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# Tax structures and economic growth

## New evidence from the Government Revenue Dataset

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**Abstract:** Recent work on the relationship between tax structure and economic growth has offered little reliable evidence for developing countries. Yet it is in such countries where the greatest changes in tax structure not only have been seen over the past 30 years but will likely continue to be seen in the future. Thus, an understanding of what, if any, links exist between the tax mix and the long-run economic growth rate is of vital importance to policymakers. Using the Government Revenue Dataset (GRD) from the International Centre for Tax and Development (ICTD), this study considers the effects of revenue-neutral changes in tax structure on a panel of 100 developing and developed countries. The results suggest that the biggest shifts in tax structure seen over the past three decades—i.e. shifts away from trade toward domestic consumption taxes—have had modest positive effects only for those economies classed as lower-middle-income. Furthermore, revenue-neutral increases in personal income taxes or social contributions are found to be harmful for long-run per capita GDP growth rates. These findings call some existing results into question; specifically, this paper finds that the effects of different taxes on growth differ according to income level, calling into question the external validity of existing studies.

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## 1 Introduction

The past five decades have seen development economists pore over the relationship between foreign aid and economic growth. However, the majority of low-income countries today receive significantly more revenue from domestic tax receipts than from aid. Indeed, a commitment to 'strengthen[ing] domestic resource mobilisation' has been embodied in the Sustainable Development Goals (UNSTATS 2016: 35) as part of a growing focus on increasing domestic resource collection in developing countries.[1] Yet we know comparatively little about the effects of increased tax collection, or changes in the composition of tax structure, on economic growth and development. In part, this has been due to a paucity of data. Aid data, for example, is recorded by donor countries or multilateral organizations, whilst tax revenues are handled by individual countries' revenue authorities, which often lack the administrative capacity to ensure that they are accurately recorded.

The primary source for researchers interested in tax has traditionally been the IMF's Government Finance Statistics (GFS); however, a glance at these statistics shows that they are of limited use for empirical analyses on developing countries on account of, amongst other reasons, extensive missing data. Indeed, IMF researchers themselves have seen fit to construct their own ad hoc datasets for empirical work (Prichard 2016 provides examples). Crucially, these are often unavailable to researchers wishing to replicate or challenge their work. One such study is that of Acosta-Ormaechea and Yoo (2012), which examined the relationship between tax structures and economic growth, finding that revenue-neutral (RN) shifts away from consumption and property taxes toward income taxes were harmful for growth in the long run. However, the study relies on a dataset that is not publically available.[2] Furthermore, the aforementioned work claims to present results for 'Low-' and 'Middle-Income' countries, but without explicitly naming these countries; it is therefore nigh on impossible to draw any policy conclusions whatsoever. Worryingly, the results of studies such as this have been cited in IMF policy documents that discuss the impact of tax structures on economic growth.[3]

This paper uses the Government Revenue Dataset (GRD) from the International Centre for Tax and Development (ICTD) in order to extend, and also challenge, existing results on the relationship between tax structure and economic growth. In particular, the empirical estimations replicate the aforementioned work of Acosta-Ormaechea and Yoo (2012), before considering some extensions and robustness checks made possible by the GRD, which presents a significant improvement in terms of the availability of revenue data on developing countries, allowing a range of new insights and policy-relevant analyses.[4,5] Specifically, we are able to gain an insight

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[1] The UN has ratified two official indicators for Goal 17.1 (Strengthen Domestic Resource Mobilisation […] to improve domestic capacity for tax and other revenue collection): (i) total government revenue (% of GDP) and (ii) the proportion of domestic budget funded by domestic taxes.

[2] When contacted, the authors were unwilling to share their dataset or their Stata .do files to assist with replication.

[3] See, for example, IMF (2011) or IMF (2015).

[4] In keeping with Clemens (2015), the empirical part is best described first as a *replication*, as I follow the same specification as the Acosta-Ormaechea and Yoo (2012) study. As the regressions herein contain a larger sample and consider some additional specifications, the work might also be described as an *extension* (which Clemens categorizes as a kind of *robustness test*). Unfortunately, it is not possible to classify the present work as a pure replication study, as the authors of the original study were unwilling to share details on the countries included in their sample.

[5] Prichard (2016) provides an overview of the GRD, whilst Prichard et al. (2014) covers its construction in depth.

into the effects of trade liberalization on economic growth in developing countries. The ongoing trends of globalization and IMF support for moves toward consumption taxes such as VAT have seen many developing countries' reliance on trade taxes, measured as either a share of total tax or a percentage of GDP, decrease. However, little is known about the impact of such structural shifts in the tax mix; Baunsgaard and Keen (2010) highlight that revenue recovery following such changes in many low-income countries has been poor. Less still is known about the impact on GDP growth rates; Acosta-Ormaechea and Yoo (2012) report that the majority of their findings did not hold for 'Low-Income' countries, blaming the poor quality of data, and crucially did not explore the effects of structural shifts away from a reliance on trade taxes.

The econometric analysis here uses the Pooled Mean Group (PMG) estimator (Pesaran et al. 1999) in order to estimate the effect of RN (i.e. holding constant the tax ratio) changes in tax structure on economic growth. This follows the approach taken in, for example, Acosta-Ormaechea and Yoo (2012), Arnold et al. (2011), and Xing (2011), but crucially extends the analysis to cover a number of developing countries. In a broad sense, the results find support for those in the aforementioned studies: RN shifts away from consumption or property taxes toward income taxes lead to lower long-run GDP growth. However, no support is found for the findings of Arnold et al. (2011) that corporate income taxes (CIT) are the most harmful for growth. Nor is there broad support for the previously reported finding (Acosta-Ormaechea 2012; Arnold et al. 2011; Xing 2011) that RN increases in property taxes are good for economic growth. Turning to the effects of trade liberalization (as measured here by RN shifts away from taxes on international trade), the results suggest that for lower-middle-income countries, there have been positive effects on GDP growth rates, but that for low-income countries, the effect is insignificant or potentially negative. Indeed, at times, the results differ dramatically between income groups, which highlights that there is no 'one size fits all' relationship between tax structure and growth and consequently no single policy prescription that can be advised to all developing countries. Certainly, any policy advice given to low-income countries using evidence from studies based on high-income countries would appear to be misguided.

The rest of this study is organized as follows: Section 2 provides a brief overview of the economic theory linking taxation and economic growth, before reviewing the related empirical literature. Section 3 introduces the data used here and examines the trends in tax structures for the sample. The following section (4) outlines the empirical approach, and the results of the PMG estimations are presented in Section 5. Section 6 considers some extensions and robustness checks. Section 7 discusses the limitations of the study, before Section 8 concludes.

## 2 Tax and growth: in theory

The following section contains a short review of the predictions from economic theory on the relationship between taxes and economic growth.[6] Thinking about tax level, there are clear arguments both for and against a higher tax ratio leading to higher GDP growth rates. On the one hand, a higher tax ratio will distort the incentives for individuals to supply more labour or for firms to produce more. On the other hand, a higher tax ratio will provide a government with the potential to invest in, for example, infrastructural improvements, education, or R&D—all of which can increase the productive capacity of an economy. Indeed, it can be argued, as in Arnold et al. (2011: F59), that the relationship between tax level and output growth might well be driven by 'societal choices as to the appropriate level of public spending'.

[6] A more comprehensive review can be found in McNabb and LeMay-Boucher (2014) or Myles (2007).

Changes in the tax rate in the neoclassical growth model (see, for example, Solow 1956; Swan 1956) can cause a shift only in the steady-state growth path, but not its slope; thus, the model does not allow an assessment of the impact of fiscal policy on the long-run (steady-state) growth rate. However, the models of Barro (1990), King and Rebelo (1990), and Mendoza et al. (1997) are somewhat more useful in this context. King and Rebelo (1990: 130) investigate the effect of an increase in the 'output tax rate applied equally to all sectoral activities', finding that whilst 'taxation may affect the growth rate in a quantitatively important way […] the magnitude of this influence depends […] on the production and tax structure' (King and Rebelo 1990: 140).

The endogenous growth model of Mendoza et al. (1997) considers the effect on economic growth of the marginal (i) human capital, (ii) physical capital, and (iii) consumption tax rates. The predictions of the model indicate that consumption taxes affect the 'net after-tax rate of return on physical capital' (Mendoza et al. 1997: 104) only indirectly via the labour–leisure choice, which in turn affects the capital-to-labour ratio employed in production. Higher taxes on consumption, such as VAT, also affect the labour–leisure choice, as consumer goods become more expensive. This can have an impact on the labour supply, as the reward for working is lower (Arnold et al. 2011). So, whilst consumption taxes have only indirect effects, the model predicts that taxes on physical capital or human capital can affect growth both directly via the labour supply and indirectly via the labour–leisure choice.[7] Whilst, ultimately, factors such as the elasticity of the labour supply will determine the extent of these impacts, the clear prediction of the model is that there are more channels through which direct taxes (i.e. taxes on physical or human capital) can cause distortions to economic growth than there are for consumption taxes. Therefore, economic theory would suggest that, whilst all taxes have the potential to distort economic growth rates, consumption taxes do so to a lesser extent than personal or corporate income taxes.

## 2.1 Tax and growth: existing empirical work

Empirical studies have, in recent years, made significant progress toward providing robust results on the relationship between tax policy and growth. Certainly, early doubt over the existence of any robust empirical relationship, such as that expressed in Easterly and Rebelo (1993), would appear to have been challenged and dispelled.[8] Empirical evidence from the past 20 years or so has consistently found that taxes do indeed 'matter' for economic growth. However, the questions asked of this relationship have evolved to consider *which* taxes matter for growth, *where* they matter for growth, and *to what extent* they do so.

Kneller et al. (1999) argue that a bias exists in much of the existing empirical research on fiscal policy and growth, as many studies ignore one side or the other of the budget—either taxation or expenditure. Classifying taxes as 'distortionary' and 'non-distortionary', Kneller et al. (1999) postulate that positive effects on growth will emerge by 'shifting' toward non-distortionary taxes (i.e. increasing the share of non-distortionary taxes in GDP whilst decreasing the share of distortionary taxes).[9] This classification is founded on the belief that the distortions to economic growth arising from incentives to invest are greater than those arising from the labour–leisure choice. Kneller et al.'s findings for a panel of OECD countries suggest that higher distortionary taxes lead to lower growth rates and vice versa; specifically, their estimations suggest that a 1 per

[7] Derivations and results are outlined in detail in Mendoza et al. (1997: 102–6).

[8] 'The evidence that tax rates matter for growth is disturbingly fragile' (Easterly and Rebelo, 1993: 442).

[9] Taxes on income and profit, social security contributions, payroll, and property taxes are classed as 'distortionary', whilst consumption and trade taxes are classed as 'non-distortionary'.

cent increase in distortionary taxes (as a percentage of GDP) would lead to a fall in GDP growth of 0.1–0.2 per cent. This finding—that increases in distortionary taxation are harmful for growth rates—confirms the predictions of Barro (1990), Barro and Sala-i-Martin (1995), and Mendoza et al. (1997).

Tax revenues as a share of GDP (as in, e.g., Kneller et al. 1999) is a convenient proxy for the marginal tax rate, which is the relevant variable in the theoretical models mentioned above. In order to arrive at more precise estimates for the marginal tax rate, however, data is required on both the income distribution and the tax rates for each type of tax. Often this information is not readily available and it might not be available at all for low-income countries—certainly not for a long time series. However, some studies have made attempts to estimate the marginal tax rate: Lee and Gordon (2005) find a negative relationship between the top corporate tax rate and GDP growth rates. Specifically, their estimations suggest that GDP growth would increase by between 1 and 2 percentage points following a 10 per cent cut in the rate of corporate tax. Mendoza et al. (1994) construct 'effective tax rates' for capital, labour, and consumption, which are the ratios of the difference between the pre- and post-tax values of capital, labour, and consumption income to the values of said incomes at pre-tax prices.[10] Using these effective tax rates, Mendoza et al. (1997) found that the investment rate increased by 1.8 per cent (1.0%) following a 10 percentage point decrease in taxes on labour (capital). Notably, however, the result did not hold when GDP growth was taken as the dependent variable. Methods such as those employed in Lee and Gordon (2005) and Mendoza et al. (1994, 1997) are appealing insofar as the tax variables used are a close fit to those in the aforementioned endogenous growth models. However, the potential for a wider application of such methods is limited by data requirements—especially where a panel of developing countries is involved. As a result, this approach has not been followed in many other empirical studies of this nature.

