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Tax Composition and Growth: A Broad Cross-Country Perspective

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Tax Composition and Growth: A Broad Cross-Country Perspective

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Abstract

We investigate the relation between changes in tax composition and long-run economic growth using a new dataset covering a broad cross-section of countries with different income levels. We specifically consider 69 countries with at least 20 years of observations on total tax revenue during the period 1970-2009—21 high-income, 23 middle-income and 25 low-income countries. To our knowledge this is the most comprehensive and up-to-date dataset on tax composition and growth. We find that increasing income taxes while reducing consumption and property taxes is associated with slower growth over the long run. We also find that: (1) among income taxes, social security contributions and personal income taxes have a stronger negative association with growth than corporate income taxes; (2) a shift from income taxes to property taxes has a strong positive association with growth; and (3) a reduction in income taxes while increasing value added and sales taxes is also associated with faster growth.

JEL Classification Numbers: E62; H21; O47

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I. Introduction

The question of how tax policy affects growth and whether these effects are short lived or rather permanent has been in the forefront of the discussions among researchers and policymakers over the last few decades. On the theoretical front, relatively recent endogenous growth models have successfully laid out the channels through which tax-policy changes affect the rate of capital accumulation (human and physical), labor-leisure tradeoffs, and thereby growth (see Barro, 1990; King and Rebelo, 1990; and Jones et al, 1993). The effects can even be long-lasting, meaning that macro variables are not only affected during the short-run adjustment process, but the steady state level of output and eventually the long-run rate of economic growth can also be affected. Although some skepticism exists regarding the magnitude of these effects (see, for example, Mendoza et al, 1997), these models suggest that tax policy can in general affect long-run growth in a non-trivial way.

Less conclusive results have been provided so far, however, on the empirical strand of this literature. Results have ranged from the findings of a weak and non-robust relation between tax policy variables and growth as suggested by Easterly and Rebelo (1993), to either the presence of only a very mild yet significant relation as shown by Mendoza et al (1997) to the finding of a robust and significant association between the two as shown in Kneller et al (1999), Gemmell et al (2011) and Arnold et al (2011). These more recent contributions have specifically looked at how changes in the tax structure–rather than changes in the overall tax burden–affect either the income level or the rate of growth of the economy over the medium and long run using different cross-country datasets.

While most of the previous studies have investigated the growth effect of tax policy focusing on OECD countries, analyses considering a broader set of countries and a comprehensive dataset of tax variables have been rather scant, with Easterly and Rebelo (1993)—a paper that considers about 100 countries during the 1970-1988 period—being an important exception.[2] Using that dataset, they document empirical findings and draw conclusions that, in principle, would apply to countries at different levels of development. This is not necessarily the case in the most recent works in this area, since they have confined the analysis to high-income countries, yielding policy conclusions that may not be relevant for non-advanced economies.

The objective of this paper is to overcome some of these limitations by investigating the relation between tax structure and long-run growth using a comprehensive dataset that covers a wide cross-section of countries for the longest possible time period. With this objective in mind, we first construct a dataset using the Government Finance Statistics (GFS) yearbook of the IMF, combined with the Revenue Statistics database of the OECD and the public finance statistics of the UN. Our main source of data is GFS, but we use either OECD or UN data when they have a better coverage than the GFS.[3] Our dataset finally comprises a total of 69 countries covering the

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[2] They also consider a historical dataset for a subset of 28 countries during 1870-1988 to investigate a number of stylized facts that would hold over the very long run.

[3] See Section II for details about the dataset.

period 1970-2009, in which each country has at least 20 years of observations on total tax revenue. As far as we are aware of, this is one of the most comprehensive and up-to-date datasets on taxation and growth considered in the related literature.

With this dataset in hand, we then consider a Pooled Mean Group (PMG) procedure as proposed by Pesaran et al (1999) to estimate the long-run equilibrium relation between tax composition and growth.[4] We specifically study how revenue-neutral changes in the tax structure affect the economy over the long run as in Arnold et al (2011), yet with a key distinctive feature: whereas they investigate the effects of changes in the composition of taxes on the long-run GDP per capita *level*, we study instead how it affects the rate of *growth* of GDP per capita. In that way our paper shares the objective of looking directly at the fiscal policy and growth relation as in Kneller et al (1999) and Gemmell et al (2011), but we undertake a more detailed analysis of the effects of key taxes on growth using a broader dataset. In fact, we also investigate here whether there is a sort of 'tax and growth ranking' when including a large set of countries with different income levels, as it has been done in Arnold (2011)'s paper.[5]

Turning to our main results, in the full-sample case we find that raising taxes on income while reducing consumption and property taxes, keeping the overall tax burden unchanged, is negatively associated with growth. This negative association is more significant in the case of social security contributions and personal income taxes relative to corporate income taxes. On the other hand, we find that a shift from income to property taxes has a robust and positive association with growth. Similarly, when the increase is in VAT and sale taxes compensated with a reduction in income taxes, we also find a positive effect on growth. When the sample is divided according to the countries' income level, we find similar and consistent results for high and middle-income countries as in those of the full sample case. For low-income countries, however, we did not find such robust results. The reasons behind this are not investigated here, but we suggest tentatively that it could be due to their poorer quality of tax administration and tax enforcement, facts that were probably reflected in tax policy data in this subsample relatively more 'disconnected' in their relation with growth.

The rest of the paper is structured as follows. Section II describes the dataset. Section III presents a number of stylized facts on the relation between tax structures and the level of development of a country drawn from it. In Section IV we describe our estimation method. We then report in Section V the estimation results for the full-sample case, whereas results for each income group are presented in Section VI. In Section VII we attempt to address endogeneity concerns testing for weak exogeneity considering those tax variables used in our estimations. Finally, Section VIII concludes.

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[4] Kneller et al (1999), Gemmell et al (2011), and Arnold et al (2011) also consider a PMG econometric approach for their respective estimations.

[5] Arnold et al (2011) suggest a 'tax and growth ranking' considering the more conventional data available for OECD countries in which property taxes, and in particular recurrent taxes on immovable property, are the least harmful taxes for economic activity over the long run, followed by consumption taxes, personal income taxes, and finally corporate income taxes. See Annex IV for a detailed discussion about this 'tax and growth ranking'.

