses how tax revenue responds to tax rates using evidence from a panel of 34 OECD countries over 1978-2014. The estimations show that the response of revenue to rates weakens as rates become higher, confirming the existence of a hump-shaped relationship between tax revenue and rates for corporate income taxation and providing a new contribution by analysing value-added taxation. Importantly, the estimated responses of revenue to tax rates vary, in some cases very strongly from an economic perspective, depending on country-specific policies and framework conditions. In particular, the corporate income tax revenue-generating potential of hiking the effective rate shrinks much more quickly in more open economies than in more closed ones. Tax revenue is found to be more responsive to tax increases in countries where the tax authorities have more resources. The investigations also cover personal income taxation. They point to diminishing revenue returns of increasing the effective marginal tax rates that apply at substantially above-average income levels.

Keywords: Laffer curve, personal income tax, social security contributions, value added tax, effective marginal tax rate, framework conditions, country-specific circumstances, interactions

JEL Codes: H20; H26; H24

La capacité des pouvoirs publics à lever l'impôt

Ce document de travail s'intéresse à ce qui détermine la capacité des administrations publiques à collecter des recettes. Pour ce faire, il analyse la manière dont les recettes fiscales évoluent en fonction des taux de taxation en s'appuyant sur l'expérience de 34 pays de l'OCDE sur la période 1978-2014. Ces estimations montrent que la réponse des recettes aux taux va en s'affaiblissant au fur et à mesure que les taux sont de plus en plus élevés, ce qui confirme la plupart de la littérature examinant cette question pour l'impôt sur les sociétés et apporte une nouvelle contribution aux études concernant la taxe sur la valeur ajoutée. Il est à signaler que les réponses estimées des recettes aux taux de taxation varient, dans certains cas de manière très marquée d'un point de vue économique, en fonction des politiques et conditions générales propres à chaque pays. En particulier, au fur et à mesure que le point de départ s'élève, des hausses successives du taux effectif d'impôt sur les sociétés apportent un produit fiscal qui s'étirole plus rapidement dans les économies plus ouvertes au commerce que dans celles qui le sont moins. Les analyses montrent aussi que les recettes sont plus sensibles aux taux d'imposition dans les pays qui consacrent davantage de ressources à leurs administrations fiscales. Cette étude s'intéresse aussi aux impôts sur les revenus des ménages, domaine dans lequel elles suggèrent un rendement fiscal décroissant des hausses du taux effectif d'imposition appliqué aux ménages dont le revenu excède nettement la moyenne.

Mots clés : courbe de Laffer, impôt sur le revenu des personnes physiques, impôt sur les sociétés, contributions sociales, taxe sur la valeur ajoutée, taux marginal effectif, conditions cadres, spécificités nationales, interactions

Codification JEL : H20; H26; H24

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THE CAPACITY OF GOVERNMENTS TO RAISE TAXES

By Oguzhan Akgun, David Bartolini and Boris Cournède¹

1. Introduction and main results

1. This paper investigates the capacity of governments to raise revenue by assessing the ways in which tax receipts respond to rates and how policies and other framework conditions influence this response. Governments need solid revenue bases to fund the basic foundations of thriving economies and societies (Gaspar et al., 2016a, 2016b), including the public services that underpin inclusive growth (Fournier and Johansson, 2016). In some cases, governments need to increase tax revenue in reaction to unexpected macroeconomic shocks, to comply with fiscal rules, or as a strategy to ensure sustainability. In this context, it is important to understand the relationship between tax rates and revenue. Setting rates and defining the tax base represent the two main policy levers that governments have to raise revenue with a given tax. This study focuses on the rate-revenue relationship in advanced economies, a choice which allows an empirical, data-based inquiry informed by the experience of a large number of comparatively homogenous OECD countries over a substantial period of time.

2. Revenue returns from tax increases can be expected to decrease with the level of tax rates, because higher rates exacerbate disincentives to produce and raise incentives to avoid taxation. These two main channels can therefore imply that tax receipts rise less than proportionately with rates and may peak at a given point. The present study advances knowledge on this rate-revenue relationship in three ways. First, it provides new evidence based on the experience of 34 OECD countries over the period 1978-2014. Second, it investigates this relationship in a consistent fashion for three categories of taxes that account for a large share of overall government revenue: corporate income tax, value added tax and personal income

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tax. Third, it brings a new dimension to the literature by systematically documenting how policies, institutions and framework conditions shape this relationship.²

3. These empirical investigations yield the following main results:

- Revenues from corporate income and value added taxes (CIT and VAT) respond increasingly weakly as tax rates rise, flatten out, and may even decline after a tipping point.
- Institutions and framework conditions shape the response of tax receipts to rates:
 - Revenues of corporate income and value-added taxes respond more strongly to changes in rates where indicators point to a greater quality or effectiveness of governance.
 - In more open economies, corporate income tax receipts react less to changes in rates.
 - Budgetary authorities that allocate more resources to tax collection benefit from corporate income, personal income and value-added tax revenues that are more responsive to tax rates.
- The revenue-maximising level of taxation is estimated to vary from 9 to 37% depending on country characteristics for the effective marginal rate of CIT and from 21 to 27% for the standard VAT rate.
- Estimates of revenue-maximising rates should not be seen as policy objectives or recommendations, as they imply high levels of economic distortions or tax avoidance.
- Revenue from broadly-defined personal income taxes, which include social security contributions and payroll taxes, responds linearly to effective marginal tax rates at and immediately above the average income level. This could reflect that personal income tax (PIT) systems are designed to minimise adverse behavioural responses around these income levels. Below and clearly above average income, PIT revenue exhibits marginal returns that are estimated to decrease when effective marginal rates increase, PIT receipts reach a turning point when effective marginal rates approach 55-57%.
- More progressive broadly defined personal income taxes generally yield more revenue, but very strong progressivity is associated with lower revenue.
- The investigation uncovers significant externalities between personal and corporate income tax (CIT). Higher effective marginal rates of CIT taxation result in higher PIT receipts for given PIT rates, and *vice versa*. These findings provide support for the view that firms and individuals use incorporation and disincorporation to optimise their tax bill in response to the joint configuration of CIT and PIT.

4. The next section reviews the related literature. Section 3 presents the conceptual and econometric framework for estimation. Section 4 applies it to probe the response of receipts from corporate income tax to the effective tax rate. Section 5 analyses the value-added tax. Section 6 looks at personal income tax,

2. Clausing (2007) pioneered this approach by allowing the revenue effects of corporate income tax rates to differ between big and small countries and depending on whether FDI is below or above average. The present study considerably advances this line of investigation by systematically analysing a broad set of policy, institution and framework condition variables.

payroll taxes and social security contributions: it investigates the responsiveness of receipts to rates as well as the role of progressivity. In conclusion, Section 7 concludes about the main lessons that can be drawn from the inquiry.

2. Related literature

5. The relationship between tax rates and revenues can be expected to be non-monotonic: the same tax revenue is consistent with two levels of the tax rate, e.g. revenue is zero when the tax rate is 0%, rises, peaks and declines to zero when rates reach 100% (Canto et al., 1981). Rising tax rates can shrink the tax base through two main channels: by (1) creating increasingly powerful economic distortions that reduce output and (2) Fraising incentives to avoid taxes (Heijman and van Ophem; 2005; Papp and Takats, 2008; Trabandt and Uhlig, 2011; Bi et al., 2013). The economic literature has investigated both channels, looking at the behavioural response of individuals to changes in the tax structure:

1. The first channel has been extensively studied by the economic literature on the welfare effects of the tax system, focusing on the deadweight loss of taxation. Since Ramsey's (1927) seminal paper, the focus has been on identifying tax structures that minimise distortions. The literature has largely focussed on the labour supply response of workers and on investment incentives for firms (Keane, 2011; Auerbach and Hassett, 2015). There is extensive evidence that taxation reduces labour supply and business investment, thus shrinking the tax base (Arnold et al., 2011; Blundell and MaCurdy, 1999; Johansson, 2016; Norwegian Ministry of Finance, 2014; Thoresen and Vattø, 2015).
2. The second channel focuses on ways to reduce the tax base due to tax evasion and avoidance. Much of the economic literature has investigated tax evasion, or non-compliance, by studying decisions to under-report income to the tax authorities given the tax rate, penalties, and the probability to be audited and convicted for tax evasion (Allingham and Sandmo, 1972; Slemrod, 2007). By contrast, tax avoidance includes many types of lawful actions to reduce the tax bill, from exploiting loopholes in the system to legally shifting the tax base to jurisdictions with a more favourable treatment (Johansson et al., 2017). This type of behaviour has been investigated mainly with respect to corporations (Slemrod and Yitzhaki, 2002; Desai and Dharmapala, 2009). Another strand of research relates the willingness to pay taxes to social and moral norms (Fortin et al., 2007).

6. Policies, institutions and broader framework conditions have the potential to shape the response of tax revenue to changes in rates. More effective institutions can be expected to make revenues respond more strongly to rates by lowering the benefits of tax avoidance and evasion for a given tax rate (Papp and Takáts, 2008; Sanyal et al., 2000). Greater trust in government and political participation should enhance the value that taxpayers place on what their taxes achieve, thereby increasing tax compliance and also enhancing revenue responsiveness to rates (Feld and Frey, 2002; de Janvry and Sadoulet, 2007). Vogel (2012) describes a general-equilibrium model where greater ease to shift activity towards the informal sector reduces government's capacity to raise revenue.

7. The empirical literature has focused on the efficiency cost due to taxation by estimating the elasticity of taxable income (ETI). In a seminal paper, Feldstein (1995) recommended measuring the efficiency cost of taxation by the elasticity of taxable income with respect to the marginal tax rate. Saez et al. (2012) highlight that this literature mainly focuses on top incomes and concludes that countries are rarely on the declining side of the Laffer curve for taxes on personal income. Creedy and Gemmell (2015) and Acheson et al. (2017) apply this methodology to personal income taxation in the United States and Ireland to estimate different revenue-maximising elasticities of taxable income for different tax brackets. However, this literature does not take into account framework conditions that might affect this elasticity

such as factors underpinning the willingness to pay taxes or the possibilities to shift taxable income to lower-tax jurisdictions. The empirical literature has mainly investigated the effect of tax reforms in a single country (usually the United States). In this context, framework conditions, which are generally persistent in time, do not play a role in the identification of the elasticity.

8. In a cross-country analysis, the empirical identification can include framework conditions that contribute to differences in the tax base elasticity across countries. Clausing (2007) allows trade openness and FDI to alter the rate-revenue relationship for corporate income tax. Heijman and van Ophen (2005) propose a model of taxation where the elasticity of the tax base depends on decisions to work and to do so in the formal or black market economy, and considering that the effect of taxation on this choice depends on an individual's willingness to pay taxes. They use a “discrepancy” method to evaluate the marginal effective tax rate based on national accounts indicators for 12 OECD countries, finding that the greater the willingness to pay, the higher the revenue-maximising tax rate. More importantly, willingness to pay provides a parameter to distinguish the effect in different countries, so that a country-specific revenue-maximising tax rate is estimated. According to their results, all the countries considered but Sweden had effective marginal tax rates in 1996 below the revenue-maximising level. For Sweden, they estimate the revenue-maximising marginal tax rate at 58% against an observed rate of 65%. Their results are, however, not comparable with many other studies (including this study), as they consider an aggregate of all income taxes plus VAT.