Some more recent studies have examined the tax structure rather than tax ratio or marginal tax rate. Specifically, papers such as Acosta-Ormaechea and Yoo (2012), Arnold et al. (2011), and Xing (2011) have sought to consider the effects of RN changes in tax structure on GDP or economic growth rates.[11] Arnold et al. (2011: F59) note that, in imposing revenue neutrality, such studies 'avoid the difficulty of taking account of how any changes in aggregate revenue might be reflected in changes in public expenditure'—precisely the problem outlined by Kneller et al. (1999). This approach is also suitable for studies that consider a wide range of countries over a long period, as researchers can utilize datasets such as the GRD, which are rich in information on tax receipts; often this is more readily available than information on tax rates, etc.[12]

Arnold et al. (2011) found that a percentage point RN increase in income taxes' share of total tax (offset by a percentage point decrease in consumption and property taxes' share of total tax) leads to lower economic growth to the tune of between 0.25 and 1 per cent, in a panel covering 21 OECD countries for 34 years. The authors also found that, when disaggregating between corporate and personal income taxes, increases in the former lead to larger reductions in GDP growth than increases in the latter. Acosta-Ormaechea and Yoo (2012) carried out a similar

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[10] Lee and Gordon (2005), however, argue that these effective tax rates capture only an average tax on labour income, and not the marginal rate.

[11] The revenue neutrality constraint requires that the estimations in such studies control for total tax receipts (as a percentage of GDP).

[12] As mentioned, the revenue neutrality constraint means that a similar level of data coverage is not required on the expenditure side. This is also an advantage in the sense that cross-country data is of somewhat lesser quality than on the taxation side.

analysis, but for the first time considered the effects of changes in tax structure in both developing and developed countries. Similar findings emerged: taking GDP growth as the dependent variable (where Arnold et al. (2011) considered GDP in levels), Acosta-Ormaechea and Yoo (2012) found that a percentage point increase in income taxes leads to a fall of GDP growth rates of around 0.07–0.14 per cent.

In terms of the questions posed at the beginning of Section 2.1, it would appear that whether the fiscal policy variable of interest is tax/GDP, the tax rate, or the tax structure, the aforementioned studies have generally arrived at similar conclusions, which support the endogenous growth models discussed: income taxes create more distortions, or lead to lower GDP growth, than do consumption taxes. A number of these studies also consider the effects of personal and corporate income taxes in isolation, finding that the latter create stronger distortions to economic growth. The extent to which these taxes affect growth would, according to the evidence discussed, appear to be relatively modest: whether the change is in tax structure or tax rate, the effects on GDP growth rates are often quite small. In terms of *where* changes in tax policy can affect growth, the majority of studies have considered only OECD members. Only Acosta-Ormaechea and Yoo (2012) and Lee and Gordon (2005) have attempted to provide evidence for low-income, or developing, countries. With regard to the former study, no indication is given as to which countries are included in the sample. However, given that their data is compiled from the IMF's GFS, it is easy to see that the group of countries they call 'Low-Income' might well, in truth, be middle-income.[13] Many previous studies have likely confined analyses to OECD countries as a result of (for example) data availability. The GRD presents a first opportunity to carry out a similar analysis on a panel of developing countries.

## 3 Tax and growth: data and trends

The most recent release of the ICTD GRD contains some 6,390 observations for 196 countries over the period 1980–2012/13. However, the econometric analysis here must rely on a smaller subsample of this data for a number of reasons. First, it is crucial that a consistent time series is present for each country included. So, for example, if there was data for a country spanning 1980–1995 and 1996–2012, it would be dropped from the analysis. There are a number of countries where this is the case. The sample is also restricted to those countries with at least 20 years of consecutive observations, so that the $t$ dimension is of sufficient length to carry out the PMG regressions. Third, the GRD includes a number of 'flags' identifying potentially problematic data. Those observations flagged as '*Problem 1: Data not Credible*' or '*Treat With Caution: Data of Somewhat Questionable Quality*' are also excluded. Finally, the analysis is restricted by the availability of some other covariates—specifically the measure of human capital (average years of schooling). The final sample for the econometric analysis comprises 2,657 observations for 100 countries.[14] Figures 1–4, however, include more data where available, including data for countries that are not included in the regression analysis.

Table 1 provides summary statistics for all variables included in the analysis for the sample as a whole, and also by income group (according to the latest available classifications from the World

[13] There are few, if any, cases where the GFS contains a series of sufficient length for any low-income country to carry out the analysis described in their paper. Furthermore, where countries are labelled 'Low-' and 'Middle-' income, it is not according to, for example, the World Bank's income classification, but according to an ad hoc procedure, taking account only of those countries in their dataset.

[14] A list of these countries, by income group, is included in Appendix A.

Bank). All tax variables come from the ICTD GRD. GDP growth is the change in (log) GDP per capita, taken from the World Bank's World Development Indicators (WDI). *Physical capital*, also from the WDI, is (log) fixed capital formation expressed as a share of GDP. *Human capital* is the average years of schooling from Barro and Lee (2013).[15] *Population growth* is the growth rate of the working-age (15–64) population, calculated from the WDI. The average GDP growth rate for the whole sample is 1.8 per cent. Investment in physical capital is on average 22 per cent of GDP. The average years of schooling across the sample is 7.5 years, but this ranges from less than 1 to over 13 years. Average years of schooling in low-income countries is just over 3, increasing to almost 10 years in the average high-income country. The tax ratio is, on average, 22 per cent. The trends in tax mix, and how these differ between income groups, are outlined in Figure 1.

Figure 1 presents the average tax ratio and tax structure for each of the four World Bank income groups from 1980 to 2012. The tax subcategories shown are income (including personal income, corporate income, and taxes on payroll and workforce), taxes on goods and services (including all domestic consumption taxes such as VAT, sales tax, and excises; for simplicity, 'other' taxes have been included in this category), trade, and property, and social contributions.

The tax ratio in high-income countries stands at between 25 and 30 per cent for the period in question; this is dramatically higher than in low-income (10–15%) or middle-income countries (15–20%). The decade 2000–2010 has seen a notable upward trend in the tax ratio in low- and middle-income countries, whereas those classed as high-income have seen their tax ratios remain fairly constant. The effects of the recent financial crisis are clear in that the average tax ratio of high-income countries dips by 2–3 per cent in the late 2000s, whilst no such effect is seen in low- or middle-income countries. There are, of course, a number of well known reasons why the tax ratio is significantly lower in low-income countries than in high-income ones. Amongst other factors, a large informal economy, a high degree of subsistence agriculture, widespread illiteracy, and a lack of administrative capacity provide significant barriers to tax collection.

Turning to the tax structure, immediately clear is the initially high reliance on taxes on international trade in low- and middle-income countries. Over the last three decades, this has declined, largely to be replaced by taxes on domestic goods and services and, to an extent, by income taxes. The reliance on trade taxes in low-income countries has more than halved, from around 40 per cent of total tax receipts in 1980 to under 20 per cent in 2012. There is a similar, if not so dramatic, shift away from trade taxes in lower- and upper-middle-income countries for the same period. These trends undoubtedly reflect the ongoing removal of many trade barriers as well as the implementation of taxes on domestic consumption such as VAT. The figure confirms that trade taxes have been falling not only in relative terms (i.e. as a share of total tax), but also in absolute terms (i.e. as a share of GDP).

Figure 1 also highlights an increasing reliance on income taxes and social contributions in those countries classed as lower-middle-income across the same period. High-income countries, perhaps as a result of more efficient tax collection and administration capabilities, are typically more reliant on income taxes or social contributions. The relative stability of the tax structure in high-income countries over this period is also noticeable. Many are members of free trade areas, such as the North American Free Trade Agreement (NAFTA) or the European Union (EU), and as such may have replaced trade barriers with consumption taxes before the timeframe in

[15] Given that this data is available only at five-year intervals, I use linear interpolation in order to gain a complete time series. This follows the approach taken in, for example, the Penn World Tables, whose human capital variable is highly correlated with the one used here (corr = 0.98).

question here. It is also clear that only high-income countries collect a significant amount of revenue from property taxation, averaging around 4–5 per cent of total revenue for the period in question.[16]

Turning to the relationship between tax and GDP per capita, Figure 2 plots the average tax ratio against average log income per capita over the period 1980–2012. A few things are noticeable. First, there is, overall, a positive relationship between per capita income levels and the tax ratio. Second, the World Bank's income groupings can roughly predict a country's tax ratio—i.e. the average tax ratio appears to increase with income group—but there are a number of outliers. A closer look at the outlying countries in Figure 3 is intriguing.

Those countries with very low tax ratios but high GDP growth (circle on left) are exclusively oil-producing countries. Four others stand out as outliers, namely San Marino, Singapore, Hong Kong, and the Bahamas. At the other end of the scale are almost exclusively former Soviet countries, including Moldova, Ukraine, Belarus, Bosnia and Herzegovina, Hungary, Poland, Croatia, Montenegro, Serbia, Macedonia, and Bulgaria (cirle on right), which all have tax ratios around 30–40 per cent of GDP but relatively low per capita income levels. Interestingly, countries in this latter group all have relatively high levels of social contributions (>10% of GDP; performing the same analysis with taxes exclusive of social contributions entirely eliminates these outlying countries).

These figures are informative, as they underline the fact that, for most countries, high per capita GDP is associated with a high tax ratio. The improved coverage in the GRD has allowed a more complete picture of this relationship, with data points for around 185 countries included in the scatter plots.[17] However, the econometric analysis below is concerned with the effects of tax *structure* on GDP *growth*. Figure 4 presents a first look at the relationship between average GDP growth over the period 1980–2012 and the average share of tax that countries collect from income, property, goods and services, and trade. The green dashed line shows the average GDP growth rate for the period across countries; the red line is a line of best fit.

There appears to be only a modest positive association between the share of taxes collected as income or property tax and the average GDP growth rate. However, the average share of taxes on goods and services appears to be positively associated with GDP growth, whilst the opposite is true for the average share of trade tax.

## 4 Econometric model

The econometric approach used follows that of, among others, Acosta-Ormaechea and Yoo (2012) and Arnold et al. (2011) by considering RN changes in the tax structure whilst controlling for the overall level of tax as a proportion of GDP. Imposing the revenue neutrality constraint allows consideration of the effects of changes in tax policy on growth, without the need to take account of how changes in tax policy might result from changes in government expenditure

[16] NB. The data for the majority of lower-middle- or low-income countries comes from IMF Article IV Staff Reports. Frustratingly, these vary in the level of disaggregation reported. Where information on property taxes was not included (i.e. there were no property taxes either collected or recorded), these are assumed zero for simplicity.

[17] Obviously, there are not 33 years of data (1980–2012) for every country in the sample. Indeed, data for the former Soviet states appears only in the early 1990s. However, the patterns displayed in Figures 2 and 3 remain if the sample is restricted to average tax and average income levels from 1991 to 2012 for all countries.

(Arnold et al. 2011), and avoids the requirement of similar levels of data on public expenditure as on tax revenue. Furthermore, given limitations on the availability of data on tax rates, this approach represents the best available proxy for the marginal tax rate, which is considered in the relevant theoretical models.

The empirical model estimated is an Error Correction Model (ECM) taking the form

$$\Delta g_{i,t} = -\phi g_{i,t-1} + \alpha_1 I_{i,t-1} + \alpha_2 h_{i,t-1} - \alpha_3 n_{i,t-1} + \alpha_4 T_{i,t-1} + \sum \alpha_j TC_{i,t-1}$$

$$+\beta_{1,i}\Delta I_{i,t} + \beta_{2,i}\Delta h_{i,t} + \beta_{3,i}\Delta n_{i,t} + \beta_{4,i}\Delta T_{i,t} + \sum \beta_j \Delta TC_{i,t} + \tau_i t + \varepsilon_{i,t} \qquad (1)$$

where $g$ is the growth rate of GDP per capita, $I$ is the investment ratio (as measured by the share of fixed capital formation in GDP), $h$ is a measure of human capital (average years of schooling), $n$ is the growth rate of the working age population, $T$ is the tax ratio, and $TC$ is a vector of tax composition variables, namely *n-1* shares of different taxes in total tax. $\tau$ is a set of time dummies and $\varepsilon$ is the error term.

The equation, estimated by Pooled Mean Group (Pesaran et al. 1999), allows simultaneous estimation of the long-run coefficients and short-run dynamics. The PMG estimator constrains long-run coefficients to be equal across groups (countries), but allows short-run coefficients and error variances to vary between groups.[18] The validity of this assumption is tested in Section 6.1 below.