II. THE DATASET

The main source to construct our dataset is the IMF's Government Finance Statistics (GFS) yearbook. A key challenge to compile it has been the significant change in methodology that took place with the introduction of the new GFSM2001 manual (previously it was the GFSM1986 manual). It involved changes in the classification of tax revenue and expenditure series, the form of accounting, and the government coverage level.[6] After a careful application of guidelines to map the two classifications (see Wickens, 2002) and an extensive work to compile the different series, we obtained 80 countries from the GFS yearbook with at least 20 years of observations at the consolidated central government level (CCG) for the period 1970-2009.[7]

This GFS dataset is supplemented with other data sources, when they either have better coverage or are more relevant for the analysis—e.g., we consider the general government level for advanced countries owing to the significant de-centralization process observed in these economies. In this regard, we use the Revenue Statistics database of the OECD for 28 countries.[8] This OECD database allows us to include figures for the consolidated general government (CGG) level for the period 1970-2009. In addition, we rely on the statistics on public finance prepared by the Economic Commission for Latin America and the Caribbean of the UN for seven Latin-American countries. In this case, figures are considered at the CGG level for Argentina and Brazil, whereas for the remaining countries' data refer to the CCG level.[9] The UN tax-revenue data for Latin American countries covers only the 1990-2009 period.

The remaining macro variables used in this study are obtained from the World Development Indicators database produced by the World Bank, with the exception of average years of schooling, which is obtained from Barro and Lee (2010). We then divide the whole sample into three groups according to their GDP per capita level (PPP prices): low, middle, and high-income countries.[10] Overall, the final dataset comprises 69 countries with at least 20 years of

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[6] See Annex I for a brief description on how we applied different guidelines to 'convert' the old series under the GFSM1986 manual with the new series under the GFSM2001 manual.

[7] Since the GFSM1986 manual did not consider the reporting of data at the consolidated general government level, we decided to undertake the analysis considering the more restrictive consolidated central government level for the construction of our dataset. Yet, for many low and middle income countries this distinction might not be that relevant, since in these economies most of the revenue data are collected by the central government.

[8] These countries are: Australia, Austria, Belgium, Canada, Switzerland, West Germany (until 1990), Denmark, Spain, Finland, France, the UK, Greece, Ireland, Italy, Japan, the Netherlands, Norway, New Zealand, Portugal, Sweden, US, Chile, Mexico, Korea, Czech, Slovak, Estonia, and Turkey.

[9] These countries are: Haiti, Nicaragua, Panama, Ecuador, and Peru

[10] High income countries refer to the following 21 OECD economies: Australia, Austria, Belgium, Canada, Switzerland, West Germany (until 1990), Denmark, Spain, Finland, France, the UK, Greece, Ireland, Italy, Japan, the Netherlands, Norway, New Zealand, Portugal, Sweden, and US. For the middle and low income countries categories, we divided the remaining dataset into two, depending on their GDP per capita (PPP prices) at each year, relative to the cross-sectional median income level at that particular year. We then computed the number of times that each country was above and below the median income level, and allocated the countries accordingly: if the

(continued…)

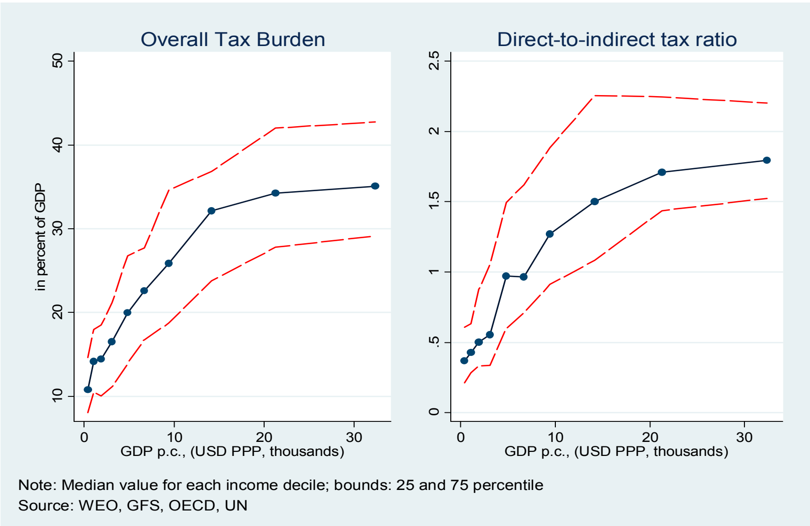
observations for both tax and macro variables: it consists of 21 high-income countries, 23 middle-income countries and 25 low-income countries. Annex V provides descriptive statistics of the full dataset.

III. Tax Structure and Development

Pooling together all countries and ordering the data according to their income level, we can examine how the tax level changes as countries become more developed. The whole sample is divided into deciles according to the GDP per capita (PPP prices) level, which is plotted in Figures 1 and 2 against the associated tax variable under consideration. Each point in Figure 1 and 2 represents the median value for each decile's income level and the associated median value of the tax-related component.[11]

Figure 1 shows that countries significantly increase the overall level of taxation (as a share of GDP) as they become richer, in line with "Wagner's law," which states that the size of the government—proxied by the tax (and expenditure) share to GDP—rises as the associated country's income level also rises.[12] In addition, as shown in the right-hand side panel of the figure, the tax structure becomes more biased towards direct taxation as countries develop.[13] Easterly and Rebelo (1993)'s work shows similar patterns in a sample of 28 countries covering the period 1870-1988.

Figure 1. Tax Revenue and Income Levels



country was most of the times with an income level above the median it was classified as a middle-income country, otherwise it was classified as a low-income country.

[11] The format of these plots follows Easterly and Rebelo (1993).