9. Finally, the relationship between tax revenue and the tax base can be analysed in a dynamic setting. A general equilibrium approach provides the natural framework to investigate the overall effect of taxation on revenue. In particular, the above-mentioned literature does not explicitly distinguish short and long-run effects. Trabandt and Uhlig (2011) derive the Laffer curves for the United States and 14 EU countries using a calibrated neoclassical growth model. Their model is consistent with the existence of a Laffer curve for income and capital but not consumption taxes. Similar models employ the Laffer curve to define long-run debt sustainability (Bi, 2012; Bi et al., 2013).

3. Conceptual and empirical framework

3.1. The empirical framework

10. The empirical analysis is conducted for three broad categories of taxes:

1. Broadly defined personal income tax (PIT), including social security contributions and payroll taxes; broad PIT represents the largest source of tax revenue in most OECD countries;
2. Corporate income tax (CIT), which although providing a much smaller share of revenue has important implications for the activity of firms; and
3. Consumption taxes, which are the other main source of government revenue. The focus for consumption taxes is on value added taxation (VAT).

11. In all three cases, the empirical framework focuses on the *effective* marginal tax rate that individuals and firms face in their decisions. The guiding principle is to use a measure or proxy for the rate that effectively applies after tax allowances, deductions and benefit withdrawal. Using effective rather than statutory rates is important for personal and corporate income, because statutory rates often change simultaneously with the rules (such as the ones mentioned immediately above) that define the base to which rates apply (Kawano and Slemrod, 2016). The study uses the following concepts for the three taxes it covers:

1. For PIT, the analysis is conducted considering marginal effective tax rates at different income levels (OECD, 2016).
2. For CIT, the effective marginal tax rate measures incremental taxation on a “representative” investment (CBT, 2016).
3. For VAT, in the absence of measures of effective marginal rates accounting for reduced rates and exemptions, the analysis is based on the standard rate. The standard rate of VAT applies to the vast majority of private consumption in OECD countries.

Section 3.3 below details the data used in the light of these principles.

12. Tax revenue is expressed as a ratio of GDP. This choice, standard in the tax literature, makes revenue indicators more easily comparable across countries. It also reduces the impact of cyclical effects, as most sources of taxable income move roughly in line with the cycle: in technical terms, the tax base elasticities to the output gap are close to one (Price et al., 2015). The subsequent analysis, nevertheless, systematically checks whether cyclical effects are significant.

13. The relationship between the effective tax rate and revenue is summarised by the following identity:

$$\frac{T}{GDP} = \frac{T}{B} * \frac{B}{GDP} \quad (1)$$

14. Tax revenue as a share of GDP is determined by two ratios: revenue over the tax base, B , and tax base over GDP. The first ratio corresponds to the effective marginal tax rate, τ , i.e. the rate that transforms the tax base into revenue, $T = \tau * B(\tau)$, from which $\tau = \frac{T}{B(\tau)}$. Non-monotonicity stems from the impact of the effective tax rate on the tax base. There are two channels through which raising the effective tax rate influences tax revenue: the change in τ times a given tax base, which is positive, and the indirect effect through the modification of the tax base $B(\tau)$ times the tax rate τ , which is expected to be negative. The overall impact of a change in the effective tax rate therefore depends on which channel prevails.

15. For the empirical analysis the following reduced-form specification of the relationship between the effective tax rate and the tax base is considered:

$$B(\tau) = \alpha + \beta\tau \quad (2)$$

Where α represents a scale factor of the tax base and can be interpreted as the income level in the absence of taxation. The parameter β represents the marginal effect of the tax rate on the base: it is expected to be negative, as increasing the effective tax rate reduces incentives to work, invest, save and consume. This concept is akin to Feldstein’s (1995) elasticity of taxable income (ETI). Substituting the expression for the tax base into equation (1) and adding a constant and an error term provides the empirical specification of the baseline model:

$$\left(\frac{T}{GDP}\right)_{it} = c + \alpha\tau_{it} + \beta\tau_{it}^2 + c_i + y_t + \theta'X_{it} + \epsilon_{it} \quad (3)$$

16. The subscripts i and t correspond to country and year, c is a constant term, and ϵ_{it} is the error term. This empirical model of tax shares does not distinguish between short and long-term responses. The identified response of the tax base to a change in the tax rate is immediate and permanent, as the model estimates persistent effects, abstracting from cyclical impacts.

17. The estimation of equation (3) includes country fixed effects c_i , which capture the effect of all country-specific characteristics that do not vary substantially over the sample period. This choice thereby reduces the risk of omitted variable bias. The estimation also includes time fixed effects y_t , which control for common shocks affecting tax revenue in all economies in a given year and common cross-country trends such as technical change. Under the vector X_{it} , the estimated equation also controls for working-age population growth (for CIT and PIT because it can influence capital stock dynamics and the labour-capital income split), openness (for CIT and VAT because it shapes the base of these taxes) and inflation (for CIT because it can alter the burden of CIT and PIT through collection lags or absence of indexation).

18. Furthermore, for corporate and personal income taxes, the effective rate of the “other” income tax may affect tax revenue from the income under consideration. The reason is that people may incorporate or (dis)incorporate depending on the difference between personal and corporate tax rates. This phenomenon is referred to as a tax externality (Saez et al., 2012). Accordingly, the effective marginal rate of corporate income taxation enters the analysis of personal income tax (PIT) revenue as a control variable in addition to the PIT effective marginal tax rate. Finally, trade openness is included in the analysis of corporate income tax, since international tax competition is expected to reduce tax revenue collected from the corporate sector (Johansson et al., 2017).

3.2. Country-specific framework and institutional features

19. The baseline model can be enriched with institutions and framework conditions that potentially influence responses to tax reforms. Country-specific framework conditions, such as the degree of trade openness or the amount of resources allocated to tax enforcement, may shape responses to changes in effective tax rates. Similarly, better institutions are expected to shift the Laffer curve upwards or rightwards by lowering the benefits of tax avoidance and evasion for a given tax rate (Papp and Takáts, 2008; Sanyal et al., 2000). Furthermore, greater trust in government and political participation should enhance the value that taxpayers place on what their taxes achieve, thereby increasing tax compliance, also shifting the Laffer curve upwards or rightwards (Feld and Frey, 2002; de Janvry and Sadoulet, 2007).

20. Framework conditions are likely to affect the response of the tax base to changes in the effective tax rate, and thereby the Laffer curve, in particular through the tax compliance channel. Households and firms may underreport their income to reduce their tax burden. The literature on tax compliance highlights the level of the tax rate and risk being punished by the judiciary system as factors that affect the decision to underreport income. The higher the tax rate is, the higher the expected net gain will generally be from underreporting income after factoring in the likelihood of being discovered.

21. Broader social factors may also influence compliance. A natural hypothesis is to anticipate lower informality and better tax compliance in countries where people place greater trust in institutions. Civic engagement (voter turnout) and confidence in public institutions may also influence the propensity of people to pay taxes. For a given level of taxation, countries that score higher on civic engagement and trust in institutions can be anticipated to display lower informality and tax evasion.

22. The administrative capacity of the government to raise taxes and enforce compliance can also influence the shape of the Laffer curve. The skills of tax inspectors are crucial in a complex economic system, where firms can have multiple cross-border ties. As a proxy for competence, the analysis employs, on the one hand, the amount of resources spent on tax administration and, on the other hand, the degree to which the authorities use information and communication technology (ICT) to manage tax data and their relationships with taxpayers.

23. For corporate income taxation, as mentioned above, the capacity of multinational companies to shift profits to lower-tax jurisdictions, could also affect the Laffer curve. Opportunities for such relocation decisions should increase with existing trade linkages, which are measured by trade openness, and the presence of multinational firms, which can be gauged by the stock of foreign direct investment (FDI). The FDI stock, however, may itself depend on the tax level: to address these concerns, financial openness is also measured using a *de jure* index (an update of Chinn and Ito's index, 2006).

24. Institutional quality is measured with a composite indicator based on the World Bank Worldwide Governance Indicators (WGI). These indicators capture several dimensions of governance ranging from government capacity to implement policies to the rule of law and control of corruption (Table 1). The analysis computes the first principal component of the six indicators listed in the first column of Table 1 as a composite indicator of institutional quality (Box 1). This index explains around 85% of the variation in the six underlying indicators. Figure 1 plots country scores for this index in 2014.

Table 1. Potential drivers of the hump-shaped relationship between tax rates and revenues

Institutional quality	Framework conditions
Government effectiveness	Voter turnout
Regulatory quality	Tax administration costs over total revenues
Control of corruption	Trade openness
Rule of law	FDI stock
Voice and accountability	Financial openness
Political stability	Product market regulation (PMR)
	Social globalisation
	Political globalisation

25. The indicators of institutional quality, i.e. the Worldwide Governance Indicators (WGI), are perception-based indicators that the World Bank collects to provide an overview of governance quality across countries (Box 1). They portray the sentiment of citizens and experts on critical issues of governance, such as political stability and voice and accountability. By contrast, framework conditions are based on quantitative indicators (voter turnout, tax administration costs, trade openness, FDI stock, KOF indices of social and political globalisation) or the coding of legal provisions (financial openness, product market regulation). The aggregate product market regulation indicator (PMR) comes from the OECD PMR database (Koske et al., 2015). The KOF index of social globalisation reflects the intensity of international interpersonal links and cultural proximity while the KOF index of political globalisation measures official participation in foreign and global affairs (Dreher, 2006; Dreher et al., 2008).

Box 1. Worldwide Governance Indicators

The World Bank collects its Worldwide Governance Indicators to provide cross-country indicators of governance. The indicators rely on surveys of firms and household, who share their perceptions of several aspects of governance, and on subjective assessments by experts (from the business sector and international organisations). The indicators are therefore perception-based and not objective. However, the variety of the sources and the methodology used in collecting information assure consistency across countries.

The database consists of six composite indicators, which cover three broad areas of governance for 200 countries starting in 1996. The first two indicators (voice and accountability; political stability) relate to the process by which the government is selected, monitored and replaced; voice and accountability additionally includes perceptions about freedom of expression and access to information. Two other indicators (government effectiveness; regulatory quality) reflect the capacity of the government to formulate and implement policies; government effectiveness also reflects the quality of the civil service and its degree of independence from political influence. The last two indicators (rule of law; control of corruption) capture the degree of commitment and respect of citizens and the government for the institutions that govern economic and social interactions.