## 5 Benchmark results

The full sample of 100 countries is included in Table 2. The sample is restricted to countries where there are at least 18 consecutive years of observations for all variables, although on average $t$ = 27.[19] All regressions contain short-run dynamics as in (1), but only the long-run coefficients are shown. The revenue neutrality constraint means that the interpretation of the coefficient on the included tax category share is as follows: a percentage point increase in the share of tax revenue for the included tax category (categories) implies a percentage point reduction in the share of total revenue from the omitted category (categories).

In columns 1 and 2, the omitted category is the share of consumption and property taxes. It appears that RN shifts away from consumption and property taxes toward income taxes have a negative effect on the long-run GDP growth rate. Specifically, the coefficient estimate suggests that for a percentage point increase in income taxes, the long-run GDP growth rate decreases by 0.062 percentage points. Column 2 disaggregates income taxes into personal taxes, social contributions, and corporate taxes. Here, the results suggest that an RN shift from consumption and property taxes toward personal income taxes or social contributions reduces long-run GDP growth rates by 0.068 and 0.09 percentage points, respectively. These findings echo those of Acosta-Ormaechea and Yoo (2012), although, notably, the coefficient estimates here are around

[18] The estimations are carried out using the *xtpmg* command in Stata (Blackburne and Frank 2007). Newton-Raphson iteration is used.

[19] The results here are directly comparable to those in table 1 of Acosta-Ormaechea and Yoo (2012).

50 per cent lower in magnitude than those reported in their study. In columns 3 and 5, income taxes are omitted. It appears that RN shifts away from income taxes and toward domestic taxes on goods and services have positive effects on long-run GDP growth rates. In column 6, the omitted category is set to Consumption Taxes (goods and services + trade) and the results suggest that, controlling for the share of income taxes in total tax, shifts away from consumption toward property taxes have no effect on long-run growth rates. This result on the role of property taxes is in direct contrast to that of Acosta-Ormaechea and Yoo (2012) and Arnold et al. (2011), who found strong positive impacts of RN shifts toward property taxes on both growth and income.

Column 6 omits trade taxes, seeking to elicit the effect of an RN shift away from trade toward either income, property, or domestic consumption taxes. This coefficient of 0.036 on domestic goods and services suggests that RN shifts away from trade toward domestic consumption taxes have modestly positive effects on GDP growth rates. This result is intriguing, especially in the light of the patterns in tax structure observed and discussed above, which showed that, for many countries, shifts away from trade toward domestic consumption taxes have been the major structural change over the last 30 years. All specifications were tested for residual nonstationarity using an Augmented Dickey Fuller (ADF) test.[20] As shown in Table 2 , for all specifications the null of nonstationary residuals was rejected at the 5 per cent level; in the majority of cases the null was also rejected at the 1 per cent level.

Table 3 replicates the results of Table 2, separating the sample into high-, upper-middle-, lower-middle-, and low-income countries according to the World Bank's 2016 income classification. Column 1 shows that there are statistically significant negative effects on growth rates from RN shifts toward income taxes in high-income countries—around 0.1 percentage points for a 1 percentage point increase. Disaggregating into PIT, social contributions, and CIT, it appears that RN shifts away from consumption and property toward corporate income taxes actually have positive effects on long-run growth rates in high-income countries. This result conflicts with both theory and existing empirical evidence. Columns 3–5 suggest that there are positive effects on long-run GDP growth rates of shifts toward property taxes: a percentage point RN shift away from either consumption or income taxes leads to an increase in GDP growth rates of around 0.3 per cent. Whilst a 0.3 per cent increase in long-run GDP growth rates might initially sound high, it is worth noting that an RN shift toward property taxes of 1 percentage point would be extreme in any one year: the average change in property tax's share of total tax for high-income countries is just 0.02 per cent of total tax revenue. There are no significant effects of RN shifts from trade taxes toward taxes on goods and services in high-income countries. However, this result is not surprising; Figure 1 highlighted that there has been little change in the share of taxes coming from trade toward goods and services in this group of high-income countries.

Turning to upper-middle-income countries, the estimates in column 7 clearly suggest that a percentage point shift toward income taxes, away from consumption taxes, is harmful for long-run growth rates, to the tune of around 0.16 percentage points. Disaggregating income taxes (column 8) shows that the negative effects from social contributions and personal income taxes are again stronger than those from corporate income taxes. Interestingly, shifts toward property taxes from either income or trade taxes also appear to have negative effects on GDP growth rates. Column 12 also suggests that RN shifts away from trade toward income taxes are harmful for growth, but those toward taxes on domestic goods and services are neither positively nor

[20] This test was carried out using the *pescadf* routine in Stata (Lewandowski 2007). Output from this test is not shown, but is available on request.

negatively related to growth rates. Interestingly, it appears that RN increases in property taxes are associated with economic growth in upper-middle-income countries.

Columns 13–18 display the results for lower-middle-income countries.[21] Intriguingly, RN shifts in tax structure toward income taxes do not appear to have either positive or negative effects on long-run GDP growth in this subsample. However, the results in columns 15–18 suggest that RN shifts away from either income or consumption taxes toward property taxes again have negative effects on GDP growth rates. Specifically, the coefficient estimate points to around a 0.8–1.1 per cent decrease in long-run GDP growth rates for a percentage point increase in the share of taxes coming from property taxes. Column 18 shows that RN shifts toward domestic goods and services, offset by decreases in trade taxes, have positive effects on long-run economic growth. Looking at the other country income groups, it would seem that the lower-middle-income group was driving the result in column 6 of Table 2.

Results for low-income countries are shown in columns 19–24. The results here suggest that RN shifts away from consumption and toward income taxes again lead to lower long-run GDP growth rates. RN shifts away from trade taxes, toward taxes on goods and services, appear to have no statistically significant positive effect on GDP growth rates. This is, again, intriguing, considering that the data and graphs presented above suggest that the largest structural shifts away from trade toward taxes on goods and services occurred in those countries classed as low-income.

## 6 Robustness tests

### 6.1 Testing the validity of parameter restrictions

The PMG estimator employed here allows for heterogeneous short-run effects across countries, but constrains the long-run coefficients to be equal. That is, it assumes that the long-run relationship between GDP growth and the independent variables is the same across countries. The assumption of long-run parameter homogeneity (i.e. that all countries in the sample grow in a similar fashion over time) might be valid for similar groups of countries, such as OECD countries, but may not hold across the sample as a whole. It is, however, possible to test the validity of this assumption using the Hausman test to compare the PMG estimates with alternative options.

The Mean Group (MG) estimator allows for full parameter heterogeneity; that is, a separate regression is estimated for each group (country) and an average reported. At the other end of the scale, dynamic fixed effects (DFE) estimation constrains all short- and long-run coefficients to be equal across countries. The estimator employed here, PMG, lies between the two, allowing short-run dynamics to vary across countries, whilst constraining the long-run coefficients to be equal. Table 4 summarizes.

Table 5 displays the coefficients of the tax share variables estimated via both PMG and MG (the different specifications here pertain to those in Table 2) and the resulting Hausman test statistic. In all specifications, the PMG estimator is preferred over the MG. Thus, the restriction of

[21] It was not possible to obtain results for the disaggregated income tax categories for low- and lower-middle-income countries. The majority of the data for these countries comes from IMF Article IV Country Reports, where the level of disaggregation reported can fluctuate wildly between countries and over time for the same country. Often only one 'Income Tax' figure is reported.

parameter homogeneity appears valid, with the PMG procedure producing estimates that are both efficient and consistent.[22] Furthermore, the coefficient estimates for some of the tax share variables in the MG regressions seem implausibly high. Thus, it appears that the assumptions underlying the PMG approach are satisfactory.

### 6.2 Alternative time controls

The benchmark results presented above include five-year dummies as time controls, in order to capture the effects of the business cycle.[23] Work by Xing (2011), which challenged the results presented in Arnold et al. (2011), suggested that results from the PMG estimator may be sensitive to how the time controls are specified. An alternative approach, taken by Acosta-Ormaechea and Yoo (2012), is to include country-specific linear time trends. These results are included in Appendix B. The majority of the results presented above are robust to this alternative time control, most differences occurring only in the magnitude of coefficient. However, the results presented in Tables 2 and 3 are strongly preferred; it is the standard approach, where growth is the dependent variable, to include some control for the business cycle—a linear trend cannot do this as effectively as the five-year dummy variables.

### 6.3 Addressing potential endogeneity concerns

The primary concern as regards endogeneity in this model results from the fact that changes in the tax level, or indeed the tax structure, might arise from changes in GDP growth rates. This study does not attempt to ascribe any interpretation to the tax ratio variable, not only for this reason but also for those outlined above in Section 2. However, it is necessary to attempt to rule out the possibility that changes in the tax structure are driven by changes in GDP growth rates. Considering the regression framework here, simultaneity bias might not appear to be a large concern. The dependent variable is the growth rate of log GDP per capita, from *t-1* to *t*; the independent variables are all measured at *t-1*. It is thus unclear how the rate of growth in a future period might drive the share of revenue from a certain tax in the previous year.

A potential source of endogeneity arises from the fact that different taxes' share of total revenue (i.e. the variables of interest here) may react to a change in the level of economic activity in different sectors. This change in economic activity might well be driven by something other than a change in the tax rate. For example, the share of taxes collected from trade may increase relative to other categories simply as a result of an increase in the volume of trade, regardless of the rate of the taxes levied on imports. In turn, this will also affect GDP growth. The volume of trade openness is included as an additional control in Tables 6 and 7. This is calculated, following Arnold (2008), by obtaining the residuals from a regression of the volume of trade (the sum of the value of imports and exports, expressed as a percentage of GDP) on log population. This therefore represents the part of trade that is not explained simply by country size. For the sake of brevity, only the base specification, where consumption and property taxes are excluded, and that excluding trade taxes are shown (pertaining to columns 1 and 6 of Table 2).

All of the aforementioned results hold, any changes being purely in the magnitude of the coefficients. Column 4 of Table 6 suggests that RN increases in income taxes, offset by reductions in trade taxes, are now statistically negatively related to long-run GDP growth rates. Turning to Table 7, column 4, the results now suggest that for high-income countries, RN

[22] One caveat that should be noted, however, is that the power of the Hausman test in this case (i.e. comparing MG and PMG) is relatively low (Pesaran et al. 1999).

[23] These are specified as 1980–84, 1985–89, … …, 2010–14.

increases in domestic consumption, offset by decreases in trade taxes, are harmful for growth. In upper-middle-income countries, the coefficient on property taxes becomes insignificant (column 8).

The regression framework employed here includes short-run dynamics and five-year dummies, both of which should help to account for the effects of the business cycle. However, a further way in which it is possible to test for the presence of endogeneity (outlined in Acosta-Ormaechea and Yoo (2012), which itself follows an approach outlined in Calderon et al. (2011)) is as follows. In order to test if the tax variables considered here are weakly exogenous, the system of equations in (2) is estimated separately for each country, *i*, included in the specifications above.[24]

$$\Delta T_{i,t} = \phi_i\left(g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 T_{i,t-1} - \sum \hat{\alpha}_j TC_{i,t-1}\right) + \varepsilon_{i,t}$$

$$\Delta INC = \phi_i\left(g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 T_{i,t-1} - \sum \hat{\alpha}_j TC_{i,t-1}\right) + \varepsilon_{i,t}$$

$$\Delta GS_{i,t} = \phi_i\left(g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 T_{i,t-1} - \sum \hat{\alpha}_j TC_{i,t-1}\right) + \varepsilon_{i,t} \qquad (2)$$

$$\Delta TRADE_{i,t} = \phi_i\left(g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 T_{i,t-1} - \sum \hat{\alpha}_j TC_{i,t-1}\right) + \varepsilon_{i,t}$$

$$\Delta PROP_{i,t} = \phi_i\left(g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 T_{i,t-1} - \sum \hat{\alpha}_j TC_{i,t-1}\right) + \varepsilon_{i,t}$$

$\phi_i$ represents the error correction component, and terms in parentheses are the long-run equilibrium errors resulting from the estimation of equation (1). This system of equations is estimated by Zellner's (1962) seemingly unrelated regression equations (SURE) method, via the *sureg* command in Stata. For weak exogeneity to hold, it is required that the $\phi_i$ coefficients are not significantly different from zero. A Wald test is carried out following the SURE regression for each country. If the null hypothesis (that the coefficients on $\phi_i$ are jointly zero) is rejected at the 5 per cent level, this suggests that the tax variables under consideration (i.e. the left-hand side variables in equation (2)) do in fact react to deviations from the long-run relationship (Acosta-Ormaechea and Yoo, 2012). That being so, the weak exogeneity condition is violated in these countries. Depending on the specification tested, between 17 and 24 countries violate the condition of weak exogeneity. Tables 8 and 9 replicate the results of Tables 2 and 3, respectively, omitting those countries where the tax policy variables cannot be considered weakly exogenous. It was not possible to replicate all specifications by country group in Table 9; due to the smaller *N* dimension, the PMG estimator did not always converge.