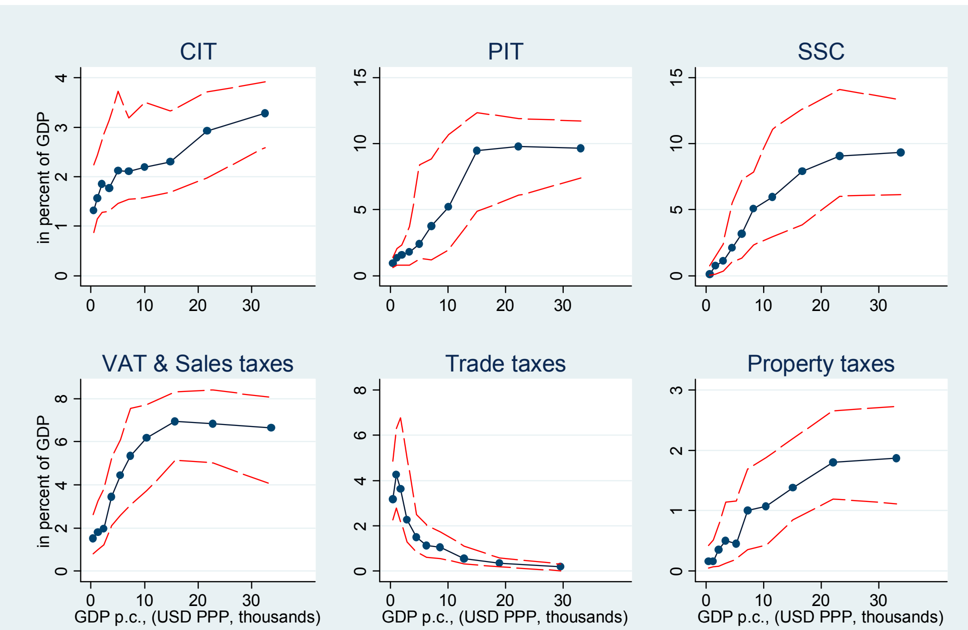
[12] See Ram (1987) for details.

[13] Direct taxes denote income taxes (personal, social security, and corporate income taxes), while indirect taxes denote consumption and property taxes.

When inspecting the overall tax burden at a more disaggregated level (Figure 2) the following facts arise:

- Corporate income taxes (CIT) increase with income, but less so than personal income taxes (PIT) or social security contributions (SSC). Differences among the latter two taxes across income groups are significant: for those countries in the top three deciles, collection of PIT and SSC is about 9.7 and 8.8 percent of GDP, respectively, whereas countries in the three lowest deciles collect only about 1.3 and 0.7 percent of GDP for the same two taxes, respectively.
- Value added tax (VAT) and sales taxes also increase with income, yet differences across income groups are relatively less significant than say the PIT or SSC.
- Trade taxes significantly decrease with the level of development, a fact that has been noted elsewhere (e.g., IMF, 2011; Baunsgaard and Keen, 2010).
- Property tax revenue also trends upwards with income, yet this trend is less pronounced than that in the case of PIT and SSC. The overall contribution of this tax is relatively modest, even for the highest income decile in the sample.

Figure 2. Tax Revenue and Income Levels: Disaggregated Analysis

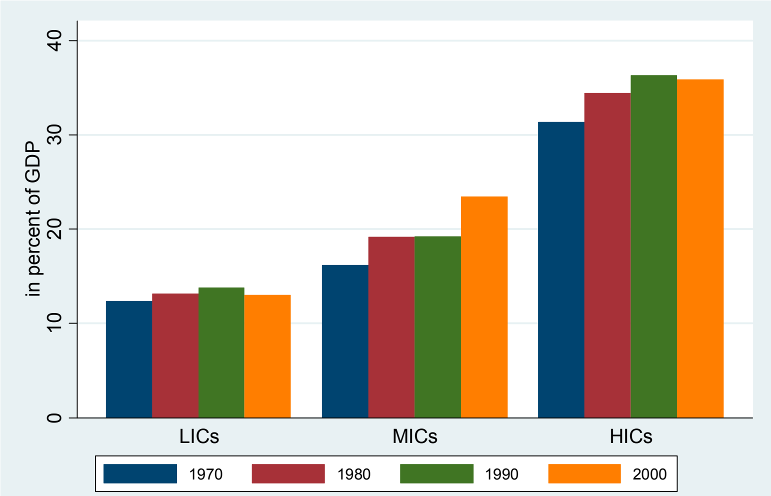


Note: Median value for each income decile; bounds: 25 and 75 percentile
Source: WEO, GFS, OECD, UN

These significant differences in the degree of taxation for different income levels, suggests the importance of studying the relation between the tax structure and growth dividing the full sample into groups as follows: high-income countries (HICs), middle-income countries (MICs), and low-income countries (LICs). Figure 3 summarizes the evolution of total tax revenue for each group over the last four decades (1970-2009), with each bar representing the median level of total tax revenue, in percent of GDP, for the respective group and decade. Only the MICs and

HICs groups show a significant increase over time in tax collection. Differences in the level of taxation, however, are quite noticeable. For instance, on average, taxes in LICs account for roughly 13 percent of GDP, which is only a third of what is collected in HICs (over 35 percent of GDP).

Figure 3. Long-Run Trends in Total Tax Revenue



Note: 10-year group median; 1970 refers to the median of 1970-79 and so forth
Source: GFS, OECD, UN

Figure 4, below, presents similar charts but for each sub-category of tax revenue. The main observations of the changes over time and across income groups are akin to those of Figure 2. For direct taxes, in all three groups, there is an upward trend in SSC over time, with CIT exhibiting a similar pattern, though to a lesser degree. There is also a little discernible trend in the case of the PIT across countries. For indirect taxes, there is an upward trend in VAT and sales taxes in all groups, while trade taxes exhibit the opposite pattern. The latter occurs even for HICs where the contribution of trade taxes to revenue in the 1970s was already relatively low. In addition, property taxes are notably low in the case of LICs and MICs, yet even for HICs the overall yield of this type of taxation appears to be moderate.

The main focus of our regression analysis is on the composition of taxes and Figure 5 shows how it varies over time for each country group. Each tax component in Figure 5 is expressed as a share of total tax revenue. The figure shows the significant differences in the composition of taxes between direct (income taxes) and indirect taxes (consumption taxes and property taxes). Specifically, HICs rely much more on direct taxes than lower-income countries: only about one-third of total taxation is due to income taxes in the case of LICs, whereas between a half and two-thirds of total tax revenue is due to income taxes in the cases of MICs and HICs, respectively.