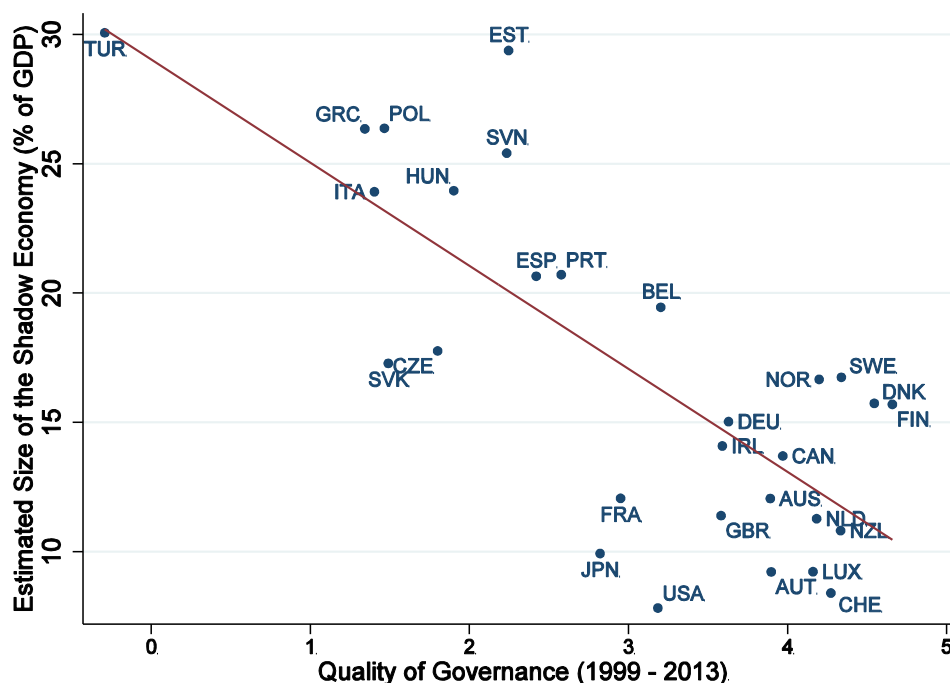
The present analyses use a composite index, which is called Quality of Governance throughout the study, to summarise performance along these six WGI indicators. The Quality of Governance index, which is calculated as the first principal component of these six indicators, is equal to:

$$\text{Quality of Governance} = 0.30 \times \text{Voice and Accountability} + 0.29 \times \text{Regulatory Quality} + 0.43 \times \text{Rule of Law} + 0.37 \times \text{Political Stability} + 0.40 \times \text{Government Effectiveness} + 0.58 \times \text{Control of Corruption}$$

This index, plotted in Figure 1, explains around 85% of the variation in the six underlying indicators. A single index effectively summarises the information, because these indicators are strongly correlated. The synthetic indicator is thus also strongly correlated with each of the six underlying indicators.

This index of Governance Quality is closely linked with the extent of informality. The index is highly correlated with Schneider's (2013) measure of the share of informal activities in GDP (Figure 1). Countries with weaker governance typically have much higher shares of informality than better governed economies.

Figure 1. Quality of Governance composite indicator and the shadow economy



Source: OECD calculation based on World Bank Governance Indicators (Kaufmann et al., 2011) for Quality of Governance and Schneider (2013) for estimates of the size of the shadow economy.

26. The baseline model is augmented with two interaction terms to test the impact of institutions and framework conditions. The composite indicator of institutional quality (I) is interacted with the tax rate, while framework conditions (F) are (one at a time) interacted with the square of the tax rate. The estimated equation therefore takes the form:

$$\left(\frac{T}{GDP}\right)_{it} = c + \alpha\tau_{it} + \beta\tau_{it}^2 + \gamma_1\tau_{it}I_{it} + \gamma_2\tau_{it}^2F_{it} + \epsilon_{it}$$

27. As in the baseline model, the estimation includes country and year fixed effects. The assumptions behind this form of the relationship are that (1) institutional quality affects the response of tax revenue in a linear way, i.e. it does not depend on the level of the tax rate, while (2) framework conditions have an impact that depends on the level of the tax rate. Taking the first derivative of the baseline model highlights these features:

$$\frac{\partial\left(\frac{T}{GDP}\right)_{it}}{\partial\tau} = \alpha + 2\beta\tau + \gamma_1I + 2\gamma_2\tau F$$

28. Institutional quality is expected to affect the marginal impact of the tax rate on revenue in a constant way, because better institutions, such as government effectiveness or regulatory quality, would improve the response regardless of the tax rate level. By contrast, the impact of framework conditions is more likely to increase with the tax rate, as they relate to tax avoidance, for which the incentive rises with the tax rate. To check the robustness of results to these assumptions, both institutional indicators and framework condition indicators are separately interacted with both the tax rate and its square term in sensitivity checks (available from the authors). These checks indicate that the results largely hold when assuming that regulatory quality interacts with the squared rather than the linear term and framework conditions with the linear rather than the squared term.

3.3. Description of the tax data

29. The analysis covers 34 OECD countries over the period 1978-2014. The following countries are included: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The effective time coverage of the data varies by country (Table 2).

30. OECD Revenue Statistics as gathered in the OECD Public Finance database (Bloch et al., 2016) provide the main data source for tax receipts. This dataset provides a set of detailed and internationally comparable tax revenue data for all OECD countries and a number of emerging economies. For most OECD countries, these data are available from 1965 onwards and for emerging economies from 1990 or later. In this study, overall tax revenue is broken down into three broad categories: (i) personal income taxes (including social security contributions and payroll taxes); (ii) corporate income taxes; and (iii) value-added taxes. Table 3 shows the codes of the revenue statistics used.

Table 2. Time coverage by country and tax

Country	Corporate income tax		Value added tax		Personal income tax	
	Period Covered	Obs.	Period Covered	Obs.	Period Covered	Obs.
AUS	1988-2014	27	2000-2014	15	1990-2014	25
AUT	1994-2014	21	1973-2014	42	1994-2014	21
BEL	1994-2014	21	1971-2014	44	1994-2014	21
CAN	1999-2014	16	1991-2014	24	1999-2014	16
CHE	1994-2014	21	1995-2014	20	1994-2014	21
CHL	1996-2014	19	1990-2014	25	2008-2014	7
CZE	2002-2014	13	1993-2014	22	2002-2007	6
DEU	1990-2014	25	1968-2014	47	1992-1999	8
DNK	1992-2014	23	1967-2014	48	1992-2014	23
ESP	1996-2014	19	1986-2014	29	1996-2014	19
EST	1995-2014	20	1995-2014	20	-	-
FIN	1992-2014	23	1994-2014	21	2000-2014	15
FRA	1990-2014	25	1968-2014	47	1990-2014	25
GBR	1990-2014	25	1973-2014	42	1991-2014	24
GRC	1998-2014	17	1987-2014	28	1998-2014	17
HUN	1994-2014	21	1991-2014	24	1995-2010	16
IRL	1994-2014	21	1972-2014	43	1994-2014	21
ISL	1995-2014	20	1990-2014	25	2000-2014	11
ISR	1998-2014	17	1995-2014	20	2005-2014	10
ITA	1990-2011	22	1973-2014	42	1990-2011	22
JPN	1983-2014	32	1989-2014	26	2000-2014	15
KOR	1999-2014	16	1977-2014	38	2000-2014	15
LUX	1999-2014	16	1970-2014	45	2000-2014	15
MEX	2002-2014	13	1980-2014	35	2002-2014	13
NLD	1998-2014	17	1969-2014	46	1998-2014	17
NOR	1992-2014	23	1970-2014	45	2000-2014	15
NZL	1999-2014	16	1987-2014	28	1999-2012	14
POL	1994-2014	21	1993-2014	22	1995-2014	19
PRT	1994-2014	21	1986-2014	29	1995-2014	20
SVK	2003-2014	10	1995-2014	20	2003-2014	3
SVN	1995-2014	20	1999-2014	16	2000-2014	15
SWE	1992-2014	23	1969-2014	46	1992-2014	23
TUR	1998-2014	17	1985-2014	30	-	-
USA	1999-2014	16	-	-	1999-2014	16
Total	1983-2014	677	1967-2014	1026	1990-2014	528

Table 3. Tax revenue breakdown used in the analysis

Label	Comments	Source
Personal income tax (PIT)	Taxes on income, profits and capital gains of individuals (1100), social security contributions (2000) and payroll taxes (3000)	OECD Revenue Statistics
Corporate income tax (CIT)	Taxes on income, profits and capital gains of corporations (1200)	OECD Revenue statistics
Value added tax (VAT)	Value added taxes (5110)	OECD Revenue Statistics

31. Data on effective marginal tax rates are gathered from various sources. The effective marginal corporate income tax rate (EMTR) is compiled by the Oxford University Centre for Business Taxation, which provides data from the early 1990s up to 2016 for 48 countries (CBT, 2015). The indicator measures “the change in the cost of capital arising from introducing the tax, expressed as proportion of the cost of capital in the absence of tax” (Bilicka and Devereux, 2012). The indicator takes into account subnational corporate income tax, including CIT deductions across government levels (Bilicka and Devereux, 2012).

32. Data on the effective marginal tax rate for personal income are derived from the OECD Taxing Wages publication (OECD, 2016). The OECD calculates the tax wedge as the difference between the cost of labour for firms and the take-home pay (including cash benefits) received by the worker. The effective marginal tax rate is then calculated as the difference in the tax wedge as the consequence of a marginal increase of income. The effective marginal tax rate (EMTR) depends on the level of income and individual characteristics of the worker.

33. The analysis focuses on single individuals with no children evaluated at low, middle and upper-middle income. More precisely, the analysis uses effective marginal rates that workers face at 67%, 100%; 133% and 167% of average income. These effective marginal tax rates take into account the withdrawal of transfers, which in some countries matter substantially at 67% of average income. The effective marginal tax rates of broad PIT are extended before 2000 (the first covered year in OECD, 2016) using the predicted values from a linear regression on the schedules of narrow PIT (from the OECD Tax Database) including country and year fixed effects.

34. The PIT analysis uses indicators of marginal effective tax rates at different income levels for single individuals rather than families for the sake of simplicity. Including families would involve three dimensions (income of the first earner, income of the second earner and the number of children) but not bring much additional information. For instance, marginal effective tax rates for single earners at average income levels are 79-96% correlated with the METRs calculated for four typical family configurations where the first earner receives average income (Appendix Table A3, Column 1). These associations remain strong when controlling for country fixed effects (Appendix Table A3, Column 2), which is important for the econometric regressions below.

35. The analysis is complemented by the use of the top statutory income tax rate as an indicator of the marginal tax rate applying in the upper part of the income distribution. The investigations in this case exclude social security contributions and payroll taxes from PIT receipts to ensure consistency between rates and revenues.