The results in Table 8 are largely in line with those in Table 2, although some differences are notable. The coefficient on income taxes in column 1 is smaller in magnitude and no longer

[24] The number of equations estimated depends on the exact specification of equation (1) being estimated.

statistically significant. In column 2, the finding that RN increases in personal income taxes, offset by reductions in consumption or property taxes, are statistically negatively associated with long-run GDP growth rates remains. However, the coefficient on social contributions is no longer significant and, interestingly, there again appears to be some evidence that RN increases in CIT actually have positive effects on long-run growth rates. The result in column 5, that RN increases in domestic consumption taxes offset by decreases in trade taxes is good for growth, also holds following the exclusion of the potentially endogenous countries. However, the coefficient estimate is again lower.

Turning to the high-income countries in Table 9, the results suggest that RN shifts toward income taxes are no longer significantly negatively correlated with long-run GDP growth. The finding that RN shifts toward property taxes, away from either consumption or income taxes, are positively associated with LR growth rates remains valid.

The findings for upper-middle-income countries are very similar to those in Table 3; again, RN shifts toward property taxes appear to be negatively correlated with long-run GDP growth rates (column 7), although the coefficient is somewhat smaller. Columns 9–12 show that the results for lower-middle-income countries also remain robust; the key finding, that RN increases in domestic consumption taxes offset by decreases in trade taxes are positively associated with long-run GDP growth rates, still holds, though the coefficient estimate is now over twice that reported in Table 3. There are no notable differences observed between Table 3 and Table 9 for low-income countries, aside from small variations in some coefficient estimates and the significance level of some of the tax variables in column 14.

### 6.5 Accounting for cross-sectional dependence

A further source of bias that might arise in a macro panel such as that used here is via residual cross-section dependence (CSD). This occurs when unobserved common shocks affect all countries or a subset of countries in the dataset. In our context, such shocks might take the form of, for example, commodity price fluctuations or tax agreements whereby a number of countries reduce tariffs on each other's imports. As proposed by Pesaran (2006), a simple way to account for the existence of CSD is to augment the equation being estimated with cross-sectional averages of the dependent and independent variables, i.e.

$$\frac{1}{N}\sum_{i=1}^{N}\Delta g_{it} \quad \& \quad \frac{1}{N}\sum_{i=1}^{N}\boldsymbol{X}_{it}$$

, respectively, where $\boldsymbol{X}_{it}$ is the vector of all explanatory variables. Given that the PMG approach uses maximum likelihood estimation, augmenting the estimated equation with *k* cross-sectional averages can lead to difficulties in the estimation procedure (the estimator might fail to converge or the likelihood function might become non-concave). Thus it was possible only to fully replicate the results of Table 2 and, indeed, for many specifications the sample size was reduced, as the estimator converges only when those countries with a sufficiently long *t* dimension were included in the analysis. These results are shown in Table 10.

The result in column 1 remains unchanged and the coefficient estimate on the income tax share is almost identical to that in Table 2. It was not possible to repeat the estimations with income tax disaggregated into PIT, social contributions, and CIT. In column 2, the results show that RN shifts toward property taxes, away from income taxes, are most growth-friendly, followed by RN shifts toward trade taxes. The result in Table 2, that RN shifts away from income toward taxes on goods and services lead to higher growth rates, is no longer statistically significant. Results in column 3 suggest that RN shifts toward income taxes, and away from consumption taxes, have

negative effects on GDP growth rates; notably, however, the coefficient estimate of -0.082 is larger than that reported in Table 2 (-0.047). Finally, in column 4, RN shifts away from trade taxes toward domestic consumption taxes are no longer significantly positively related to GDP. However, RN increases in property taxes are.

Thus, after attempting to control for cross-sectional averages, we find a couple of differences from the benchmark results. However, a potential issue with this set of results is that the sample size is reduced for each estimation; it is therefore difficult to say whether the difference in results is due to the inclusion of the cross-sectional averages, or to the smaller sample. It is hoped that in future work these results will become clearer via use of the dynamic common correlated effects estimator (Ditzen 2016), which is to be released in the near future. This should avoid the issues with convergence experienced with *xtpmg*, which uses OLS in order to estimate Pooled Mean Group regressions, allowing the effects of CSD to be investigated in the full panel of countries.

### 6.6 Excluding resource-rich countries

As highlighted in Figure 3, there are a number of resource-rich (specifically, oil-producing) countries where the tax ratio is very low but per capita income is high. Thus, in order to ensure that the results reported previously are not biased by the inclusion of resource-rich countries, where growth can fluctuate wildly on the basis of, for example, commodity prices, the specifications above are re-run excluding resource-rich countries. These were identified by searching the data in the GRD for (i) countries reporting non-tax revenues above 10 per cent of GDP and (ii) countries reporting a high level of resource tax revenues. Those dropped from the sample above are Algeria, Bahrain, Botswana, Egypt, Gabon, Morocco, Sudan, Trinidad and Tobago, and Venezuela. Table 11 reports the results for the full sample with these countries excluded.[25]

All of the previously reported results hold, with similar coefficient estimates. Notably, however, the result in column 1 suggests a somewhat stronger effect of RN increases in income tax, offset by consumption and property taxes; a percentage point increase in income taxes leads to a 0.097 per cent reduction in the long-run growth rate.

## 7 Further limitations

There are a number of further limitations to a study of this nature. First, it is inherently difficult to account for the fact that changes in tax policy are often announced some time in advance of implementation. Individuals and firms may therefore adjust their behaviour (which in turn will influence the share of tax from any one component) before the tax rate has actually changed. A further challenge lies in the fact that it is difficult to account for (changes in) the efficiency of tax collection, which has clear implications for GDP growth: even a well designed tax system might be undermined by poor administration. However, the human capital variable might go some way to capturing citizens' ability to understand and comply with tax laws, and the inclusion of the tax level (as a share of GDP), to an extent, serves as a control for the ability of the government to administer the tax system.[26] Parallel to the difficulty in accounting for the *ability* of a country to collect different taxes is the difficulty in controlling for the *cost* of collecting different types of

[25] In the interests of space, results by country grouping are not shown, but these are available upon request.

[26] That is, assuming that larger governments (as proxied by larger tax/GDP figures) are more able to collect taxes. Of course, this says nothing about the *efficiency* of tax collection, but it is plausible that where more people are employed in the public sector, tax collection will be more sophisticated.

tax. The above analysis, and related studies in the literature, assume that the costs of collecting different taxes are equal. This is, of course, unlikely to be true in practice. Similarly, studies of this nature assume that tax *design* does not matter for growth but, again, it obviously does. IMF (2013) makes this clear, noting the difference between a corporate tax on rents and one on total returns; the former would not affect the marginal incentive to invest, whilst the latter most certainly would. Whilst the assumption of revenue neutrality makes possible this kind of empirical analysis, there may be limits to the insights presented; many tax authorities in developing countries may alter their tax mix in the hope that the tax ratio itself increases. Furthermore, the magnitudes of the coefficients are quite small, suggesting limited direct effects of any RN changes in the tax mix on long-run GDP growth rates. Future work may seek to relax the revenue neutrality constraint, which is perhaps unrealistic in reality; some taxes are, naturally, better revenue-raisers than others. Thus an interesting next step might be an attempt to disentangle whether increases in certain types of taxation raise more revenue (which may fuel faster economic growth), have direct impacts on economic growth, or a combination of the two. Finally, the distinction between domestic taxes on goods and services and trade taxes is often somewhat blurry, especially in developing countries; whilst one country collecting VAT at the border might classify this as a trade tax, the next may count it as a tax on goods and services. The results that distinguish between domestic consumption and trade taxes should be interpreted with this in mind. It is hoped that future development of the GRD will seek improvement in this respect.

## 8 Conclusion

It is clear from the results presented here that different revenue-neutral changes in the tax mix seem to matter to a different extent in different countries. In short, this calls into question the external validity of studies based only on high-income countries and also highlights the pitfalls of promoting a 'one size fits all' policy recommendation. This finding is key; Prichard (2016) notes that the belief that increases in personal and corporate income taxes are bad for growth has become policy orthodoxy at the IMF. One need not look far to see evidence of this: IMF (2011) and IMF (2015) both make reference to the thinking that indirect taxes are more growth-friendly than income taxes. But any empirical evidence supporting this view comes from studies that have used data from high-income or OECD countries.

A knowledge of those taxes that are most growth-friendly at different levels of income can aid policymakers in a way that results from a sample containing only high-income countries cannot. Not only has GDP growth over the last 30 years been, on average, lower in high-income countries than in developing countries, but the tax structure in those countries has remained remarkably stable. Thus, any growth effects of a change in tax structure are likely to be very small. However, in low- and middle-income countries, the past 30 years have seen dramatic changes in the tax mix, with large-scale shifts away from a reliance on trade taxes toward taxes on domestic goods and services and, to a lesser extent, income taxes. In many countries, this is likely to continue in the future. Thus the potential to affect long-run growth rates with tax policy is much greater in such countries.

The results presented here provide several new insights: first, RN reductions in trade taxes, offset by increases in domestic consumption taxes, appear to be growth-friendly. Importantly, however, this result seems to be driven by the group of countries classed as lower-middle-income. No such effect is found for low-income countries. Indeed, after controlling for the degree of openness to trade, the results suggest a significant *negative* effect of RN shifts toward taxes on goods and services. Thus one might tentatively conclude that trade liberalization in the

very poorest countries does not lead to higher economic growth but, at later levels of development, it can make a positive contribution to growth rates. When viewed alongside the results of Baunsgaard and Keen (2010), who found revenue recovery to be extremely poor in low-income countries that had removed trade barriers, the difficulty in promoting trade liberalization in the very poorest of countries is further underlined.

Second, the results presented here confirm that RN shifts away from consumption and property taxes, toward income taxes, are harmful for GDP growth rates, as previously found by, for example, Acosta-Ormaechea and Yoo (2012) and Arnold et al. (2011). However, again, the magnitude of the effect differs at different levels of development, with the strongest negative effects seen in upper-middle-income countries and no significant effects in lower-middle-income countries. Personal income taxes and social contributions appear most harmful for long-run GDP growth rates, but no evidence is found that increases in corporate income taxes are harmful for growth.

Third, the thinking that RN increases in property taxes are good for economic growth, as suggested in previous studies, is called into question. The results suggest that, whilst this may be the case for high-income countries, RN increases in property taxes in low- or middle-income countries might have limited or indeed detrimental effects on long-run GDP growth rates.

As a result of the much improved data availability in the GRD, this study has been able to challenge, and in some cases overturn, the results of existing research, whilst also offering insights that are more relevant to developing countries. This is done in a transparent manner: all of the data used here is publically available, unlike that used in other recent work. If advice on the direction of fiscal policy or the structure of the tax mix is to be provided to developing countries, then at the very least this should be based on evidence of the experience of other developing countries.