Figure 4. Trends in Tax Revenue: Disaggregated Analysis

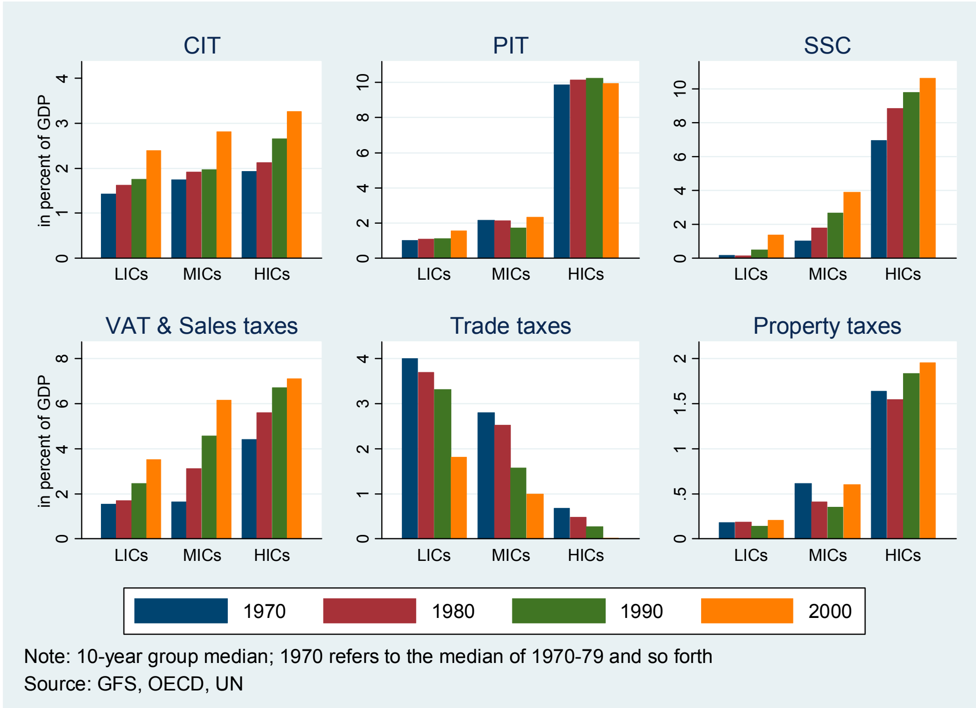
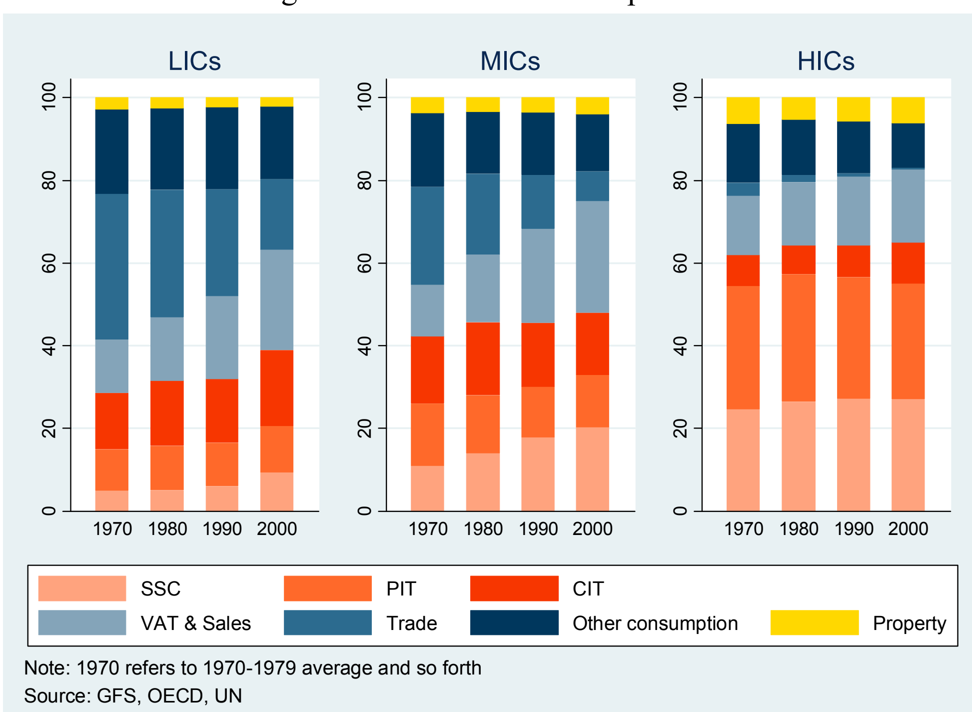


Figure 5. Trends in Tax Composition



IV. EMPIRICAL STRATEGY

In order to estimate the relation between tax composition and growth, we first divide total tax revenue into two broad categories: aggregate income taxes and aggregate consumption and property taxes. We then estimate how changes in the composition between the two affect growth. We also consider a further disaggregation of each broad category to analyze the effects on growth of changes in the different sub-components.[14] After this we divide the sample into high, middle, and low-income countries to determine how robust results are to cross-country differences in income levels.

Tax data for the 21 HICs are relatively complete: there are usually no missing observations across time and tax categories. Tax data for MICs and LICs are less comprehensive in the detailed components, yet large enough to undertake estimations for broad tax categories. In any case, we only consider those countries with at least 20 years of observations on total tax revenue, since the time span of the dataset should be 'long enough' to analyze the long-run effects of tax composition on growth.[15] For basic control variables, we also include population growth, and measures of physical and human capital.

The specification of our econometric model, including control variables and the classification of taxes, builds on Arnold et al (2011). However, we consider the growth rate of GDP per capita rather than the associated per capita income level of the economy as studied by them. The empirical model then takes the following error correction form: [16 17]

$$\begin{aligned}\Delta g_{i,t} &= -\phi(g_{i,t-1} - \alpha_1 I_{i,t-1} - \alpha_2 \ln h_{i,t-1} - \alpha_3 n_{i,t-1} - \alpha_4 \cdot T_{i,t-1} - \sum_{j=5}^{m} \alpha_j \cdot TC^j{}_{i,t-1}) \\ &\quad + \beta_{1,i}\Delta I_{i,t} + \beta_{2,i}\Delta \ln h_{i,t} + \beta_{3,i}\Delta n_{i,t} + \beta_4 \Delta T_{i,t} - \sum_{j=5}^{m} \beta_j \cdot \Delta TC^j{}_{i,t} + \gamma_i \cdot t + \eta_i + \varepsilon_{i,t},\end{aligned} \tag{1}$$

[14] See Annex II for definitions of tax categories. These are essentially consistent with Arnold et al (2011)'s paper with one exception: whereas we separate SSC and taxes on payroll and workforce from taxes on income, profits, and capital gains payable by individuals, Arnold et al (2011) refers to the sum of all the three sub-categories as PIT.