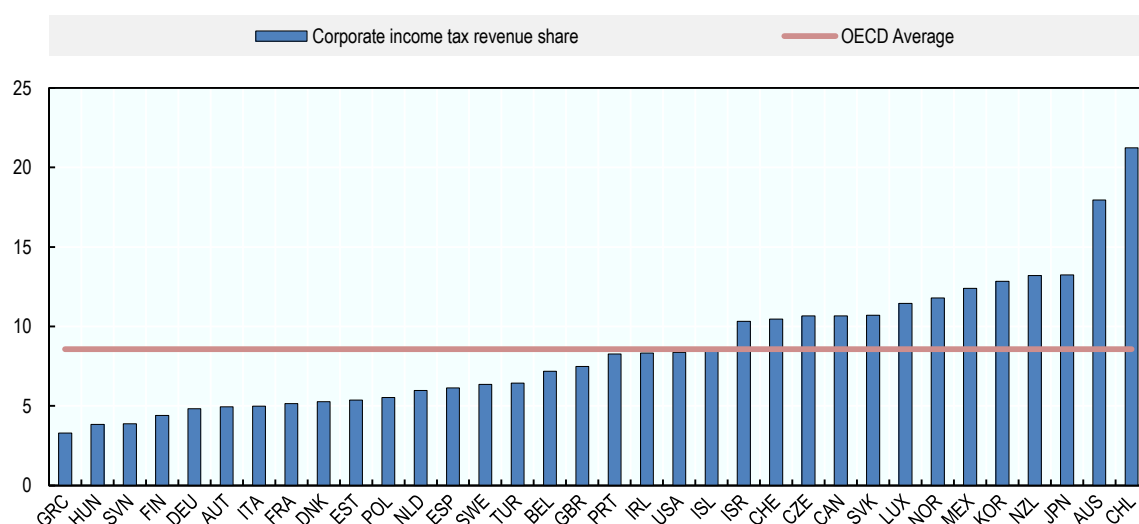
36. Data on standard VAT tax rates are obtained from the OECD Revenue Statistics database. This standard rate is what consumers pay on most goods and services subject to the tax. However, some goods and services may be taxed at special rates or exempt from VAT. This raises two questions: first, tax revenue may change even if the standard rate does not, because of changes in special rates or

inclusion/exclusion of categories of products; second, the substitution effect triggered by an increase in the standard VAT rate is not only towards leisure but also other goods that are taxed at lower rates (or untaxed). The analysis is based on the standard rate for three reasons: first, it applies to most of the tax base; second, it avoids the endogeneity that would arise from using a weighted average rate, which not only reflects rate changes but also the consumption shifts they induce; third, no weighted average series are available (Matthews, 2003).

4. Corporate income tax

37. The corporate income tax brings in about 9% of government revenue on average across OECD countries. Reliance on CIT, however, varies a lot across countries and is particularly high in commodity exporting countries (Figure 2). Corporate income tax represents the main form of taxation of corporate profits, thus affecting incentives to invest and innovate, with effects for growth and employment (Arnold et al., 2011; Djankov et al., 2010).

Figure 2. Share of corporate income tax in total tax revenue
2014



Note: The OECD average corresponds to the unweighted mean across the OECD countries in the sample. The figure presents tax ratios for 2014 except for Australia, Greece, Japan, Mexico, the Netherlands and Poland for which the data comes from 2013.

Source: OECD Revenue Statistics database.

4.1. Results from the baseline model

Main results

38. The results of estimating the baseline model (without framework conditions, i.e. $\gamma_1 = 0$ and $\gamma_2 = 0$) are presented in Table 4, where equations with different combinations of explanatory and control variables are considered. The estimated coefficients of the tax rate and its square term suggest the presence of a non-monotonic relationship with respect to both the EMTR and the statutory rate (column 2).

Table 4. The effect of the tax rate on corporate income tax revenue

Dependent variable:					
CIT revenue (ratio to GDP)	(1)	(2)	(3)	(4)	(5)
EMTR	0.014*	0.089***	0.092***	0.092***	0.12***
	(0.0083)	(0.022)	(0.022)	(0.022)	(0.027)
EMTR squared		-0.19***	-0.19***	-0.19***	-0.24***
		(0.054)	(0.055)	(0.057)	(0.067)
Population growth			0.36***	0.36***	0.29***
			(0.086)	(0.083)	(0.073)
Inflation			-0.00096	-0.0020	0.0092
			(0.0047)	(0.0045)	(0.010)
Trade openness				-0.0048	-0.0062*
				(0.0029)	(0.0037)
PIT EMTR167					0.040**
					(0.020)
Observations	677	677	670	670	536
R-squared	0.758	0.762	0.768	0.770	0.826
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Turning point	-	0.23	0.24	0.24	0.25
Standard error	-	0.023	0.027	0.027	0.022

Note: Robust standard errors are in parenthesis. EMTR stands for effective marginal tax rate applied to corporate income. Standard errors for turning points are calculated using the delta method.

39. The non-monotonic relationship is confirmed also when adding more control variables (columns 3-5). Trade openness is found to reduce CIT revenue. The latter is consistent with at least two explanations. The first is that firms shift profits to jurisdictions with more favourable tax treatment, as documented by the OECD research on base erosion and profit shifting (Johansson and Sorbe, 2017). The other is related to international tax competition, which is likely to increase the effects of tax rates on the location of firms or more broadly of their profit-generating activities (IMF, 2014). Finally, the effective marginal tax rate for personal income tax (PIT EMTR167) has a positive and significant effect on CIT revenue, implying that an increase in the PIT effective tax rate provides an incentive to report earnings as corporate rather than personal income (Saez et al., 2012). Interestingly, it is only the marginal tax rate at the 167% of average income that is statistically significant, indicating that this tax externality kicks in only at relatively high income levels.

Sensitivity checks

40. The output gap is not statistically significant. This result is in line with the hypothesis made in Section 3.1 based on Price et al.'s (2015) finding that the elasticity of profits with respect to the cycle is not very far from unity in most OECD countries. This robustness to cyclical effects represents one of the benefits of conducting the estimation in levels rather than differences. The analysis therefore does not include the output gap apart from robustness checks (not reported).

41. Excluding the crisis period from the sample does not modify the results qualitatively. Results remain statistically significantly but are weaker, as excluding the crisis period substantially shortens the sample (CIT EMTR series start only in the 1990s).

42. The results are also robust to excluding commodity-exporting countries. CIT revenues typically make up comparatively large sources of government revenue in commodity-exporting countries;

furthermore, special tax regimes can apply to oil and gas production. Consequently, commodity exporters could be outliers in this analysis. The results are qualitatively unchanged and quantitatively very close when excluding commodity exporters, indicating that these countries are not driving the estimation.

43. Furthermore, the findings do not vary depending on imputation possibilities (whereby shareholders can deduct part of the CIT paid by companies they own from their personal income tax). The OECD Tax Database allows building a variable that measures the presence, or not, and the size of imputation possibilities. This variable was set to zero in countries that offer no imputation possibilities and at their observed imputation rates (taken from Table II.4 of the OECD Tax Database) for countries that do. Neither this variable nor its interactions with the level or square of the effective marginal tax rate are significant in explaining the CIT revenue ratio.

44. An alternative specification investigated if, rather than being inverse-U shaped, the relationship might not be one where successive rate hikes generate smaller and smaller increases but no fall in revenue. This alternative specification estimated as a hyperbolic form as below could explain the rate-revenue relationship. Estimation using panel non-linear least squares with country and year fixed effects shows no such relationship in the data: the estimated coefficients are statistically undistinguishable from zero at any standard confidence levels.

$$\left(\frac{T}{GDP}\right)_{it} = c + \frac{a\tau_{it}}{1 + b\tau_{it}} + c_i + y_t + \epsilon_{it}$$

Statutory rates

45. Analyses using the statutory rate of corporate income tax yield results that are unstable. This instability presumably reflects that the rules translating statutory rates into effective ones that companies actually face can vary over time: an increasing disconnect has developed between effective and statutory rates over the past two and a half decades (Dyreng et al., 2017). Furthermore, rules governing how CIT is calculated often evolve at the same time as statutory rates are changed (Kawano and Slemrod, 2016). Consistent with this viewpoint, regressions using statutory rates are quite sensitive to including or dropping specific countries.

Interpretation in terms of illustrative turning points

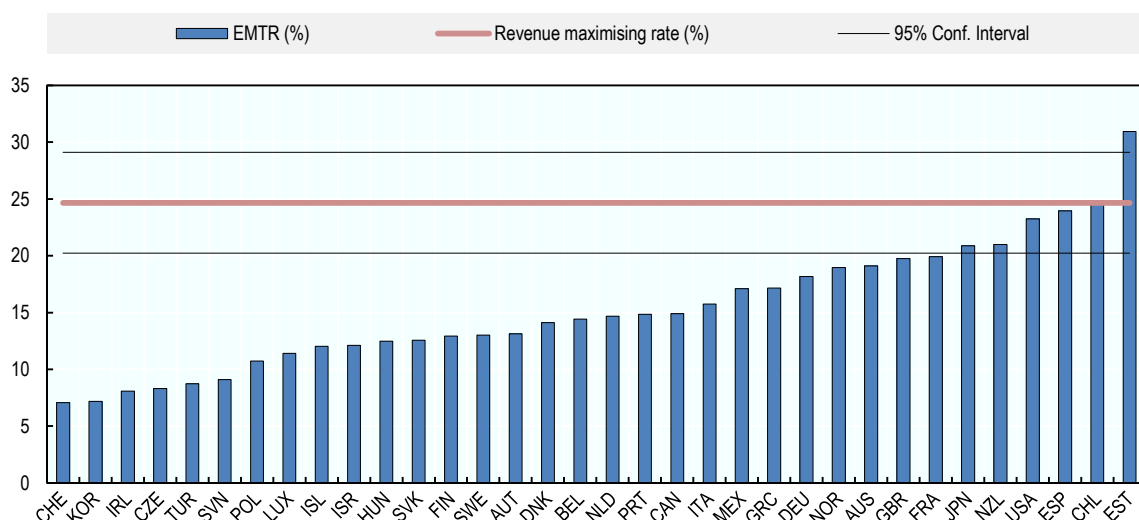
46. For illustrative purposes, the hump-shaped relationship emerging from the estimation of the empirical model indicates a turning point above which tax revenue would decrease when further raising rates. This turning point is the estimated revenue-maximising level of the effective marginal tax rate. The turning point is equal to:

$$\tau^* = -\frac{\beta_1}{2\beta_2}$$

47. This turning point does not maximise economic growth or social welfare. At the turning point, a rate hike increases distortions (as otherwise revenue would increase) without generating revenue: consequently, at this point, the marginal cost of public funds is infinite. The level of taxation is optimal in the sense of maximising social welfare when the marginal cost of public funds equals the marginal benefits of public spending, that is to say the left of the turning point.

48. According to the estimated coefficients in model 5 of Table 3, an EMTR of 25% maximises CIT revenue. In 2016 only one country (Estonia) had an effective marginal tax rate above this turning point (Figure 3). Several countries lie within the 95% confidence interval, amongst which Chile, Spain and the United States find themselves particularly close to the estimated revenue-maximising level.

Figure 3. Actual and estimated revenue-maximising effective marginal rates of corporate income tax
2016



Note: The EMTR represents the effective marginal tax rate in 2016 (for Italy the value is for 2011).

Source: Authors' estimates and data from Oxford Centre for Business Taxation.