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## Tables

Table 1: Summary statistics

| Variable | | Obsv. | Avg. | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| Per capita GDP growth | *All* | 2753 | 0.018 | 0.042 | -0.649 | 0.316 |
| | *HI* | 1236 | 0.020 | 0.033 | -0.149 | 0.171 |
| | *UMI* | 722 | 0.018 | 0.046 | -0.216 | 0.168 |
| | *LMI* | 392 | 0.022 | 0.031 | -0.156 | 0.122 |
| | *LI* | 402 | 0.009 | 0.062 | -0.649 | 0.316 |
| Physical capital | *All* | 2753 | 0.216 | 0.067 | 0.000 | 0.748 |
| | *HI* | 1236 | 0.227 | 0.047 | 0.085 | 0.463 |
| | *UMI* | 722 | 0.222 | 0.069 | 0.000 | 0.484 |
| | *LMI* | 392 | 0.227 | 0.089 | 0.055 | 0.748 |
| | *LI* | 402 | 0.162 | 0.063 | 0.000 | 0.343 |
| Human capital | *All* | 2753 | 7.510 | 2.988 | 0.796 | 13.247 |
| | *HI* | 1237 | 9.734 | 1.745 | 4.803 | 13.247 |
| | *UMI* | 722 | 7.186 | 1.824 | 2.836 | 11.289 |
| | *LMI* | 392 | 5.605 | 2.257 | 1.571 | 11.147 |
| | *LI* | 402 | 3.104 | 1.581 | 0.797 | 7.865 |
| Population growth rate | *All* | 2753 | 0.018 | 0.014 | -0.033 | 0.139 |
| | *HI* | 1237 | 0.010 | 0.012 | -0.025 | 0.111 |
| | *UMI* | 722 | .023 | 0.012 | -0.021 | 0.139 |
| | *LMI* | 392 | 0.023 | 0.009 | -0.012 | 0.048 |
| | *LI* | 402 | 0.028 | 0.013 | -0.033 | 0.069 |
| Tax/GDP | *All* | 2675 | 0.224 | 0.114 | 0.006 | 0.628 |
| | *HI* | 1236 | 0.301 | 0.096 | 0.011 | 0.506 |
| | *UMI* | 722 | 0.181 | 0.079 | 0.006 | 0.464 |
| | *LMI* | 392 | 0.173 | 0.105 | 0.047 | 0.628 |
| | *LI* | 402 | 0.11 | 0.045 | 0.018 | 0.326 |
| Income tax | *All* | 2752 | 0.444 | 0.177 | 0.000 | 0.894 |
| (share of total tax) | *HI* | 1236 | 0.576 | 0.120 | 0.000 | 0.894 |
| | *UMI* | 722 | 0.387 | 0.147 | 0.128 | 0.799 |
| | *LMI* | 392 | 0.313 | 0.125 | 0.088 | 0.685 |
| | *LI* | 402 | 0.270 | 0.100 | 0.044 | 0.635 |
| Personal income tax | *All* | 2162 | 0.205 | 0.124 | 0.000 | 0.787 |
| (includes payroll) | *HI* | 1117 | 0.266 | 0.126 | 0.000 | 0.787 |
| (share of total tax) | *UMI* | 493 | 0.130 | 0.091 | 0.000 | 0.440 |
| | *LMI* | 288 | 0.142 | 0.068 | 0.000 | 0.412 |
| | *LI* | 264 | 0.156 | 0.088 | 0.004 | 0.518 |
| | *LI* | 402 | 0.009 | 0.017 | 0.000 | 0.094 |
| Social contributions | *All* | 2499 | 0.137 | 0.143 | 0.000 | 0.476 |
| (share of total tax) | *HI* | 1225 | 0.211 | 0.141 | 0.000 | 0.476 |
| | *UMI* | 722 | 0.104 | 0.117 | 0.000 | 0.413 |
| | *LMI* | 288 | 0.035 | 0.084 | 0.000 | 0.391 |
| | *LI* | 264 | 0.003 | 0.009 | 0.000 | 0.036 |
| Corporate income tax | *All* | 2162 | 0.111 | 0.068 | 0.000 | 0.516 |
| (share of total tax) | *HI* | 1117 | 0.092 | 0.059 | 0.000 | 0.484 |
| | *UMI* | 493 | 0.139 | 0.079 | 0.000 | 0.516 |
| | *LMI* | 288 | 0.133 | 0.069 | 0.030 | 0.391 |
| | *LI* | 264 | 0.112 | 0.051 | 0.017 | 0.258 |
| Consumption & property tax | *All* | 2752 | 0.555 | 0.176 | 0.106 | 1.000 |
| (share of total tax) | *HI* | 1236 | 0.424 | 0.12 | 0.106 | 1.000 |
| | *UMI* | 722 | 0.613 | 0.146 | 0.201 | 0.872 |
| | *LMI* | 392 | 0.687 | 0.125 | 0.315 | 0.912 |
| | *LI* | 402 | 0.73 | 0.099 | 0.365 | 0.956 |
| Consumption tax | *All* | 2690 | 0.528 | 0.194 | 0.100 | 1.000 |
| (Goods & services + trade) | *HI* | 1198 | 0.372 | 0.125 | 0.100 | 1.000 |
| (share of total tax) | *UMI* | 702 | 0.599 | 0.152 | 0.157 | 0.870 |
| | *LMI* | 391 | 0.681 | 0.126 | 0.299 | 0.911 |
| | *LI* | 399 | 0.721 | 0.097 | 0.365 | 0.953 |

Table 1 (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| Tax on goods and services | *All* | 2690 | 0.374 | 0.14 | 0.000 | 0.870 |
| (Includes 'other tax') | *HI* | 1198 | 0.33 | 0.108 | 0.028 | 0.644 |
| (share of total tax) | *UMI* | 702 | 0.4 | 0.163 | 0.017 | 0.870 |
| Variable | | Obsv. | Avg. | Std. Dev. | Min. | Max. |
| | *LMI* | 391 | 0.423 | 0.134 | 0.097 | 0.681 |
| | *LI* | 399 | 0.412 | 0.151 | 0.000 | 0.723 |
| Trade tax | *All* | 2691 | 0.154 | 0.176 | 0.000 | 0.888 |
| (share of total tax) | *HI* | 1199 | 0.043 | 0.092 | 0.000 | 0.888 |
| | *UMI* | 702 | 0.199 | 0.168 | 0.000 | 0.700 |
| | *LMI* | 391 | 0.258 | 0.171 | 0.016 | 0.799 |
| | *LI* | 399 | 0.308 | 0.171 | 0.030 | 0.847 |
| Property tax | *All* | 2745 | 0.03 | 0.035 | 0.000 | 0.176 |
| (share of total tax) | *HI* | 1236 | 0.052 | 0.036 | 0.000 | 0.176 |
| | *UMI* | 715 | 0.018 | 0.022 | 0.000 | 0.086 |
| | *LMI* | 392 | 0.006 | 0.013 | 0.000 | 0.072 |

Notes: Standard errors in parentheses; *P<0.1; **P<0.05;***P<0.01.

All tax variables come from the ICTD GRD. Per capita GDP growth, physical capital and population growth are taken from the World Bank's World Development Indicators (WDI). Human capital is from Barro and Lee (2013).

Source: Author's estimations.

Table 2: PMG estimation, full sample

| Dependent variable: Δ(log) GDP per capita | | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Physical capital | 0.013 | 0.009 | 0.048*** | 0.058*** | 0.047** | 0.058*** |
| | (0.019) | (0.023) | (0.017) | (0.020) | (0.020) | (0.020) |
| Human capital | -0.030*** | -0.051*** | -0.026*** | -0.033*** | -0.029*** | -0.033*** |
| | (0.009) | (0.012) | (0.009) | (0.008) | (0.009) | (0.008) |
| Population growth | -0.423*** | -0.444*** | -0.274** | -0.504*** | -0.568*** | -0.504*** |
| | (0.133) | (0.161) | (0.124) | (0.152) | (0.143) | (0.152) |
| Tax/GDP | 0.061** | 0.096*** | 0.039 | 0.124*** | 0.092*** | 0.124*** |
| | (0.029) | (0.008) | (0.025) | (0.032) | (0.029) | (0.032) |
| Tax structure variables | | | | | | |
| **Income taxes** | -0.062*** | | | | -0.047** | -0.034 |
| | (0.018) | | | | (0.021) | (0.022) |
| PIT | | -0.068** | | | | |
| | | (0.030) | | | | |
| Social contributions | | -0.090*** | | | | |
| | | (0.033) | | | | |
| CIT | | 0.045 | | | | |
| | | (0.031) | | | | |
| **Consumption & property taxes** | | | | | | |
| Consumption taxes | | | 0.037** | | | |
| | | | (0.018) | | | |
| Goods & services | | | | 0.069*** | | 0.036*** |
| | | | | (0.021) | | (0.012) |
| Trade taxes | | | | 0.034 | | |
| | | | | (0.022) | | |
| Property taxes | | | 0.090 | 0.058 | -0.015 | 0.024 |
| | | | (0.073) | (0.076) | (0.077) | (0.076) |
| Observations | 2650 | 1802 | 2545 | 2290 | 2296 | 2290 |
| Groups | 100 | 68 | 96 | 84 | 84 | 84 |
| Stationarity: | I(0) | I(0) | I(0) | I(0) | I(0) | I(0) |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05;***P<0.01.

Source: Author's estimations.

Table 3: PMG results, by income group

| Dependent variable: Δ(log) GDP per capita | High income | | | | | | Upper-middle income | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Physical capital | -0.082** | -0.036 | -0.016 | 0.017 | -0.021 | 0.017 | -0.141** | -0.158*** | -0.136*** | -0.091** | -0.136*** | -0.091** |
| | (0.038) | (0.037) | (0.039) | (0.038) | (0.039) | (0.038) | (0.039) | (0.049) | (0.039) | (0.036) | (0.039) | (0.036) |
| Human capital | -0.140*** | -0.161*** | -0.123*** | -0.100*** | -0.122*** | -0.100 | 0.640** | 0.030 | 0.072*** | 0.067*** | 0.072*** | 0.067*** |
| | (0.019) | (0.019) | (0.02) | (0.020) | (0.020) | (0.020) | (0.025) | (0.030) | (0.025) | (0.025) | (0.025) | (0.025) |
| Population growth | -0.632*** | -0.888*** | -0.822*** | -0.830*** | -0.820*** | -0.830*** | 1.573*** | 2.158*** | 1.688*** | 2.049*** | 1.688*** | 2.049*** |
| | (0.190) | (0.187) | (0.214) | (0.212) | (0.214) | (0.212) | (0.265) | (0.286) | (0.255) | (0.220) | (0.255) | (0.220) |
| Tax/GDP | 0.213** | 0.198*** | 0.199*** | 0.195*** | 0.203*** | 0.195*** | 0.142** | 0.122* | 0.180*** | 0.239*** | 0.180*** | 0.239*** |
| | (0.048) | (0.049) | (0.047) | (0.047) | (0.048) | (0.047) | (0.056) | (0.072) | (0.059) | (0.054) | (0.059) | (0.054) |
| Tax structure Variables | | | | | | | | | | | | |
| **Income taxes** | -0.101*** | | | | -0.024 | -0.122* | -0.154*** | | | | -0.170*** | -0.142*** |
| | (0.035) | | | | (0.037) | (0.068) | (0.033) | | | | (0.034) | (0.036) |
| PIT | | -0.113** | | | | | | -0.348*** | | | | |
| | | (0.048) | | | | | | (0.079) | | | | |
| Social contributions | | -0.120** | | | | | | -0.303*** | | | | |
| | | (0.47) | | | | | | (0.064) | | | | |
| CIT | | 0.163*** | | | | | | -0.056 | | | | |
| | | (0.052) | | | | | | (0.056) | | | | |
| **Consumption & property taxes** | | | | | | | | | | | | |
| Consumption taxes | | | 0.022 | | | | | | 0.170*** | | | |
| | | | (0.037) | | | | | | (0.034) | | | |
| Goods & services | | | | 0.023 | | -0.099 | | | | 0.120*** | | -0.022 |
| | | | | (0.036) | | (0.064) | | | | (0.036) | | (0.034) |
| Trade taxes | | | | 0.122* | | | | | | 0.142*** | | |
| | | | | (0.068) | | | | | | (0.036) | | |
| Property taxes | | | 0.341*** | 0.293*** | 0.327*** | 0.171 | | | -0.463** | -0.345* | -0.630*** | -0.487*** |
| | | | (0.099) | (0.095) | (0.100) | (0.112) | | | (0.190) | (0.184) | (0.184) | (0.181) |
| Omitted tax variable | **Consumption & property** | | **Income** | | **Consumption** | **Trade** | **Consumption & property** | | **Income** | | **Consumption** | **Trade** |
| Observations | 1202 | 1033 | 1121 | 1121 | 1123 | 1121 | 695 | 377 | 663 | 663 | 663 | 663 |
| Groups | 42 | 36 | 38 | 38 | 38 | 38 | 27 | 16 | 26 | 26 | 26 | 26 |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Table 3 (continued)