[15] Specifically, if a country has aggregate income taxes data for more than 20 years but not for their sub-components, we use the country to estimate the growth impact of changes in aggregate income taxes, but the country is then excluded from those specifications which involve more detailed sub-components.

[16] The residuals of the different estimated equations presented below have been tested for non-stationarity, using Fisher-type of panel unit root tests: augmented Dickey-Fuller and Phillip-Perron tests. These tests allow for gaps in the data that can handle unbalanced panels, as in our case. Each of these tests strongly rejects the non-stationarity of the residuals at 1 percent of significance level (the null hypothesis for these Fisher-type of tests is that all panels contain unit roots).

[17] See Annex III for a brief discussion on the advantages of estimating models of the error-correction form.

where g is the GDP per capita growth rate (log difference of GDP per capita) for country i at year t; I is the investment ratio; h is the average years of schooling;[18] n is population growth; T is total tax revenue as a share of GDP;[19] TC denotes a vector of tax-composition variables, expressed as a share of total tax revenue, which vary depending on which tax components are considered in the respective equation. A country-specific linear time trend and intercept is also included. A merit of the above error correction form is that it separates and simultaneously estimates the long-run equilibrium relation and its associated short-run adjustment dynamics: the first-difference terms in equation (1) capture short-run dynamics, whereas the expression in parentheses, i.e., the error correction term, captures the long-run linear equilibrium relation.[20]

We use a Pooled Mean Group (PMG) estimation approach to estimate equation (1), as proposed by Pesaran et al (1999). The PMG estimator is a useful intermediate procedure between two extreme methods often used to analyze dynamic panel models: Mean Group (MG) estimator and Dynamic Fixed Effect (DFE) estimator. At one end, the DFE estimator imposes the strong homogeneity assumption that all the long-run and short-run coefficients and error variances are the same across countries. At the other end, the MG model estimates the long-run and short-run coefficients separately for each country and examines the distribution of country-specific estimates, usually the average. The PMG, an intermediate case between these two, allows for short-run coefficients and error variances to differ across countries, but constrains the long-run coefficients to be the same across them. As a result, the PMG estimators provide more efficient estimates than the MG approach, while addressing cross-country heterogeneity in short-run dynamics. For completeness, we also report MG and DFE estimates along with PMG estimates.

As the focus of our study is on the growth effects of changes in tax composition rather than on the overall tax level, all tax variables are expressed as a share of total tax revenue. Since total tax revenue (as a share of GDP) is also taken as a control variable, any change in one tax component should be equally offset by a change in other component to keep the overall tax burden unchanged. In light of this and following Arnold et al (2011), we then omit one tax component at a time in the regression, to interpret the estimated coefficient as the effect of a shift from the omitted variable to the relevant variable under consideration. For instance, we exclude aggregate consumption and property taxes in each equation when estimating the growth impact of changes in income taxes, and vice versa. In this case the rationale is that changes in income taxes are offset by changes in consumption and property taxes in the opposite direction, while keeping the overall tax revenue collection unchanged. This implies that the tax-policy change is undertaken in a context of revenue neutrality.

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[18] We use the average years of schooling for population aged between 25 and 64 as a proxy for investment in human capital. The average years-of-schooling data is calculated using the Barro and Lee (2010) database, which provide data on education attainment at 5-year intervals. The missing years are imputed by linear interpolation.

[19] Total tax revenue is included as a control variable, implying that any change in a tax component should be offset by an equivalent change in another component to leave total tax revenue as a share of GDP unchanged.

[20] GDP per capita, gross fixed capital formation and population growth data are obtained from the World Bank World Development Indicators database.

V. TAX COMPOSITION AND GROWTH I: FULL SAMPLE

Table 1 presents the PMG estimates of the long-run coefficients. Columns (1) and (2) report results of an increase in income taxes compensated through a reduction in consumption and property taxes. Consumption and property taxes are omitted as indicated at the bottom of the table. Hence, according to column (1), a percentage point increase in the income-tax share offset by a reduction in the share of consumption and property taxes is associated with a decrease in the long-run growth rate of GDP per capita by 0.07 percentage points.

Column (2) considers a similar exercise, but disaggregates personal income taxes (PIT), corporate income taxes (CIT), and social security contributions (SSC). The coefficients for all three sub-components are negative, yet only the coefficients on PIT and SSC are significant: a percentage point increase in either SSC or PIT, while reducing consumption and property taxes by the same amount, is associated with a slowdown in growth of 0.17 or 0.14 percentage points, respectively. We also find that the effect of the CIT is somewhat weaker and sensitive to the specification considered in the model.[21]

Columns (3) to (6) summarize the relation between consumption and property taxes and growth. As noted in the table, income taxes are excluded from the estimation. Consistent with column (1), the coefficient on aggregate consumption and property taxes in column (3) is positive and significant, suggesting that a shift from income taxes to consumption and property taxes by one percentage point would be associated with an increase in long-run per capita growth of 0.04-0.07 percentage points.

Column (5) in turn shows that increasing the property-tax share while reducing income taxes is also associated with faster growth, whereas the evidence for consumption taxes, at least at its aggregate level, is somewhat weaker. When disaggregating the latter into VAT and sales taxes (combined), trade taxes, and the rest of consumption taxes a different picture takes place.[22] We find that the coefficient on VAT and sales taxes is positive and significant, implying that a percentage point increase in these taxes accompanied by a reduction of income taxes is associated with a 0.1 percentage point increase in long-run growth. On the other hand, we do not find a significant relation between growth and trade taxes in the full sample case—the reason could be associated with the fact that trade taxes have different effects on growth for different country groups, as shown in Section VI.

As mentioned, the PMG estimation method is an intermediate procedure between mean group (MG) and dynamic fixed effect (DFE) estimators. While the PMG estimator yields efficient and consistent estimates when the homogeneity assumption on long-run parameters is valid, it is inconsistent if the true model is heterogeneous. To test the difference between these models' estimates of the long-run coefficients we perform a Hausman test. Comparing MG and PMG, in

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[21] See section VI for details.