4.2. Institutions and framework conditions

49. The capacity of governments to raise tax revenue may depend on the institutional framework and other socio-economic characteristics that are country specific. As described in Section 3.2, institutions and framework conditions augment the baseline model by entering as interaction terms. The empirical analysis considers one model for each framework condition, which is interacted with the square term of the tax rate. In each equation there is also the interaction of the tax rate with the composite indicator of governance quality.

$$\left(\frac{T}{GDP}\right)_{it} = c + \alpha\tau_{it} + \beta\tau_{it}^2 + \gamma_1\tau_{it}I_{it} + \gamma_2\tau_{it}^2F_{it} + c_i + y_t + \epsilon_{it}$$

50. To better understand the estimation results, it is worth considering the equation for the revenue-maximising rate, obtained from the first order condition for maximisation applied to the equation above,

$$\tau^* = -\frac{\beta_1 + \beta_3 I}{2(\beta_2 + \beta_4 F)}$$

51. The parameter β_3 is anticipated to be positive, as better institutions should facilitate tax collection and result in a higher τ^* (the revenue-maximising level of EMTR). The parameter β_4 is expected to be negative when the tax rate is interacted with trade openness, which raises tax avoidance by offering more opportunities to shift activity or profits towards other jurisdictions. The coefficient β_4 is expected to be positive for tax collection expenditure, as using more resources to screen tax compliance should make it more difficult for firms to avoid corporate income tax.

52. Table 5 shows that the quality of governance has the anticipated sign: better governance is linked with greater responsiveness of tax revenue to changes in the tax rate. The interaction term is positive and statistically significant in all model specifications.

Table 5. Quality of governance and framework conditions affect CIT revenue responsiveness

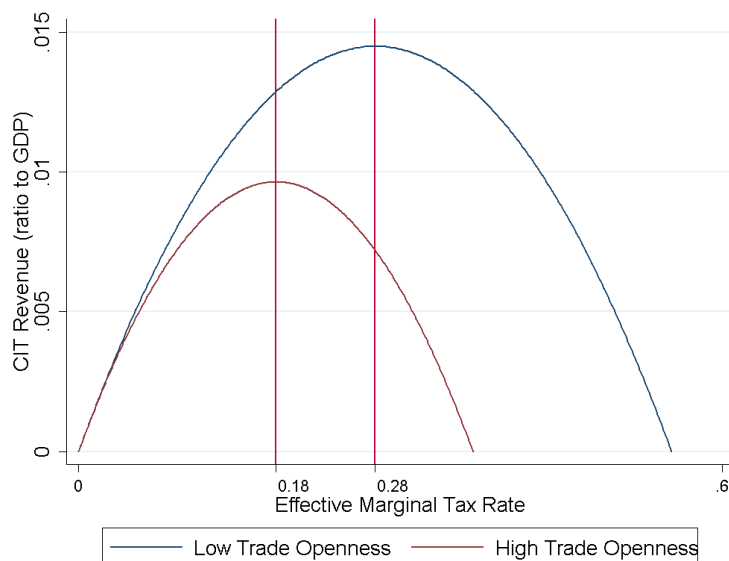
Dependent variable: CIT revenue (ratio to GDP)	Framework indicator							
	Voter turnout	Tax admin. costs	FDI stock	Trade openness	Financial openness	PMR	Social glob.	Political glob.
EMTR	0.11*** (0.019)	0.084*** (0.020)	0.10*** (0.020)	0.11*** (0.021)	0.10*** (0.024)	0.085*** (0.021)	0.12*** (0.022)	0.086*** (0.023)
EMTR squared	-0.26*** (0.049)	-0.16*** (0.049)	-0.22*** (0.050)	-0.20*** (0.048)	-0.24*** (0.076)	-0.15*** (0.053)	-0.20*** (0.052)	-0.17*** (0.056)
EMTR * Quality of governance	0.012*** (0.0045)	0.017*** (0.0037)	0.019*** (0.0040)	0.020*** (0.0039)	0.016*** (0.0042)	0.021*** (0.0042)	0.028*** (0.0051)	0.016*** (0.0045)
EMTR squared * Framework indicator	-0.0028* (0.0015)	0.13*** (0.039)	-0.00022 (0.00044)	-0.083** (0.037)	0.020 (0.027)	0.12** (0.053)	-0.58*** (0.14)	0.23** (0.093)
Observations	517	582	599	599	583	599	566	566
R-squared	0.841	0.803	0.795	0.797	0.767	0.796	0.809	0.804
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Turning point at mean	0.21	0.26	0.24	0.26	0.22	0.29	0.32	0.26
Standard error	0.014	0.029	0.020	0.026	0.033	0.044	0.047	0.030

Note: The dependent variable is CIT revenue (as a ratio to GDP). EMTR represents the effective marginal tax rate of CIT; Quality of Governance is the first principal component of the six variables described in Box 1; Framework indicator is the variable mentioned at the top of each column. The study demeans quality of governance and framework indicators before interacting them with tax rates. Turning points are therefore computed at the mean values of quality of governance and framework indicators. Standard errors for turning points are computed using the delta method.

53. Regarding framework conditions, the estimation indicates that resources spent by the tax administration, the degree of trade openness and product market regulation affect the response of CIT revenue to tax policy changes.

- The revenue potential of CIT is found to be lower in countries with greater trade openness. This finding is in line with the view that firms in more open countries have more possibilities to avoid profit taxation by shifting income to lower-tax jurisdictions (Johansson et al., 2017). The same results do not obtain for financial openness, possibly reflecting that very financially open economies include financial centres, which concentrate substantial amounts of corporate profits. Another explanatory factor may be that the estimation looks at CIT revenue and rates in levels rather than changes and differences with trading partners.
- Spending more on tax administration appears to make revenue more responsive to the tax rate. This result is consistent with the idea that more resources can help to build a tax administration that enforces CIT more effectively. The interaction with the squared tax rate shows that the revenue impact of a better-resourced tax administration is larger for higher tax rates.
- Finally, the stringency of product market regulation (PMR) affects firms' response to changes in the tax rate. More stringent regulation (measured as a higher value of the PMR indicator) is found to increase corporate income tax revenue. In countries with more anti-competitive regulations, increasing the effective marginal tax rate would generate a larger increase in tax revenue than in countries with lower market protection (when the tax rate is below the revenue-maximising point). The reason may be that anti-competitive regulations imply higher profits, thus expanding the CIT base.

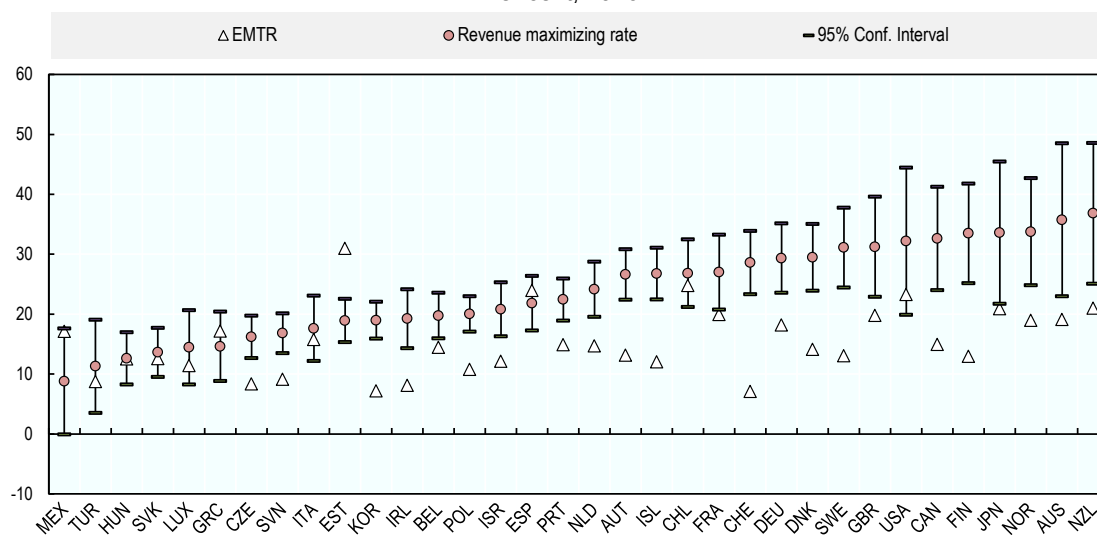
54. These interactions with country-specific characteristics means that estimated revenue-rate relationships vary across countries. For CIT, trade openness has a strong impact: Figure 4 depicts the estimated revenue curves at the bottom 10th and upper 90th percentiles of the distribution of trade openness (with the composite indicator of governance quality set at its mean).

Figure 4. Estimated revenue-rate relationships at low and high trade openness

Note: Low (high) refers to the bottom 10th (top 90th) percentile of the cross-country distribution of trade openness in 2014. EMTR refers to the effective marginal tax rate for corporate income. The composite indicator of governance quality is set at its mean value. The curves rely on the estimates in column 4 of Table 5.

Source: Authors' estimates.

55. The current (2016) level of the EMTR in each country can be compared with an indication that the estimation gives about its revenue-maximising point (Figure 5). The estimated country-specific revenue-maximising point is influenced by governance quality (Figure 1) and trade openness according to the estimated coefficients shown in the fourth column of Table 4. Countries that are more open are generally found to have a lower revenue-maximising effective rate of CIT. Institutional quality also matters for the turning point, so that countries with better institutions or lower trade openness exhibit the highest indicative turning points.

Figure 5. Country-specific revenue-maximising effective corporate income tax rates
Per cent, 2016

Note: Country-specific revenue-maximising rates are calculated based on each country's readings on the composite indicator of the quality of governance (Figure 1) and trade openness. The bands show 95% confidence intervals. Effective marginal tax rates, which refer to 2016, come from the Oxford University Centre on Business Taxation (see Section 3.3).

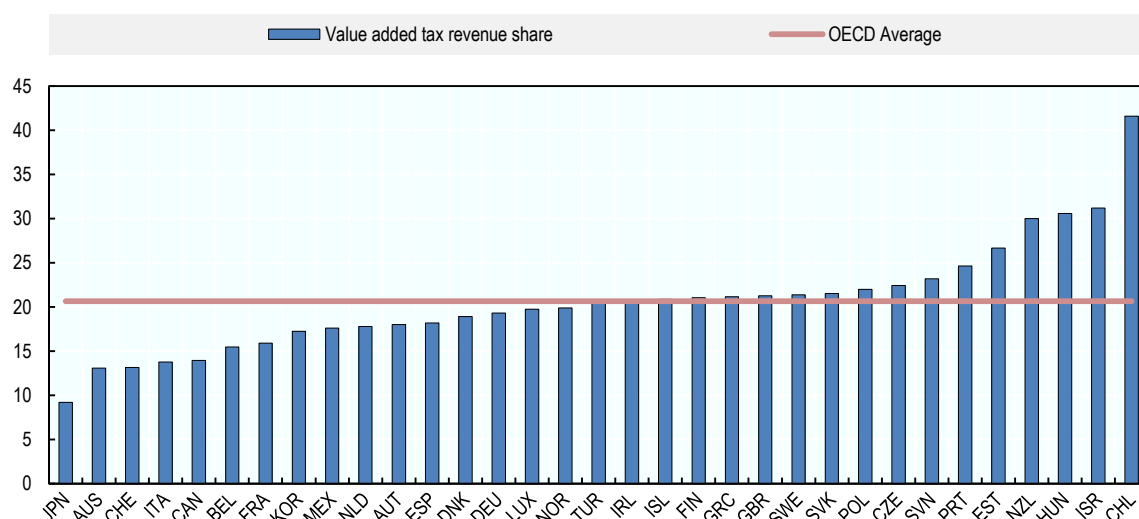
Source: Authors' estimates and Oxford University Centre for Business Taxation data.