| | Lower-middle income | | | | | | Low income | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Physical capital | 0.117*** | - | 0.115*** | -0.016 | 0.115*** | -0.016 | 0.152*** | - | 0.200*** | 0.213*** | 0.132*** | 0.213*** |
| | (0.027) | - | (0.025) | (0.016) | (0.025) | (0.016) | (0.056) | - | (0.062) | (0.064) | (0.057) | (0.064) |
| Human capital | -0.039*** | - | -0.036*** | -0.004 | -0.035 | -0.004 | 0.044* | - | 0.031* | 0.043 | 0.047*** | 0.043 |
| | (0.012) | - | (0.010) | (0.006) | (0.010) | (0.006) | (0.025) | - | (0.026) | (0.028) | (0.025) | (0.028) |
| Population growth | -1.133*** | - | -1.123*** | 0.421*** | -1.091*** | 0.421*** | 0.049 | - | 0.511 | 0.421 | 0.298 | 0.421 |
| | (0.295) | - | (0.274) | (0.101) | (0.272) | (0.101) | (0.303) | - | (0.324) | (0.346) | (0.320) | (0.346) |
| Tax/GDP | -0.024 | - | -0.003 | 0.071*** | 0.002 | 0.071*** | -0.241* | - | -0.246* | -0.313** | -0.272** | -0.313** |
| | (0.041) | - | (0.039) | (0.020) | (0.039) | (0.020) | (0.132) | - | (0.131) | (0.142) | (0.130) | (0.142) |
| Tax structure | | | | | | | | | | | | |
| **Income taxes** | 0.001 | | | | 0.016 | 0.081*** | -0.120** | | | | -0.173*** | -0.193*** |
| | (0.030) | | | | (0.030) | (0.023) | (0.052) | | | | (0.060) | (0.064) |
| PIT | | - | | | | | | - | | | | |
| | | - | | | | | | - | | | | |
| Social contributions | | - | | | | | | - | | | | |
| | | - | | | | | | - | | | | |
| CIT | | - | | | | | | - | | | | |
| **Consumption & property taxes** | | - | | | | | | - | | | | |
| Consumption taxes | | | -0.015 | | | | | | 0.182*** | | | |
| | | | (0.030) | | | | | | (0.061) | | | |
| Goods & services | | | | -0.041 | | 0.040*** | | | | 0.205*** | | 0.011 |
| | | | | (0.026) | | (0.011) | | | | (0.068) | | (0.026) |
| Trade taxes | | | | -0.081*** | | | | | | 0.193*** | | |
| | | | | (0.023) | | | | | | (0.064) | | |
| Property taxes | | | -0.845*** | -1.109*** | -0.822*** | -1.028*** | | | -0.308 | -0.271 | -0.490** | -0.465* |
| | | | (0.246) | (0.278) | (0.242) | (0.274) | | | (0.210) | (0.226) | (0.235) | (0.247) |
| Omitted tax variable | **Consumption & property** | | **Income** | | **Consumption** | **Trade** | **Consumption & property** | | **Income** | | **Consumption** | **Trade** |
| Observations | 374 | - | 359 | 359 | 360 | 359 | 386 | - | 383 | 383 | 383 | 383 |
| Groups | 16 | - | 15 | 15 | 15 | 15 | 15 | - | 15 | 15 | 15 | 15 |
| 5-year dummies | Yes | - | Yes | Yes | Yes | Yes | Yes | - | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05;***P<0.01.

Source: Author's estimations.

Table 4: Parameter restrictions for different estimators

| Estimator | SR coefficients | LR coefficients |
|---|---|---|
| Mean Group (MG) | Heterogeneous | Heterogeneous |
| Pooled Mean Group (PMG) | Heterogeneous | Homogeneous |
| Dynamic Fixed Effects (DFE) | Homogeneous | Homogeneous |

Source: Author's estimations.

Table 5: Hausman test: MG vs. PMG

| | MG | PMG |
|---|---|---|
| Specification (1) | | |
| Income taxes | -0.174 | -0.062*** |
| | (0.103) | (0.018) |
| Hausman test: Chi2 (5): 1.08; P=0.956 | | |
| Specification (2) | | |
| PIT | -0.393 | -0.068** |
| | (0.230) | (0.03) |
| SC | -2.627 | -0.090*** |
| | (2.263) | (0.033) |
| CIT | 0.297 | 0.045 |
| | (0.157) | (0.031) |
| Hausman test: Chi2 (7): 2.16; P=0.950 | | |
| Specification (3) | | |
| Consumption | 0.115 | 0.037** |
| | (0.092) | (0.018) |
| Property | -16.083 | 0.090 |
| | (14.291) | (0.073) |
| Hausman test: Chi2 (6): 0.95; P=0.987 | | |
| Specification (4) | | |
| GS | 0.701 | 0.069*** |
| | (0.486) | (0.021) |
| Trade | 0.231 | 0.034 |
| | (0.417) | (0.022) |
| Property | -12.977 | 0.058 |
| | (11.745) | (0.076) |
| Hausman test: Chi2 (7): 0.054; P=0.999 | | |
| Specification (5) | | |
| Income | -0.114 | -0.047*** |
| | (0.093) | (0.021) |
| Property | -16.102 | -0.015 |
| | (0.015) | (0.077) |
| Hausman test: Chi2 (6): 0.76; P=0.993 | | |
| Specification (6) | | |
| Income | -0.249 | -0.034 |
| | (0.422) | (0.022) |
| GS | 0.459 | 0.036*** |
| | (0.676) | (0.012) |
| Property | -13.025 | 0.024 |
| | (11.696) | (0.076) |
| Hausman test: Chi2 (7): 3.59; P=0.825 | | |

Source: Author's estimations.

Table 6: Full sample, including openness to trade

| Dependent variable: Δ(log) GDP per capita | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Physical capital | 0.013 | 0.009 | 0.058*** | 0.078*** |
| | (0.019) | (0.017) | (0.020) | (0.019) |
| Human capital | -0.030*** | -0.048*** | -0.033*** | -0.036*** |
| | (0.009) | (0.014) | (0.008) | (0.013) |
| Population growth | -0.423*** | 0.467** | -0.504*** | 0.777*** |
| | (0.133) | (0.208) | (0.152) | (0.210) |
| Tax/GDP | 0.061** | 0.070** | 0.124*** | 0.149*** |
| | (0.029) | (0.027) | (0.032) | (0.028) |
| Tax structure variables | | | | |
| **Income taxes** | -0.062*** | -0.105*** | -0.034 | -0.075*** |
| | (0.018) | (0.018) | (0.022) | (0.0230 |
| PIT | | | | |
| Social contributions | | | | |
| CIT | | | | |
| **Consumption & property taxes** | | | | |
| Consumption taxes | | | | |
| Goods & services | | | 0.036*** | 0.032*** |
| | | | (0.012) | (0.012) |
| Trade taxes | | | | |
| Property taxes | | | 0.024 | 0.096 |
| | | | (0.076) | (0.077) |
| Openness | | 0.002 | | -0.001 |
| | | (0.001) | | (0.002) |
| Omitted tax variable | **Consumption & property** | | **Trade** | |
| Observations | 2650 | 2657 | 2290 | 2274 |
| Groups | 100 | 100 | 84 | 83 |
| 5-year dummies | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05;***P<0.01.

Source: Author's estimations.

Table 7: Results by income group, including openness to trade

| Dependent variable: Δ(log) GDP per capita | High income | | | | Upper-middle income | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Physical capital | -0.082** | -0.065* | 0.017 | 0.044 | -0.141** | -0.051* | -0.091** | -0.003 |
| | (0.038) | (0.039) | (0.038) | (0.039) | (0.039) | (0.027) | (0.036) | (0.032) |
| Human capital | -0.140*** | -0.080*** | -0.100 | -0.038 | 0.640** | -0.024 | 0.067*** | 0.094*** |
| | (0.019) | (0.025) | (0.020) | (0.026) | (0.025) | (0.033) | (0.025) | (0.035) |
| Population growth | -0.632*** | -0.097 | -0.830*** | 0.301*** | 1.573*** | 0.869*** | 2.049*** | 1.915*** |
| | (0.190) | (0.357) | (0.212) | (0.373) | (0.265) | (0.319) | (0.220) | (0.337) |
| Tax/GDP | 0.213** | 0.174*** | 0.195*** | 0.150*** | 0.142** | -0.129*** | 0.239*** | 0.201*** |
| | (0.048) | (0.048) | (0.047) | (0.047) | (0.056) | (0.048) | (0.054) | (0.050) |
| Tax structure variables | | | | | | | | |
| **Income taxes** | -0.101*** | -0.104*** | -0.122* | -0.135** | -0.154*** | -0.223*** | -0.142*** | -0.173** |
| | (0.035) | (0.036) | (0.068) | (0.068) | (0.033) | (0.032) | (0.036) | (0.036) |
| PIT | | | | | | | | |
| Social contributions | | | | | | | | |
| CIT | | | | | | | | |
| **Consumption & property taxes** | | | | | | | | |
| Consumption taxes | | | | | | | | |
| Goods & services | | | -0.099 | -0.124** | | | -0.022 | -0.007 |
| | | | (0.064) | (0.063) | | | (0.034) | (0.032) |
| Trade taxes | | | | | | | | |
| Property taxes | | | 0.171 | 0.128 | | | -0.487*** | -0.269 |
| | | | (0.112) | (0.114) | | | (0.181) | (0.162) |
| Openness | | -0.007** | | -0.005 | | -0.006 | | -0.739** |
| | | (0.003) | | (0.003) | | (0.296) | | (0.320) |
| Omitted tax variable | **Consumption & property** | | **Trade** | | **Consumption & property** | | **Trade** | |
| Observations | 1202 | 1202 | 1121 | 1121 | 695 | 695 | 663 | 637 |
| Groups | 42 | 42 | 38 | 38 | 27 | 27 | 26 | 24 |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Table 7 (continued)

| | Lower-middle income | | | | Low income | | | |
|---|---|---|---|---|---|---|---|---|
| | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Physical capital | 0.117*** | 0.168*** | -0.016 | 0.105*** | 0.152*** | 0.176*** | 0.213*** | 0.158** |
| | (0.027) | (0.029) | (0.016) | (0.028) | (0.056) | (0.061) | (0.064) | (0.037) |
| Human capital | -0.039*** | 0.020 | -0.004 | -0.052*** | 0.044* | -0.115*** | 0.043 | -0.130*** |
| | (0.012) | (0.017) | (0.006) | (0.012) | (0.025) | (0.041) | (0.028) | (0.039) |
| Population growth | -1.133*** | -0.265 | 0.421*** | -0.365 | 0.049 | 0.475 | 0.421 | -3.010*** |
| | (0.295) | (0.428) | (0.101) | (0.253) | (0.303) | (0.579) | (0.346) | (0.447) |
| Tax/GDP | -0.024 | 0.050 | 0.071*** | 0.119*** | -0.241* | -0.156 | -0.313** | 0.226** |
| | (0.041) | (0.050) | (0.020) | (0.041) | (0.132) | (0.127) | (0.142) | (0.111) |
| Tax structure variables | | | | | | | | |
| **Income taxes** | 0.001 | 0.029 | 0.081*** | 0.062** | -0.120** | -0.138*** | -0.193*** | -0.258*** |
| | (0.030) | (0.027) | (0.023) | (0.025) | (0.052) | (0.049) | (0.064) | (0.032) |
| PIT | | | | | | | | |
| Social contributions | | | | | | | | |
| CIT | | | | | | | | |
| **Consumption & property taxes** | | | | | | | | |
| Consumption taxes | | | | | | | | |
| Goods & services | | | 0.040*** | 0.050*** | | | 0.011 | -0.051*** |
| | | | (0.011) | (0.010) | | | (0.026) | (0.020) |
| Trade taxes | | | | | | | | |
| Property taxes | | | -1.028*** | -0.865*** | | | -0.465* | -0.554*** |
| | | | (0.274) | (0.282) | | | (0.247) | (0.222) |
| Openness | | -0.933*** | | 0.001 | | 1.203*** | | 1.309 |
| | | (0.244) | | (0.002) | | (0.345) | | (0.231) |
| Omitted tax variable | **Consumption & property** | | **Trade** | | **Consumption & property** | | **Trade** | |
| Observations | 359 | 359 | 359 | 359 | 386 | 386 | 383 | 383 |
| Groups | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05; ***P<0.01.

Source: Author's estimations.