[22] In estimating the model we use the tax category of general taxes on goods and services (GFS), which include other general taxes on goods and services as well as VAT and sales taxes; the size of other general taxes is quite small, and general taxes mostly consist of VAT and sales taxes.

every regression equation, the Hausman test strongly suggests that we cannot reject the homogeneity assumption on the long-run coefficients—the p-values are very high for all specifications. Accordingly, we can conclude that the PMG estimator seems to be preferred to the MG estimator.[23]

For completeness, however, we also present MG and DFE estimates in Table 2. Although coefficients are often different in size across models, they are generally consistent in their sign and statistical significance.[24] They usually have the proper signs and are significant in all three models: at the aggregate level, a shift from consumption and property taxes to income taxes is associated with slower growth.[25] In a more detailed decomposition, all three estimation methods suggest that there is a negative association between SSC and growth; and that VAT and sales taxes consistently have a positive and significant effect on growth.

VI. Tax Composition and Growth II: High, Middle and Low-Income Countries

One of the main observations in Section III was that countries with different income levels have different tax burdens and tax structures. To further investigate whether this relation varies with the degree of development, we now conduct a similar analysis considering each country group separately.

Table 3 summarizes results. Similar to the full-sample case, we obtain negative and significant coefficients on income taxes for both HICs and MICs: raising income taxes while reducing consumption and property taxes is growth reducing. The size of coefficients for both groups is bigger than in the full-sample case: a percentage point increase in income taxes is associated with a slowdown in growth by about 0.1 percentage points. Similar to the full-sample case, both HICs and MICs show a negative relation between income taxes and growth that appears to be driven by social security contributions and personal income taxes, rather than by corporate income taxes. This can be seen by noticing that the coefficients on PIT and SSC are negative, significant and larger in absolute value than that of CIT, which tends to be non-significant.[26]

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[23]Notice that the Hausman test has a relatively low power in this case (Pesaran et al, 1999). This suggests that the Hausman test may fail to reject the null hypothesis even when this is false. This concern is also noted in Gemmell et al (2011) and Xing (2012).

[24] The size of coefficients of PMG and DFE models are within a similar range, whereas the MG estimates are much larger—both the coefficients and standard errors. This is not surprising because MG model estimates both long-run and short-run coefficients with only the limited observations in each country's time series.

[25] There is one exception when comparing consumption taxes and property taxes in row (3). The PMG estimate of the coefficient on property taxes is positive and significant, whereas the coefficient on consumption taxes is not significant. However, the MG and DFE coefficients on consumption taxes are positive and significant, whereas those on property taxes are not.

[26] For HICs, we examine whether results are robust to the use of different data sources. While we find that coefficients on SSC and PIT are always negative and significant regardless of the source, the coefficient on CIT becomes negative and significant when OECD data are used instead—it was not significant with WDI's macro variables were used. When OECD data are considered in combination with Barro and Lee (2010)'s human capital variable, Wald tests still strongly suggest that SSC and PIT have a significantly stronger negative relation with

(continued…)

Table 4 presents the growth impact of the tax shift in opposite direction: from income taxes towards consumption and property taxes. For HICs, we have a positive and significant coefficient on consumption and property taxes, and the absolute size of the coefficient is similar to the one for aggregate income taxes in column (1) of Table 3. When we separate consumption and property taxes for HICs, results remain as in the full-sample case: property taxes have a stronger association with growth than consumption taxes.[27] [28] We also find, as in the full-sample case, that the coefficient on VAT and sales taxes is positive and significant: a percentage point shift from income taxes to VAT and sales taxes boosts growth by about 0.2 percentage points over the long run.

The coefficient on consumption and property taxes (combined) for MICs is positive, yet non-significant, which conflicts with the negative and significant coefficient on aggregate income taxes shown in Table 3. Similar to HICs, however, when property taxes are separated from consumption taxes in column (5), we find that they have a strong relation with growth. The coefficient on consumption taxes, on the other hand, is still not significant for MICs, suggesting an ambiguous growth impact of consumption taxes on growth. A more detailed decomposition shown in column (8) provides a plausible explanation for this. The coefficient on two of the major components, VAT and sales taxes and trade taxes, are both significant but with opposite signs: a positive coefficient on VAT and sales taxes and a negative coefficient on trade taxes. These two major components of consumption taxes working in opposite directions might render the aggregate effect of consumption taxes ambiguous for MICs.

For LICs, however, we did not find a significant association between economic growth and most of the tax-structure variables studied here. We tentatively associate this finding with the poor quality of tax administration and tax enforcement in many of these economies. These facts have probably been reflected in the relatively poorer empirical association between tax policy variables and growth in this subsample.

VII. Endogeneity Checks

There are several shortcomings in regressing growth equations that include tax-policy variables, related to measurement errors, omitted variables and endogeneity problems, to name just a few. These problems would bias results, thus limiting the explanatory power of the econometric

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growth than the CIT. It is only when we use Arnold et al (2007)'s human capital variable that we cannot reject the hypothesis that the CIT has similar effects on growth as SSC and PIT.

[27] A standard Wald test strongly rejects the null hypothesis that the coefficient on consumption taxes equals that on property taxes (p-value of 0.015).

[28] Regardless of which data sources are used (WDI or OECD for macro variables, and Arnold et al (2007) or Barro and Lee (2010) for human capital data), we consistently find that property taxes have significantly stronger association with growth than consumption taxes: the size of coefficient on property taxes is always greater than that of consumption taxes, and standard Wald test rejects the hypothesis that there is no significant difference between consumption and property taxes.

analysis. The endogeneity problem, in particular, makes it difficult to interpret the estimated coefficients as impact of tax policy on growth, because of the simultaneous relation between the two—not only the tax burden affects growth, but also changes in GDP growth may induce changes in the tax level or its associated structure. The estimated coefficients then might suffer from simultaneous-equation bias and capture merely the correlation between the two, rather than the causal effect of tax changes on growth.

The most likely source of this problem is Wagner's law. While it suggests that regressions considering aggregate income levels are likely to suffer from endogeneity problems, it appears to be less of a concern in regressions considering growth rates of GDP per capita (Kneller et al, 1999), like ours. By taking first differences, i.e., using growth rates, we control for the country-specific, income-level factor that affects tax structures. Nevertheless, in consideration of this potential short-coming, we take the following approach. First, we examine the relevance of the problem in our estimation in a country by country basis. We then check whether our main results remain robust after excluding those countries that seem to be driving the endogeneity problem.