5. Value added tax

56. Most governments rely on value added taxation for a good share of their tax mix (Figure 6). In 2014, value added tax receipts accounted for nearly a fifth of total tax revenue on average across the OECD countries that implement this tax.

Figure 6. Share of value added tax in total tax revenue

Per cent, 2014



Note: The OECD average corresponds to the unweighted mean across the OECD countries in the sample. The figure presents tax ratios for 2014 except for Australia, Greece, Japan, Mexico, the Netherlands and Poland for which the data comes from 2013.

Source: OECD Revenue Statistics database.

57. The relationship between the tax rate and revenue of value-added taxes is likely to be non-monotonic for the same reason as for corporate income tax. An increase in the tax rate will prompt responses that shrink the tax base, that is to say a fall in the amount of goods and services consumed or declared so. Besides, an increase in VAT may not be fully reflected in final good prices because of limited competition and a high elasticity of demand. Market conditions such as product market regulation may therefore influence the elasticity of the tax base to changes in the rate.

5.1. Results from baseline model

58. Table 6 presents the results of estimating a baseline model in which tax revenue depends on the standard VAT rate. Column (1) shows that a rate rise increases VAT revenue. Inserting a non-linear term in the equation is important: the coefficient associated with the square of the rate is negative and statistically highly significant. This result underlines that the marginal impact on revenue of rate hikes is weaker when the starting rate is higher.

59. Adding the above-mentioned control variables (population growth and trade openness) does not alter the non-monotonic relationship. Greater trade openness is associated with a higher VAT/GDP ratio: decomposing between imports and exports shows that, quite naturally, greater import penetration generally implies higher VAT revenues. Population growth, however, is not significant; as a rising working age population does not increase VAT revenue relative to GDP (which is plausible given that everybody consumes). As for income taxes and as anticipated in Section 3.1, the output gap does not significantly affect the revenue to GDP ratio.

60. Figure 7 shows actual VAT rates as compared to the estimated turning point in column 2 of Table 6. Most OECD countries are located significantly below the estimated turning point, but a few are close to or inside the confidence band around it.

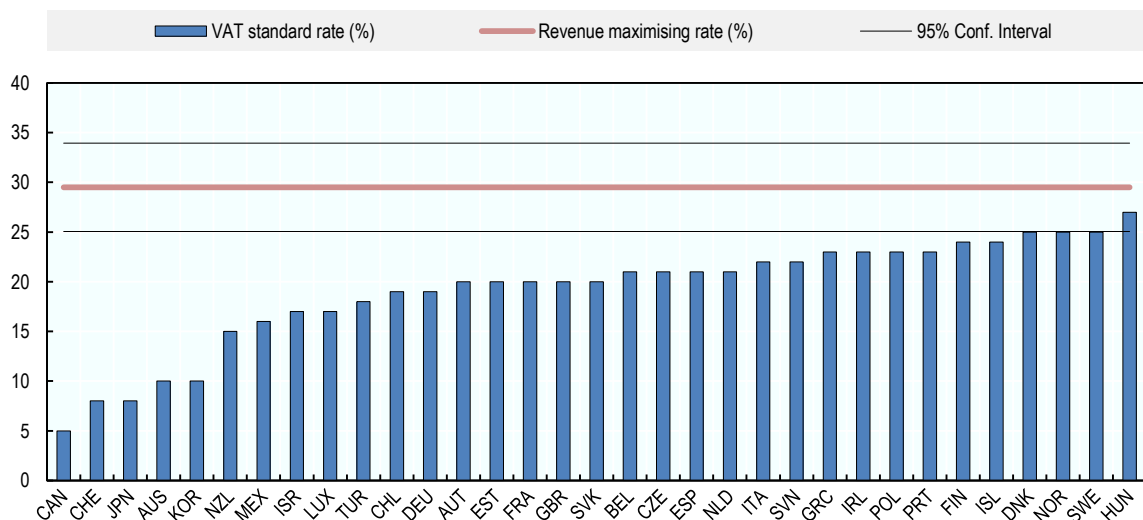
Table 6. Estimated effect of VAT standard rate on revenue

Dependent variable: VAT revenue (ratio to GDP)					
	(1)	(2)	(3)	(4)	(5)
Standard rate	0.19*** (0.016)	0.50*** (0.047)	0.51*** (0.049)	0.44*** (0.051)	0.41*** (0.052)
Standard rate squared		-0.86*** (0.13)	-0.86*** (0.14)	-0.62*** (0.14)	-0.52*** (0.14)
Population growth			0.090 (0.063)	0.0032 (0.058)	-0.017 (0.057)
Trade openness				0.0100*** (0.0018)	
Imports (ratio to GDP)					0.027*** (0.0037)
Observations	1,054	1,054	1,037	1,032	1,032
R-squared	0.908	0.912	0.917	0.922	0.925
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Turning point	-	0.29	0.30	0.36	0.40
Standard error	-	0.020	0.023	0.044	0.064

Note: Robust standard errors appear between brackets. New Zealand and the United States do not belong to the sample because of a different consumption tax system.

Figure 7. Estimated uniform revenue-maximising VAT rate

Comparison with countries' VAT rate in 2016, per cent



Source: OECD (2016), "Revenue Statistics: Comparative Tables", OECD Tax Statistics (database).
DOI: <http://dx.doi.org/10.1787/data-00262-en> and OECD calculations.

5.2. Institutions and framework conditions

61. Administering a complex tax such as VAT requires well-resourced government services. Particular framework conditions such as product market regulation and trade openness may also influence the revenue-raising potential of VAT.

- The empirical results indeed indicate that spending more on tax collection strongly boosts the response of VAT revenue to its standard rate (Table 7, Column 1). This finding likely stems from the relative complexity of administering VAT.
- Anti-competitive product market regulation is linked with a stronger VAT revenue response to rate increases (Table 7, Column 2), presumably reflecting higher profits, as discussed above.
- VAT revenue expands more when the standard rate increases in more open economies (Table 7, Columns 3-4). Very plausibly, as VAT applies to imports (used for final consumption) and not exports, the estimated effect of greater trade openness is particularly strong and well identified when focussing on import penetration (Table 7, Column 4).
- There is no identified effect of governance quality, broadly measured by the above-described composite index.

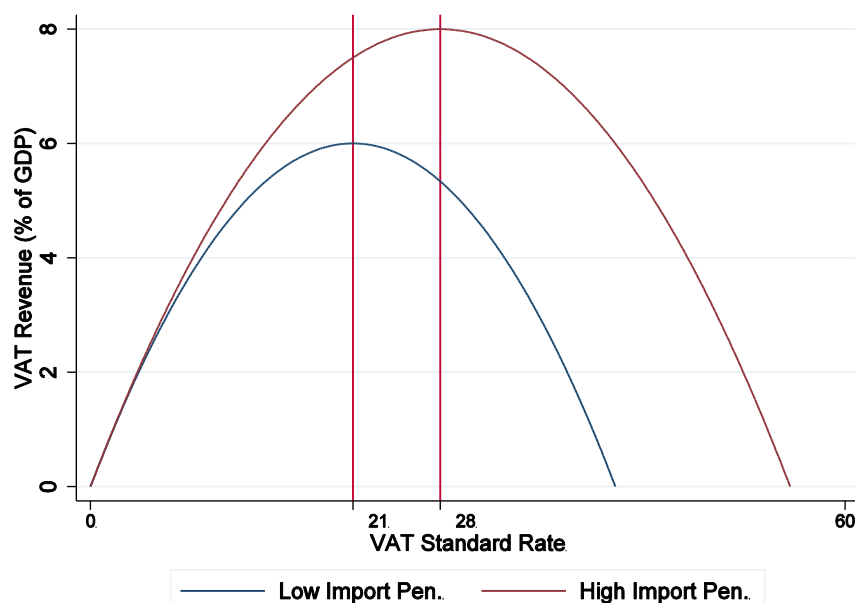
Table 7. Interactions of the VAT standard rate with framework conditions

Dependent variable: VAT revenue (ratio to GDP)	Framework Indicator			
	Tax admin. costs	Product mkt reg	Trade openness	Imports (ratio to GDP)
Standard rate	0.55*** (0.091)	0.53*** (0.090)	0.59*** (0.075)	0.63*** (0.074)
Standard rate squared	-1.38*** (0.27)	-1.20*** (0.26)	-1.34*** (0.21)	-1.46*** (0.21)
Standard rate * Quality of governance	0.0024 (0.0064)	-0.0027 (0.0059)	-0.0015 (0.0052)	-0.0020 (0.0052)
Standard rate squared * Framework indicator	0.43*** (0.12)	-0.068 (0.19)	0.15** (0.069)	0.58*** (0.14)
Observations	601	620	620	620
R-squared	0.946	0.944	0.945	0.948
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Turning point at mean	0.20	0.22	0.22	0.22
Standard error	0.011	0.014	0.011	0.0098

Note: The dependent variable is VAT revenue (as a ratio to GDP). Quality of Governance is the first principal component of the six variables described in Box 1. Framework indicator is the variable mentioned at the top of each column. PMR is the OECD index of product market regulation. The PMR indicator is available only for the years 1998, 2003, 2008, and 2013: the variable used in the regression is the time average of available observations. The quality of governance and framework indicators are demeaned before interacting them with tax rates. Turning points are therefore computed at the mean values of the quality of governance and framework indicators. Standard errors for turning points are computed using the delta method.

62. Interaction with country characteristics implies turning points for VAT that vary across countries. Figure 8 provides graphical representations of the revenue curves at the bottom 10th and upper 90th percentiles of the distribution of import penetration.

Figure 8. Estimated revenue-rate relationship for high and low import penetration]

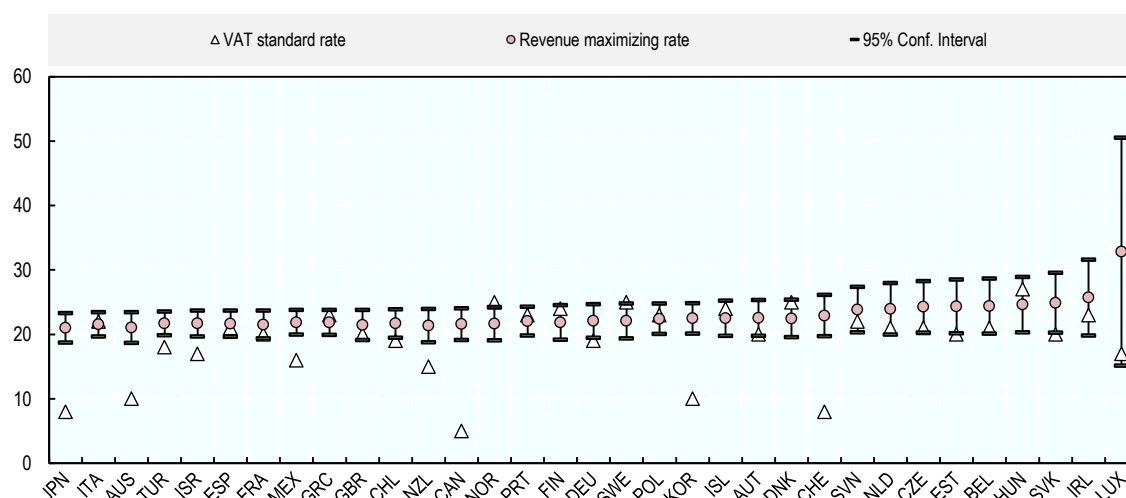


Note: Low (high) represents the 10th (90th) percentile of the cross-country distribution of import penetration in 2014. The curves are based on the estimates in column 4 of Table 7.