Table 8: Replication of Table 2, excluding countries identified as potentially endogenous

| Dependent variable: Δ(log) GDP per capita | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Physical capital | 0.030 | 0.032 | -0.012 | 0.050** | 0.068*** |
| | (0.020) | (0.025) | (0.017) | (0.021) | (0.022) |
| Human capital | -0.041*** | -0.025* | 0.007 | -0.031*** | -0.041*** |
| | (0.012) | (0.013) | (0.007) | (0.011) | (0.012) |
| Population growth | -0.415** | -0.163 | 0.425*** | -0.628*** | -0.602*** |
| | (0.133) | (0.193) | (0.108) | (0.165) | (0.180) |
| Tax GDP | 0.025 | 0.017 | 0.098*** | 0.081*** | 0.070** |
| | (0.031) | (0.036) | (0.022) | (0.031) | (0.034) |
| Tax structure variables | | | | | |
| **Income taxes** | -0.020 | | | -0.040* | -0.031 |
| | (0.021) | | | (0.023) | (0.026) |
| PIT | | -0.086** | | | |
| | | (0.037) | | | |
| Social contributions | | -0.032 | | | |
| | | (0.042) | | | |
| CIT | | 0.146*** | | | |
| | | (0.039) | | | |
| **Consumption & property taxes** | | | | | |
| Goods & services | | | 0.012 | | 0.026*** |
| | | | (0.024) | | (0.017) |
| Trade | | | -0.039 | | |
| | | | (0.024) | | |
| Property | | | 0.189* | 0.114 | 0.164 |
| | | | (0.098) | (0.092) | (0.099) |
| Omitted tax variable | **Consumption & property** | | **Income** | **Consumption** | **Trade** |
| Observations | 2001 | 1273 | 1719 | 1812 | 1745 |
| Groups | 76 | 48 | 63 | 66 | 64 |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05; ***P<0.01.

Source: Author's estimations.

Table 9: Replication of Table 3, excluding countries identified as potentially endogenous

| Dependent variable: Δ(log) GDP per capita | High income | | | | Upper-middle income | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Physical capital | -0.060 | 0.039 | -0.025 | 0.027 | -0.132*** | -0.003 | -0.099** | 0.003 |
| | (0.045) | (0.043) | (0.043) | (0.044) | (0.042) | (0.042) | (0.049) | (0.042) |
| Human capital | -0.118*** | - | -0.121*** | -0.089 | 0.057* | 0.110** | 0.074 | 0.110** |
| | (0.025) | (0.022) | (0.022) | (0.022) | (0.030) | (0.055) | (0.046) | (0.055) |
| Population growth | -0.617** | - | -0.897*** | - | 1.801*** | 2.248*** | 2.069*** | 2.248*** |
| | (0.264) | (0.240) | (0.237) | (0.244) | (0.269) | (0.205) | (0.275) | (0.205) |
| Tax/GDP | 0.142** | 0.120** | 0.184*** | 0.109** | 0.147** | 0.308*** | 0.191*** | 0.308*** |
| | (0.057) | (0.054) | (0.052) | (0.054) | (0.057) | (0.065) | (0.073) | (0.065) |
| Tax structure | | | | | | | | |
| **Income taxes** | -0.307 | | 0.016 | -0.028 | -0.131*** | | -0.227*** | - |
| | (0.040) | | (0.040) | (0.078) | (0.036) | | (0.061) | (0.055) |
| PIT | | | | | | | | |
| Social contributions | | | | | | | | |
| CIT | | | | | | | | |
| **Consumption & property** | | | | | | | | |
| Goods & services | | 0.009 | | 0.022 | | 0.173*** | | -0.088* |
| | | (0.039) | | (0.073) | | (0.061) | | (0.047) |
| Trade | | 0.059 | | | | 0.261*** | | |
| | | (0.076) | | | | (0.055) | | |
| Property | | 0.393** | 0.471*** | 0.442*** | | 0.549** | -0.149*** | 0.288*** |
| | | (0.125) | (0.124) | (0.152) | | (0.268) | (0.227) | (0.264) |
| Omitted tax variable | **Consumption & property** | **Income** | **Consumption** | **Trade** | **Consumption & property** | **Income** | **Consumption** | **Trade** |
| Observations | 902 | 850 | 921 | 834 | 511 | 288 | 289 | 288 |
| Groups | 32 | 29 | 31 | 29 | 20 | 11 | 11 | 11 |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Table 9 (continued)

| | Lower-middle income | | | | Low income | | | |
|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Physical capital | 0.118*** | -0.011 | 0.117*** | -0.009 | 0.144** | 0.282*** | 0.156** | 0.266*** |
| | (0.027) | (0.022) | (0.026) | (0.022) | (0.062) | (0.074) | (0.066) | (0.068) |
| Human capital | -0.045*** | -0.011 | -0.025 | -0.005 | 0.091*** | 0.057 | 0.070** | 0.026 |
| | (0.015) | (0.008) | (0.013) | (0.008) | (0.034) | (0.039) | (0.034) | (0.028) |
| Population growth | -1.511*** | 0.379** | -1.642*** | 0.416** | -0.141 | 0.287 | 0.356 | 0.706* |
| | (0.355) | (0.103) | (0.351) | (0.118) | (0.477) | (0.507) | (0.469) | (0.419) |
| Tax/GDP | -0.024 | 0.083** | 0.022 | 0.106** | -0.259 | -0.241 | -0.229 | -0.225 |
| | (0.044) | (0.026) | (0.042) | (0.028) | (0.165) | (0.181) | (0.167) | (0.152) |
| Tax structure | | | | | | | | |
| **Income taxes** | 0.016 | | -0.018 | 0.104** | -0.170** | | -0.126* | -0.205*** |
| | (0.036) | | (0.030) | (0.029) | (0.068) | | (0.071) | (0.067) |
| PIT | | | | | | | | |
| Social contributions | | | | | | | | |
| CIT | | | | | | | | |
| **Consumption & property** | | | | | | | | |
| Goods & services | | - | | 0.084** | | 0.156* | | 0.011 |
| | | (0.026) | | (0.024) | | (0.084) | | (0.026) |
| Trade | | - | | | | 0.125 | | |
| | | (0.027) | | | | (0.080) | | |
| Property | | - | -0.787*** | -0.579** | | 0.623* | 0.281 | -0.485** |
| | | (0.279) | (0.259) | (0.289) | | (0.312) | (0.304) | (0.247) |
| Omitted tax variable | **Consumption & property** | **Income** | **Consumption** | **Trade** | **Consumption & property** | **Income** | **Consumption & property** | **Trade** |
| Observations | 304 | 268 | 291 | 290 | 275 | 304 | 307 | 333 |
| Groups | 13 | 11 | 12 | 12 | 11 | 12 | 12 | 13 |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05; ***P<0.01.

Source: Author's estimations.

Table 10: Replication of Table 4.2, after including cross-sectional averages of all variables

| Dependent variable: Δ(log) GDP per capita. | | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Physical capital | -0.004 | 0.046*** | 0.026 | 0.037* |
| | (0.017) | (0.022) | (0.018) | (0.023) |
| Human capital | -0.005 | -0.088*** | -0.092*** | -0.077*** |
| | (0.018) | (0.024) | (0.022) | (0.025) |
| Population growth | -0.297** | -0.545*** | 0.032 | -0.707*** |
| | (0.140) | (0.186) | (0.168) | (0.184) |
| Tax/GDP | 0.138*** | 0.066* | 0.133*** | 0.075** |
| | (0.030) | (0.039) | (0.034) | (0.038) |
| Tax structure variables | | | | |
| **Income** | -0.059*** | | -0.082*** | -0.017 |
| | (0.017) | | (0.018) | (0.027) |
| PIT | | | | |
| Social contributions | | | | |
| CIT | | | | |
| **Consumption & property taxes** | | | | |
| Goods & services | | 0.011 | | -0.020 |
| | | (0.024) | | (0.024) |
| Trade | | 0.056** | | |
| | | (0.028) | | |
| Property | | 0.247*** | 0.006 | 0.190*** |
| | | (0.072) | (0.067) | (0.071) |
| Omitted tax variable | **Income** | | **Consumption** | **Trade** |
| Observations | 2388 | 1777 | 2040 | 1777 |
| Groups | 85 | 58 | 70 | 58 |
| 5-year dummies | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05; ***P<0.01.

Source: Author's estimations

Table 11: Replication of Table 2 excluding resource-rich countries

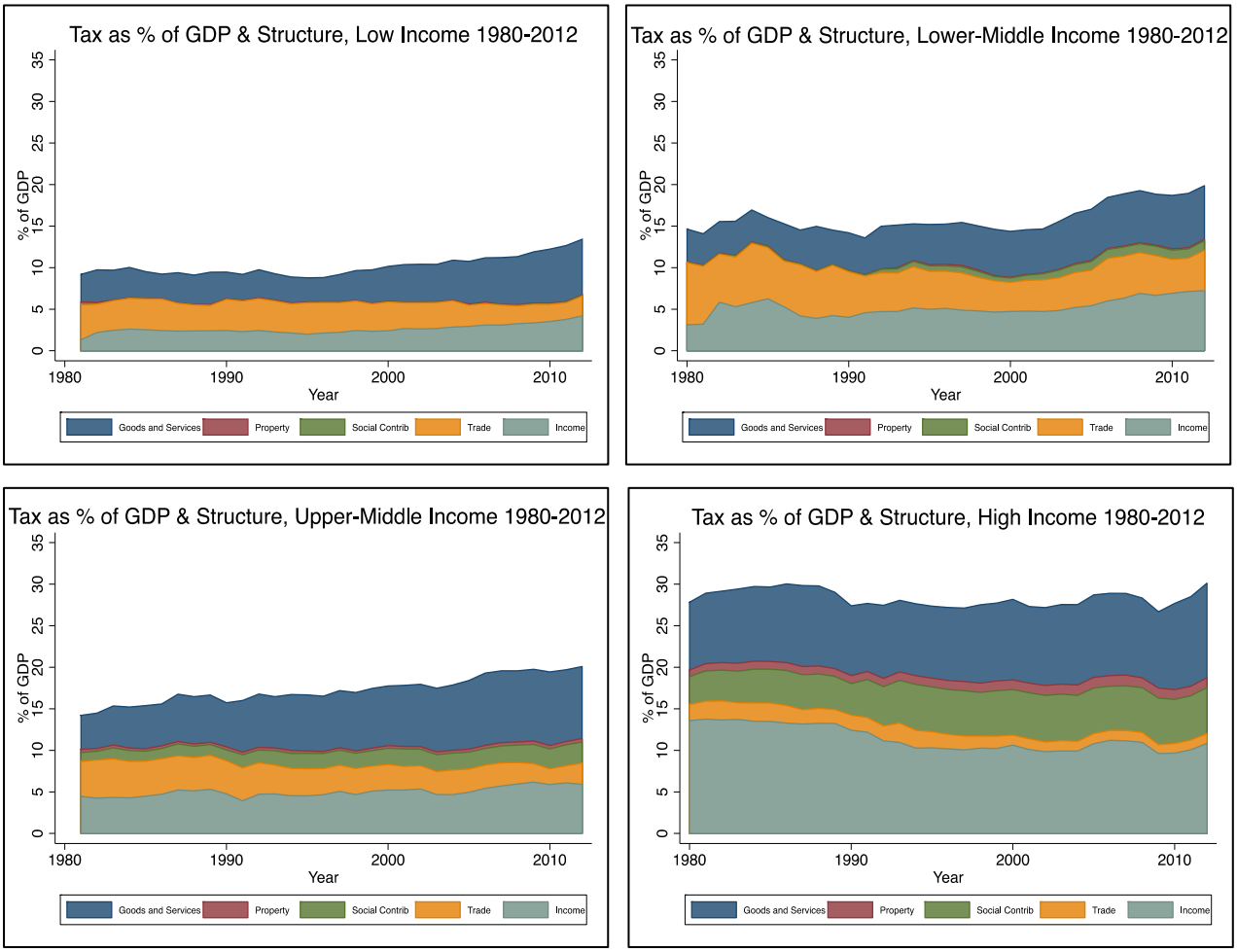
| Dependent variable: Δ(log) GDP per capita. | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Physical capital | 0.022 | 0.030 | 0.045** | -0.030* | 0.039* | 0.046*** |
| | (0.020) | (0.022) | (0.021) | (0.016) | (0.021) | (0.022) |
| Human capital | -0.027*** | -0.047*** | -0.030*** | 0.011** | -0.028*** | -0.031*** |
| | (0.009) | (0.011) | (0.010) | (0.005) | (0.009) | (0.009) |
| Population growth | -0.493*** | -0.538*** | -0.586*** | 0.371*** | -0.600*** | -0.441*** |
| | (0.137) | (0.160) | (0.148) | (0.106) | (0.148) | (0.158) |
| Tax/GDP | 0.046 | (0.019)** | 0.094*** | 0.100*** | 0.095*** | 0.135*** |
| | (0.030) | (0.008) | (0.031) | (0.020) | (0.031) | (0.033) |
| *Tax structure variables* | | | | | | -0.070*** |
| | | | | | | (0.024) |
| **Income taxes** | -0.097*** | | | | -0.074*** | |
| | (0.021) | | | | (0.023) | |
| PIT | | -0.052* | | | | |
| | | (0.029) | | | | |
| Social contributions | | -0.092*** | | | | |
| | | (0.033) | | | | |
| CIT | | 0.048 | | | | |
| | | (0.030) | | | | |
| **Consumption & property taxes** | | | | | | |
| Consumption taxes | | | 0.074*** | | | |
| | | | (0.023) | | | |
| Goods & services | | | | 0.066*** | | 0.042*** |
| | | | | (0.022) | | (0.012) |
| Trade taxes | | | | 0.015 | | |
| | | | | (0.021) | | |
| Property taxes | | | 0.048 | 0.039 | -0.019 | 0.003 |
| | | | (0.079) | (0.083) | (0.080) | (0.080) |
| Omitted tax variable | **Consumption & property** | | **Income** | | **Consumption** | **Trade** |
| Observations | 2413 | 1804 | 2134 | 2134 | 2134 | 2134 |
| Groups | 91 | 68 | 78 | 78 | 78 | 78 |
| 5-year dummies | Yes | Yes | Yes | Yes | Yes | Yes |

Note: Standard errors in parentheses; *P<0.1; **P<0.05; ***P<0.01.