A minimum requirement to interpret results as causal effects of tax changes on growth is that the tax variables should be at least weakly exogenous relative to the estimated long-run coefficients. In this regard, we adopt the method used by Calderon et al (2011) for testing weak exogeneity in a PMG-estimation context.[29] [30] Specifically, weak exogeneity in our model implies that changes in tax variables should not react to deviations from the long-run equilibrium relation estimated in equation (1).

Accordingly, we test the significance of the coefficients on the error correction terms, δ_i, in the following system of marginal models:[31]

$$\begin{aligned}
\Delta T_{i,t} &= \delta_i (g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 \ln h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 \cdot T_{i,t-1} - \sum_{j=5}^{m} \hat{\alpha}_j \cdot TC^{j}{}_{i,t-1}) + \varepsilon_{i,t}, \\
\Delta CIT_{i,t} &= \delta_i (g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 \ln h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 \cdot T_{i,t-1} - \sum_{j=5}^{m} \hat{\alpha}_j \cdot TC^{j}{}_{i,t-1}) + \varepsilon_{i,t}, \\
\Delta PIT_{i,t} &= \delta_i (g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 \ln h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 \cdot T_{i,t-1} - \sum_{j=5}^{m} \hat{\alpha}_j \cdot TC^{j}{}_{i,t-1}) + \varepsilon_{i,t}, \\
\Delta SSC_{i,t} &= \delta_i (g_{i,t-1} - \hat{\alpha}_1 I_{i,t-1} - \hat{\alpha}_2 \ln h_{i,t-1} - \hat{\alpha}_3 n_{i,t-1} - \hat{\alpha}_4 \cdot T_{i,t-1} - \sum_{j=5}^{m} \hat{\alpha}_j \cdot TC^{j}{}_{i,t-1}) + \varepsilon_{i,t},
\end{aligned} \tag{2}$$

where the terms in parentheses are the estimated long-run equilibrium errors derived from equation (1). We estimate the system of equations on a country by country basis using the seemingly unrelated regression equation estimator proposed by Zellner (1962). With these

[29] This approach is first proposed by Johansen (1992) and Boswijk (1995).

[30] Gemmell et al (2012) follow a similar approach to test for weak exogeneity in a paper that studies the composition of government expenditure and economic growth.

[31] See Calderon et al (2011) for details.

estimates, we then test the null hypothesis that the coefficients on the error terms are jointly zero using a Wald test at a 5 percent of significance level. If the null hypothesis is rejected, this would imply that the associated tax variables react to deviations from the long-run relation, thus suggesting that the particular country under consideration violates the weak exogeneity condition.[32] Table 5 shows the number of countries that seem to violate this condition. Taking this into account, and as a way of testing the robustness of our results, we carry out a similar analysis as before after excluding those 'problematic' countries.

As can be seen in Table 6, the main results remain similar to those before the exclusion (see Table 1). In column (1), the coefficient on income taxes is negative and significant, suggesting again the existence of a negative association between the increase in the income-tax share and economic growth; conversely, the positive coefficient in column (3) suggests that increases in the share of consumption and property taxes are associated with faster growth. The size of the coefficients on aggregate income taxes and consumption and property taxes are slightly smaller in absolute terms after the exclusion, whereas the standard errors are larger—this is not surprising, however, given that we lose over 400 and 200 observations, respectively, in each estimation. What is most important is that these coefficients remain significant and properly signed.

Our results remain robust when considering a more granular decomposition as well. The coefficients on PIT and SSC are both negative and significant, while that on the CIT remains insignificant. We also find that between consumption and property taxes, the former have a relatively stronger positive association with growth, which is mostly driven by other property taxes. Finally, the coefficient on VAT and sales taxes remain positive and significant. Table 7 and Table 8 present similar estimations by country groups. In short, the main results remain robust to the exclusion of those countries that seem to be driving the potential endogeneity problem.

VIII. Concluding Remarks

This paper investigates empirically the relation between changes in the tax structure and long-run growth, a topic extensively studied for high-income countries (e.g., Kneller et al, 1999; Gemmell et al, 2011; and Arnold et al, 2011). We contribute to this literature, however, by extending the analysis in two ways. First, we construct a large and comprehensive dataset covering 69 countries with a wide range of income levels to obtain more general results. Second, while we adopt the estimation approach considered in Arnold et al (2011), we consider the long-run effects of changes in the tax composition on the GDP per capita growth rate, rather than on the long-run GDP per capital level as considered by them.

Turning to our main results, we find that a shift from consumption and property taxes to income taxes is negatively associated with long-run growth. In particular, we find that higher SSC and

[32] Although the system in equation (2) is specified only for the estimation related to the PIT, CIT, and SSC, we test these marginal models for the full set of components considered in the analysis.

PIT shares in total taxation exhibit a stronger negative association with growth relative to the CIT, and this result is quite robust to different data sources and model specifications.

We also find that a shift from income to property taxes has a more significant and positive association with long-run growth than a shift to consumption taxes. In the disaggregation of consumption taxes, however, we also find a robust and positive association between VAT and sales taxes on growth. While we consistently find these results to hold in high and middle-income countries, we did not find strong evidence on the significance of shifts in the tax composition and economic growth in the case of low-income countries.

In an effort to address potential endogeneity problems, we followed the approach taken by Calderon et al (2011) to test for the weak exogeneity of the tax variables. After excluding those countries that may suffer from this potential problem, we find that our main results remain essentially unchanged. Although this strategy is useful and intuitive, it does not obviate the need for a more thorough and comprehensive method to address endogeneity issues. Hence, we plan to address this concern more extensively in future work through the use of system GMM estimation techniques and IV methods.