63. Import penetration drives the country-specific turning points reported in Figure 9. Most countries lie within the confidence band around their estimated revenue-maximising point: the difference between this result (shown on Figure 9) and the one that assumed a uniform turning point for all countries (plotted on Figure 7) underlines the importance of taking into account relevant national circumstances such as import penetration. The estimations suggest that countries lying within the confidence band around their turning point have limited or no room to expand VAT revenue through increases in the standard rate. If they have the objective of increasing VAT revenue, they can instead consider base broadening especially by narrowing exemptions and bringing reduced rates closer to the standard one.

64. The empirical analysis estimates the inverse-U shape of the rate-revenue relationship mostly using observations with VAT rates below the estimated turning points. Few countries have VAT rates above the estimated turning point and none significantly so at 95% statistical confidence (Figure 9). Therefore, the main result from the non-linear estimates is that VAT revenues (as a ratio to GDP) saturate when getting close to the turning point. However, a specific study of one country (Greece) where the actual VAT rate has been increased above the estimated turning point indicates that this hike has shrunk VAT revenues (Hondroyannis and Papaoikonomou, 2017). Furthermore, in Italy, increases in the VAT standard rate from 20 to 21% in September 2011 and 22% in October 2013 were associated with a decrease in consumption, with the consequence that VAT receipts responded more weakly than the government had anticipated.

Figure 9. Country-specific revenue-maximising VAT standard rates
Per cent, 2016

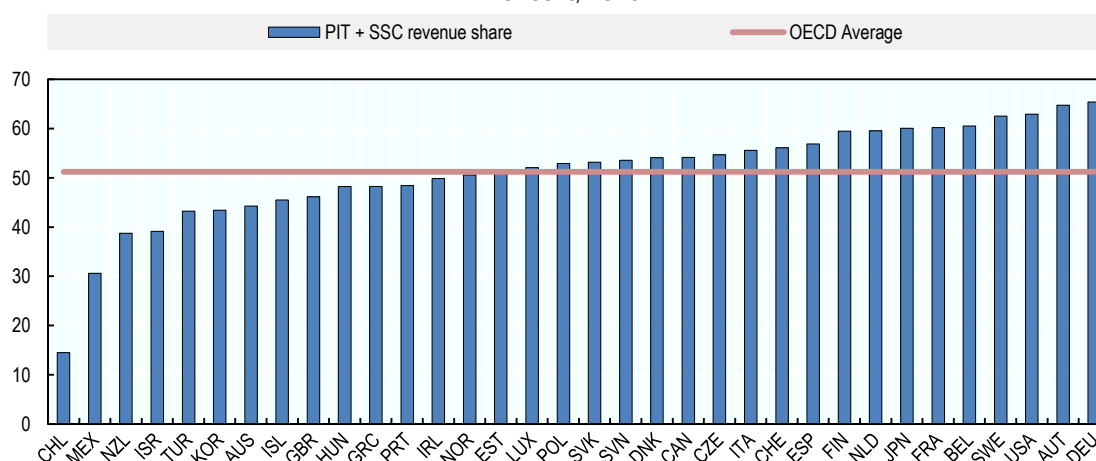


Note: Cross-country differences in import penetration rates drive the variation in country-specific revenue-maximising rates, which are calculated using Column 4 of Table 7. The bands show 95% confidence intervals.

6. Personal income tax, payroll taxes and social security contributions

65. The taxation of personal income is a major source of government revenue (Figure 10). The personal income tax of individuals is generally levied on labour and capital income as well as realised capital gains. In addition, the taxation of labour income for a large part relies on social security contributions (SSC) and other payroll taxes. The relative contributions of social security charges, payroll taxes and personal income taxes however vary considerably across countries, but ultimately they all represent taxes on household income. For this reason, the analysis is conducted by using effective marginal tax rates that cover PIT, SSC and other payroll taxes and also lumping together revenue from these various taxes. Nevertheless, as a robustness check, some analysis is replicated for the revenue from and rates of narrowly defined personal income tax.

Figure 10. Share of broad personal income tax revenue in total tax revenue
Per cent, 2016



Note: Data refer to 2016 for all countries but Australia, Greece, Japan, Mexico, the Netherlands and Poland for which data refer to 2013. The OECD average, plotted as a horizontal line, corresponds to the unweighted average across OECD countries in the sample. Source: Bloch et al. (2016), "Trends in Public Finance: Insights from a New Dataset", OECD Economics Department Working Papers, No. 1345.

6.1. Results of the baseline model

66. The empirical analysis considers the effective marginal tax rate for different levels of income. Table 8 shows that the non-monotonic relationship is present for all income levels except at and a third above the average one. A possible explanation for the absence of a hump-shaped relationship at and slightly above the average wage is that the tax system is designed in ways that minimise tax avoidance opportunities in this income bracket, where much of tax revenue is generated.

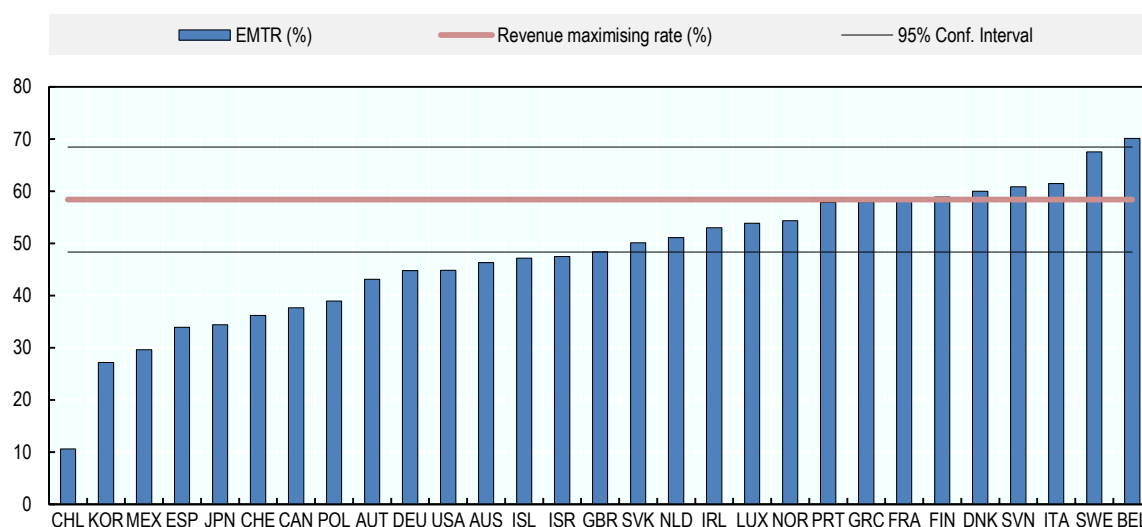
Table 8. Effect of marginal tax rate on broad personal income tax revenue

Dependent variable: PIT + SSC revenue (rate of GDP)	EMTR67		EMTR100		EMTR133		EMTR167	
EMTR	0.10** (0.045)	0.68*** (0.14)	0.16*** (0.062)	0.24 (0.15)	0.17*** (0.055)	0.41** (0.18)	0.087** (0.042)	0.69*** (0.19)
EMTR squared		-0.62*** (0.13)		-0.073 (0.15)		-0.24 (0.17)		-0.61*** (0.19)
Population growth	-0.58*** (0.17)	-0.58*** (0.16)	-0.54*** (0.16)	-0.54*** (0.16)	-0.55*** (0.17)	-0.56*** (0.17)	-0.50*** (0.17)	-0.48*** (0.17)
Inflation	0.079*** (0.020)	0.087*** (0.018)	0.082*** (0.019)	0.084*** (0.019)	0.074*** (0.019)	0.074*** (0.018)	0.073*** (0.018)	0.068*** (0.016)
CIT EMTR	0.047*** (0.018)	0.040** (0.018)	0.039** (0.017)	0.038** (0.017)	0.044*** (0.016)	0.041** (0.016)	0.050*** (0.016)	0.052*** (0.016)
Observations	528	528	528	528	528	528	536	536
R-squared	0.977	0.978	0.977	0.977	0.977	0.977	0.977	0.977
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Turning point	-	0.55	-	-	-	-	-	0.57
Standard error	-	0.035	-	-	-	-	-	0.043

Note: Robust standard errors in parenthesis. EMTR corresponds to the marginal tax wedge at 67%, 100%, 133% and 167% of average income for a single worker with no children.

67. These results indicate that raising the effective tax rate for a given income level below or above the average increases the total amount of revenue in a non-monotonic way. The estimation at 167% of average income shows a revenue-maximising level of 57% with a 95% confidence interval spanning 48% to 66%. As of 2014, many countries taxed incomes 67% above average at effective marginal rates that lie within the confidence band around the estimated revenue-maximising point (Figure 11).

68. The estimates highlight externalities between personal and corporate income taxation. Higher marginal effective tax rates of CIT are linked with higher PIT revenue (Table 8). This finding provides novel empirical evidence in support of the view that increasing the effective CIT rate prompts a shift in the tax base towards personal income, presumably as owners of very small companies switch to being self-employed. This result and the above finding that higher PIT taxation is associated with larger CIT receipts reinforce each other.

Figure 11. Countries' marginal effective broad PIT rate at 167% of average income

Note: The revenue-maximising rate is calculated according to model 8 of Table 7.

69. The regressions also show that higher inflation is associated with more PIT revenue. This result is likely to reflect that tax bracket adjustments do not always keep up with inflation. The estimates also point to a negative effect of working-age population growth. A possible reason behind this link is that a faster growing working-age population will be more tilted towards larger young cohorts, who earn less, and therefore generate smaller PIT revenue than a working-age population with a flatter age structure because of PIT progressivity. In addition, a quickly rising working-age population growth can shift the income split from labour towards capital (a view consistent with this finding for PIT as well as the above one for CIT that a faster expanding working-age population is linked with more CIT revenue).

6.2. Progressivity of the tax structure

70. Considerable debate surrounds the question of whether more progressive tax systems, which underpin income equality objectives, generate more or less revenue than flatter systems. The empirical setup of this study allows addressing this question in several ways.

71. Looking at broadly defined personal income tax, progressivity seems to enhance revenue generation, up to a point above which a trade-off appears. The investigation combines the effective marginal tax rate for broad PIT at average incomes with an indicator of progressivity. This indicator measures, as a ratio, the degree to which the marginal effective rate of taxation rises between 67% and 167% of average incomes. The analysis points to a non-monotonic rather than a linear relationship between progressivity and broad PIT revenue (Columns 1 and 2 in Table 9). The results of Column 2 show strongly significant effects of the EMTR at average incomes, the progressivity indicator and its squared value. They indicate a maximum revenue-generating capacity at a progressivity ratio of 1.4. Some countries are above this ratio (Figure 13).