Source: Author's estimations

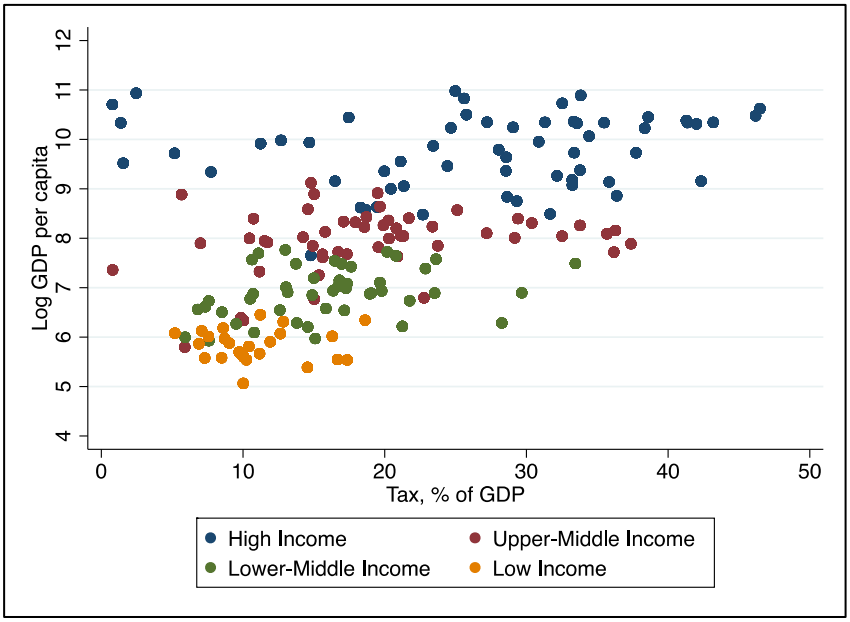
## Figures

Figure 1: Tax structure and ratio, by income level



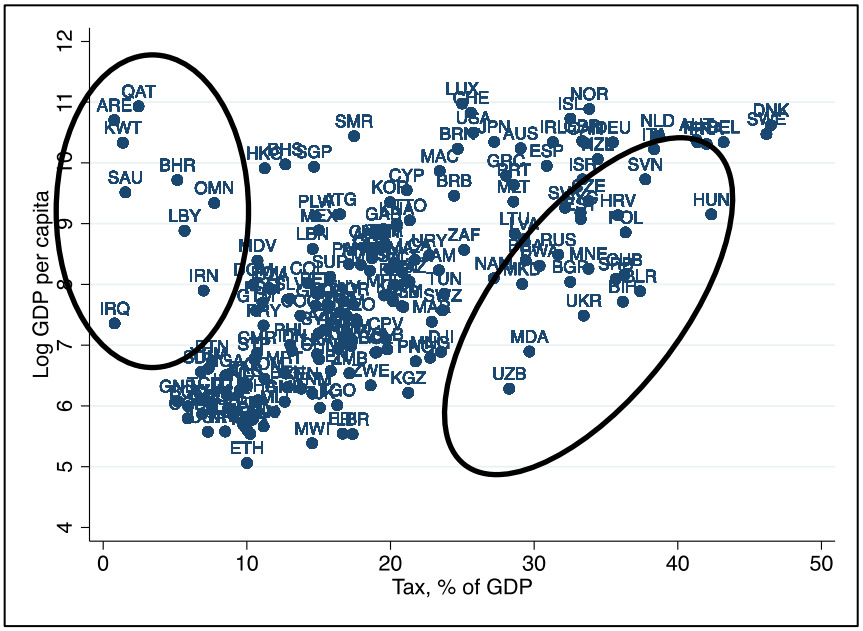

Source: ICTD Government Revenue Dataset.

Figure 2: Tax ratio and income, by income level




Sources: ICTD Government Revenue Dataset (2016) and World Development Indicators (2016).

Figure 3: Tax ratio and income, labelled




Sources: ICTD Government Revenue Dataset (2016) and World Development Indicators (2016).

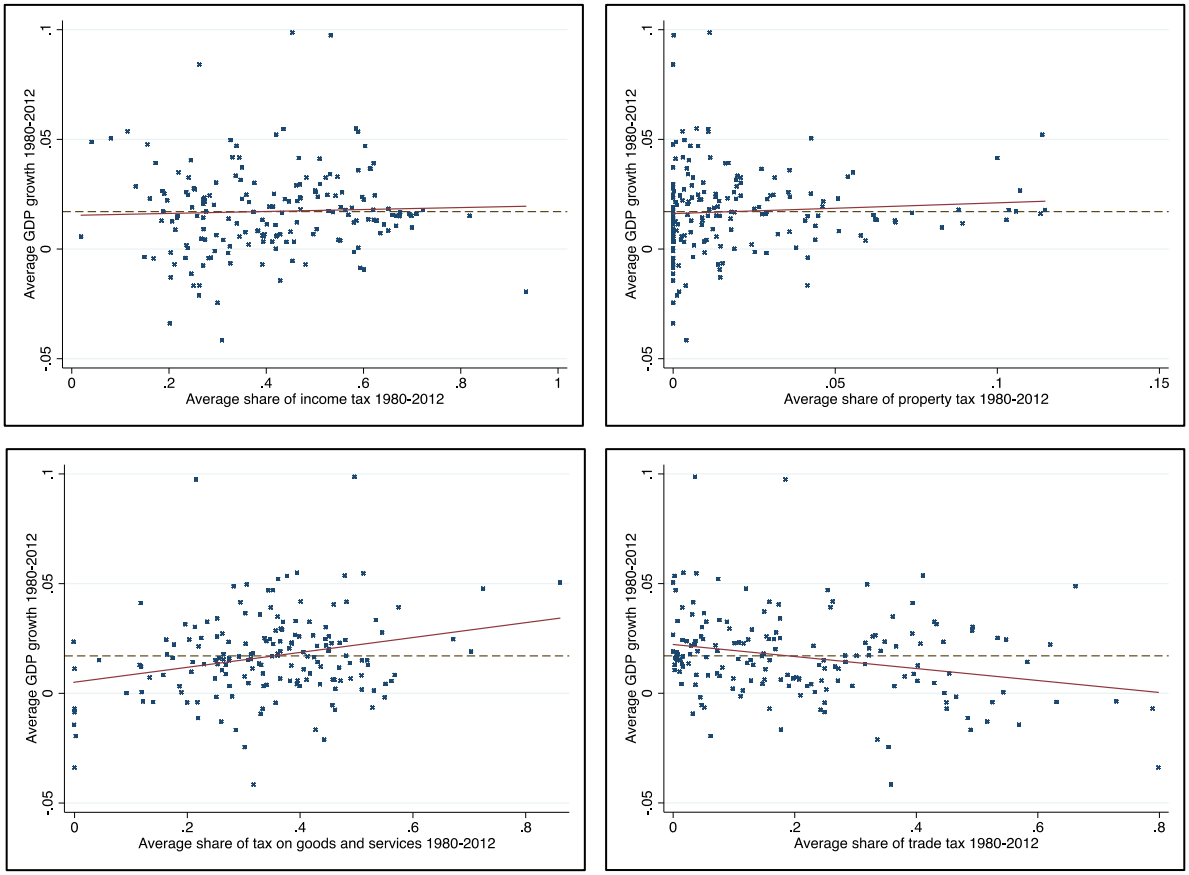



Figure 4: Average GDP growth vs. tax structure; 1980–2012

Sources: ICTD Government Revenue Dataset (2016) and World Development Indicators (2016).

## Appendix A: Countries included

*Low Income*

Benin, Burundi, Cambodia, Central African Republic, Gambia, Malawi, Mali, Mozambique, Nepal, Niger, Rwanda, Sierra Leone, Tanzania, Uganda, Zimbabwe

*Lower-Middle Income*

Bangladesh, Egypt, El Salvador, Ghana, Guatemala, India, Kenya, Lesotho, Morocco, Nicaragua, Philippines, Senegal, Sri Lanka, Sudan, Swaziland, Ukraine

*Upper-Middle Income*

Albania, Algeria, Belize, Botswana, Brazil, Bulgaria, Republic of the Congo, Costa Rica, Cuba, Dominican Republic, Ecuador, Gabon, Iran, Jordan, Mauritius, Mexico, Mongolia, Namibia, Pakistan, Panama, Paraguay, Peru, South Africa, Thailand, Tonga, Tunisia, Turkey

*High Income*

Argentina, Australia, Austria, Bahrain, Barbados, Belgium, Canada, Chile, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Kingdom, United States, Uruguay, Venezuela

**Appendix B:** PMG estimation, full sample with alternative time controls

| Dependent variable: Δ(log) GDP per capita. | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Physical capital | -0.003 | 0.007 | 0.002 | 0.001 | 0.004*** | 0.003 |
| | (0.013) | (0.014) | (0.013) | (0.014) | (0.013) | (0.014) |
| Human capital | -0.017** | -0.022** | -0.011 | -0.020** | -0.009 | -0.028*** |
| | (0.008) | (0.010) | (0.008) | (0.010) | (0.008) | (0.010) |
| Population growth | -0.328*** | -0.535*** | -0.338*** | -0.288*** | -0.457*** | -0.387*** |
| | (0.097) | (0.120) | (0.100) | (0.103) | (0.093) | (0.107) |
| Tax/GDP | 0.030 | 0.031*** | 0.065*** | 0.117*** | 0.068*** | 0.119*** |
| | (0.022) | (0.006) | (0.022) | (0.025) | (0.022) | (0.027 |
| *Tax structure variables* | | | | | | |
| **Income taxes** | -0.023 | | | | -0.025* | -0.039** |
| | (0.014) | | | | (0.014) | (0.017) |
| PIT | | -0.064*** | | | | |
| | | (0.021) | | | | |
| Social contributions | | -0.077*** | | | | |
| | | (0.025) | | | | |
| CIT | | 0.012 | | | | |
| | | (0.012) | | | | |
| **Consumption & property taxes** | | | | | | |
| Consumption taxes | | | 0.022 | | | |
| | | | (0.014) | | | |
| Goods & services | | | | 0.074*** | | 0.020* |
| | | | | (0.016) | | (0.012) |
| Trade taxes | | | | 0.042*** | | |
| | | | | (0.016) | | |
| Property taxes | | | -0.068 | -0.027 | -0.046 | -0.007 |
| | | | (0.055) | (0.055) | (0.055) | (0.055) |
| Omitted tax variable | **Consumption & property** | | **Income** | | **Consumption** | **Trade** |
| Observations | 2664 | 1811 | 2559 | 2562 | 2562 | 2290 |
| Groups | 100 | 68 | 96 | 96 | 96 | 84 |
| Time controls | | | | | | |
| Country-specific time trends | Yes | Yes | Yes | Yes | Yes | Yes |
| 5-year dummies | No | No | No | No | No | No |

Note: Standard errors in parentheses; *P<0.1; **P<0.05;***P<0.01

Source: Author's estimations.