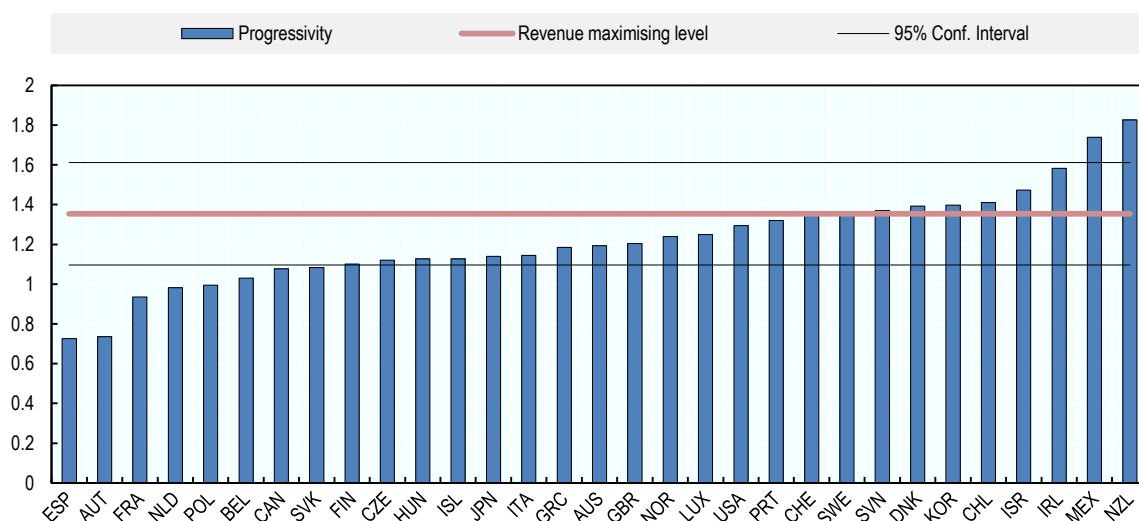
Table 9. Impact of progressivity on income tax revenue

Dependent variable: (revenue, ratio to GDP)	(1) PIT + SSC	(2) PIT + SSC	(3) PIT	(4) PIT
EMTR167/EMTR67	-0.010 (0.015)	0.16** (0.077)		
(EMTR167/EMTR67) squared		-0.058** (0.027)		
TMR/MR67			-0.0028*** (0.00082)	0.0037* (0.0021)
(TMR/MR67) squared				-0.00085*** (0.00025)
EMTR100	0.16** (0.062)	0.16** (0.062)		
MR100			-0.014 (0.013)	-0.00068 (0.013)
Population growth	-0.55*** (0.16)	-0.57*** (0.16)	-0.040 (0.13)	-0.029 (0.13)
Inflation	0.083*** (0.019)	0.083*** (0.018)	0.059** (0.029)	0.056** (0.028)
CIT EMTR	0.041** (0.017)	0.039** (0.017)	0.065*** (0.015)	0.069*** (0.015)
Observations	528	528	497	497
R-squared	0.977	0.977	0.976	0.976
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Turning point	-	1.35	-	2.18
Standard error	-	0.13	-	0.68

Note: EMTR167/EMTR67 represents the ratio between the effective marginal rate at the 167% and the 67% of average wage income, for combined PIT and SSC; TMR represents the top statutory marginal rate for PIT; MR67 represents the marginal statutory rate at 67% of average income.

72. Sensitivity checks for narrow PIT confirm that strong progressivity seems to reduce revenue-generating capacity. Focussing on narrowly defined PIT allows incorporating the marginal rate facing high income levels (as opposed to only 67% above average) in the study of progressivity. Here, the progressivity indicator for narrow PIT compares, as a ratio, the top marginal rate of narrow PIT to the marginal rate at 67% of average income. Narrow PIT revenue appears to shrink when progressivity increases (Columns 3 and 4). Only the squared term is significant when both the linear and squared progressivity indices enter the equation (Column 4), which suggests that progressivity raises an increasingly acute trade-off with revenue as it becomes steeper.

Figure 12. Progressivity of broad personal income tax compared with the estimated revenue-maximising level



Note: Progressivity is measured as the ratio between the effective marginal tax rate at 167% and 67% of average wage income.

7. Concluding remarks

73. The analysis in this paper should not be interpreted as recommendations, even implicit ones, to move towards estimated revenue-maximising rates. When tax rates reach the turning point, economic behaviour and tax-avoidance distortions by definition get so large that their impact on the tax base outweighs the effect of a higher tax rate. Any plausible definitions of social optimality, where the marginal benefit of spending equals the marginal cost of public funds, is likely to be reached before the revenue-maximising rate is reached.

74. The estimated relationships however indicate that increasing tax rates is a diminishing-return method to generate revenue. The net revenue of rate hikes weakens as tax rates increase owing to a combination (not decomposed in this study) of less economic activity and more avoidance. The estimates also underline the importance of governance quality and spending on tax collection, which both boost revenue-raising potential. It also highlights that framework conditions, some not or only partly under policy control, such as foreign openness, have an effect on revenue-raising potential for corporate-income and value-added taxes.

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APPENDIX

Table A1. Descriptive statistics

Variable	Description	N	Mean	S.D.	Min.	Max.	Source
<i>Tax Revenue</i>							
CIT Revenue	CIT revenue, ratio to GDP	1376	0.03	0.01	0.00	0.08	OECD Revenue Statistics
VAT Revenue	VAT revenue, ratio to GDP	1435	0.10	0.03	0.03	0.18	OECD Revenue Statistics
PIT Revenue	Broad PIT revenue, ratio to GDP	1389	0.17	0.06	0.01	0.34	OECD Revenue Statistics
<i>Effective Tax Rates</i>							
EMTR	Effective CIT marginal tax rate	747	0.17	0.07	0.02	0.39	Oxford Centre for Business Taxation
VAT Standard Rate	Standard VAT rate	1132	0.18	0.05	0.03	0.30	OECD Revenue Statistics
PIT EMTR67	Effective PIT MR for single worker at 67% of average income	627	0.42	0.13	0.06	0.68	OECD Tax Database
PIT EMTR100	Effective PIT MR for single worker at average income	627	0.46	0.12	0.06	0.75	OECD Tax Database
PIT EMTR133	Effective PIT MR for single worker at 133% of average income	627	0.49	0.12	0.08	0.70	OECD Tax Database
PIT EMTR167	Effective PIT MR for single worker at 167% of average income	635	0.49	0.12	0.09	0.70	OECD Tax Database
<i>Statutory Tax Rates</i>							
CIT Statutory Rate	Statutory CIT rate	952	0.34	0.10	0.13	0.62	OECD Tax Database
PIT MR 67	PIT MR for single worker at 67% of average income	627	0.20	0.11	0.00	0.48	OECD Tax Database
PIT MR 100	PIT MR for single worker at average income	627	0.27	0.12	0.00	0.50	OECD Tax Database
PIT MR 133	PIT MR for single worker at 133% of average income	627	0.30	0.11	0.03	0.52	OECD Tax Database
PIT MR 167	PIT MR for single worker at 167% of average income	635	0.33	0.11	0.03	0.60	OECD Tax Database
Top MR	Top PIT MR	922	0.41	0.14	0.07	0.84	OECD Tax Database

Table A1. Descriptive statistics (cont.)

<i>Control Variables</i>							
Population Growth	Working age (15-74) population growth (trend)	1724	0.01	0.01	-0.01	0.04	Economic Outlook No 99
Inflation	CPI Inflation	1560	0.10	0.30	-0.02	5.68	Economic Outlook No 99
Trade Openness	Trade Openness, ratio to GDP	1573	0.69	0.46	0.07	3.74	Economic Outlook No 99
<i>World Bank's WGI</i>							
Voice and Accountability	see Kaufmann et al. (2010)	646	1.17	0.43	-0.84	1.83	WGI, World Bank
Regulatory Quality	see Kaufmann et al. (2010)	646	1.27	0.44	0.03	2.08	WGI, World Bank
Rule of Law	see Kaufmann et al. (2010)	646	1.27	0.61	-0.76	2.12	WGI, World Bank
Political Stability	see Kaufmann et al. (2010)	646	0.76	0.66	-1.62	1.67	WGI, World Bank
Government Effectiveness	see Kaufmann et al. (2010)	646	1.36	0.58	-0.28	2.36	WGI, World Bank
Control of Corruption	see Kaufmann et al. (2010)	646	1.33	0.82	-0.73	2.59	WGI, World Bank
Quality of Governance	see Box 1	646	2.87	1.36	-1.09	4.87	WGI, World Bank
<i>Framework Conditions (Time Varying)</i>							
Imports	Imports, ratio to GDP	1571	0.33	0.22	0.00	1.71	Economic Outlook No 99
Exports	Exports, ratio to GDP	1573	0.35	0.25	0.03	2.03	Economic Outlook No 99
Financial Openness	Chinn-Ito financial openness index, see Chinn and Ito (2006)	1317	1.04	1.45	-1.89	2.39	Chinn and Ito (2006)
<i>Framework Conditions (Time Fixed)</i>							
Voter Turnout	Average of voter turnout	29	75.36	12.61	46.20	94.85	OECD Social Indicators database
Tax Administration Cost	Average tax administration costs, ratio to tax revenue	33	0.95	0.41	0.33	2.30	OECD Tax Administration database
FDI Stock	Average FDI stock, ratio to GDP	34	107.15	119.22	20.43	579.70	OECD Investment Statistics
PMR	Average product market regulation	34	1.73	0.35	1.18	2.80	OECD Product Market Regulation data

Table A2. Estimation results without commodity-exporting countries

Dependent variable: CIT revenue (ratio to GDP)					
	(1)	(2)	(3)	(4)	(5)
EMTR	0.013 (0.0086)	0.073*** (0.021)	0.074*** (0.021)	0.077*** (0.021)	0.11*** (0.027)
EMTR squared		-0.16*** (0.052)	-0.14*** (0.054)	-0.16*** (0.055)	-0.17** (0.071)
Population growth			0.29*** (0.090)	0.31*** (0.079)	0.20** (0.077)
Inflation			-0.0014 (0.0048)	-0.0024 (0.0046)	0.0051 (0.010)
Trade openness				-0.0042 (0.0030)	-0.0047 (0.0041)
PIT EMTR167					0.073*** (0.022)
Observations	579	579	572	572	460
R-squared	0.797	0.801	0.806	0.808	0.801
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Turning point	-	0.23	0.26	0.25	0.32
Standard error	-	0.029	0.039	0.034	0.064

A3. Links between broad PIT marginal effective tax rates for single individuals and various household configurations

The marginal effective tax rate of broad personal income tax for a single individual earning average income has the following		
correlation coefficient with		coefficient in a country-fixed effect panel regression where it explains:
the PIT METR for the household type in the first column		
Two-child family where the first earner gets average income and the second earner:		
- 0% of average income	0.79	0.63***
- 33% of average income	0.89	0.77***
- 67% of average income	0.92	0.74***
Childless couple with a single earner getting average income	0.96	0.76***

Note: *** denotes 99% statistical confidence.

Source: OECD Taxing Wages database and authors' calculations.