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Table 1. Estimation Results, Full Sample

Dependant Variable:	Income taxes		Consumption and property taxes		
△ log GDP p.c.	(1)	(2)	(3)	(4)	(5)
Baseline model					
Physical capital	0.053***	0.026	0.040**	0.031	0.057**
	(0.019)	(0.024)	(0.020)	(0.021)	(0.023)
Human capital	0.024**	0.039**	0.023**	0.032***	0.013
	(0.011)	(0.016)	(0.011)	(0.011)	(0.012)
Population growth	-1.549***	-1.572***	-1.600***	-1.708***	-1.791***
	(0.147)	(0.148)	(0.150)	(0.153)	(0.168)
Control variable					
Overall tax burden	-0.062**	-0.073***	-0.076***	-0.061**	-0.098***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.030)
Tax structure variables					
Income taxes	-0.065***				
	(0.017)				
Personal Income taxes		-0.140***			
		(0.025)			
Social Security Contributions		-0.169***			
		(0.027)			
Corporate income taxes		-0.005			
		(0.023)			
Consumption and property taxes			0.044***		
			(0.017)		
Consumption taxes				0.027	
				(0.018)	
VAT& Sales taxes					0.103***
					(0.027)
Trade taxes					-0.029
					(0.029)
Other consumption taxes					0.054*
					(0.030)
Property taxes				0.242***	0.248***
				(0.056)	(0.061)
Observations	2,092	1478	2,092	1,872	1,504
Omitted tax variable	Consumption and property taxes		Income taxes		

Note: *Significant at 10% level; ** at 5% level; *** at 1% level. Standard errors are in brackets. Overall tax revenue is expressed as a share of GDP, and tax structure variables are expressed as a share of total tax burden. All equations include short-run dynamics, but only the long-run coefficient estimates are reported.

Table 2. Comparing Estimation Methods: PMG, MG, and DFE Estimates

Regression		Coefficients (S.E.)		
		PMG	MG	DFE
(1)	Income taxes	-0.065***	-0.170*	-0.038**
		(0.017)	(0.087)	(0.017)
	Hausman test: PMG vs. MG	chi2(5) = 1.330, p-value = 0.931		
(2)	PIT	-0.140***	-0.440	-0.046
		(0.025)	(0.420)	(0.029)
	SSC	-0.169***	-0.925***	-0.083**
		(0.027)	(0.316)	(0.033)
	CIT	-0.005	0.034	-0.054**
		(0.023)	(0.109)	(0.025)
	Hausman test: PMG vs. MG	chi2(7) = 1.330, p-value = 0.931		
(3)	Consumption and property taxes	0.044***	0.170**	0.037**
		(0.017)	(0.086)	(0.017)
	Hausman test: PMG vs. MG	chi2(5) = 1.330, p-value = 0.931		
(4)	Consumption taxes	0.027	0.360*	0.038**
		(0.018)	(0.193)	(0.018)
	Property taxes	0.242***	2.379	0.062
		(0.056)	(1.969)	(0.068)
	Hausman test: PMG vs. MG	chi2(6)= 1.330, p-value = 0.931		
(5)	VAT & Sales taxes	0.103***	0.863*	0.056**
		(0.027)	(0.470)	(0.023)
	Trade taxes	-0.029	-0.728	0.025
		(0.029)	(0.899)	(0.023)
	Other consumption taxes	0.054*	-0.271	0.001
		(0.030)	(0.717)	(0.027)
	Property taxes	0.248***	3.103	0.068
		(0.061)	(1.908)	(0.066)
	Hausman test: PMG vs. MG	chi2(8) = 1.330, p-value = 0.931		

Note: We only report the long-run coefficients of tax-composition variables. All the estimation equations in this table is the same as the ones in Table 1, except that different assumptions are imposed on long-run and short-run coefficients depending on estimation methods, PMG, MG, and DFE.

Table 3. Estimation Results, The Income-Tax Share and Growth, HICs, MICs, and LICs

Dependant Variable: Δ log GDP p.c.	Income taxes			PIT / SSC / CIT		
	HICs	MICs	LICs	HICs	MICs	LICs
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline model						
Physical capital	0.087**	0.044	0.064*	0.043	-0.003	0.055
	(0.036)	(0.036)	(0.033)	(0.037)	(0.044)	(0.048)
Human capital	0.063**	0.097***	0.009	0.089***	0.091***	-0.057**
	(0.031)	(0.029)	(0.015)	(0.031)	(0.026)	(0.025)
Population growth	-1.750***	-0.021***	-0.001	-1.785***	-1.589***	-0.368*
	(0.191)	(0.004)	(0.003)	(0.190)	(0.313)	(0.477)
Overall tax revenue	-0.031	-0.076	-0.057	-0.049	-0.010	-0.171
	(0.035)	(0.063)	(0.065)	(0.034)	(0.065)	(0.135)
Tax structure variables						
Income taxes	-0.149***	-0.105***	0.016			
	(0.031)	(0.036)	(0.028)			
PIT				-0.197***	-0.247***	0.077
				(0.033)	(0.057)	(0.091)
SSC				-0.199***	-0.248***	0.185*
				(0.034)	(0.066)	(0.102)
CIT				0.009	-0.066*	-0.012
				(0.048)	(0.038)	(0.046)
Observations	778	665	649	722	478	278
Omitted tax variable	Consumption and property taxes					

Note: *Significant at 10% level; ** at 5% level; *** at 1% level. Standard errors are in brackets. Overall tax revenue is expressed as a share of GDP, and tax structure variables are expressed as a share of total tax burden. All equations include short-run dynamics, but only the long-run coefficient estimates are reported.

Table 4. Estimation Results, The Consumption-and-Property-Tax Share and Growth, HICs, MICs, and LICs

Dependant Variable: Δ log GDP p.c.	Consumption and Property taxes			Consumption taxes / Property taxes			VAT & Sales / Trade taxes		
	HICs	MICs	LICs	HICs	MICs	LICs	HICs	MICs	LICs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Baseline model									
Physical capital	0.087**	0.018	0.044	0.093**	0.001	0.024	0.100***	0.101**	-0.063
	(0.036)	(0.040)	(0.034)	(0.037)	(0.045)	(0.036)	(0.036)	(0.049)	(0.050)
Human capital	0.061**	0.087***	0.010	0.049	0.080***	0.027*	0.015	0.049	0.037**
	(0.031)	(0.030)	(0.016)	(0.030)	(0.031)	(0.015)	(0.032)	(0.038)	(0.016)
Population growth	-1.742***	-0.025***	-0.001	-1.855***	-0.020***	-0.005	-2.133***	-0.017***	-0.017***
	(0.192)	(0.004)	(0.003)	(0.192)	(0.004)	(0.003)	(0.200)	(0.004)	(0.006)
Overall tax revenue	-0.034	-0.140**	-0.013	-0.027	-0.147**	0.054	-0.057*	-0.080	0.269**
	(0.035)	(0.064)	(0.069)	(0.035)	(0.062)	(0.070)	(0.033)	(0.080)	(0.137)
Tax composition variables									
Consumption and property taxes	0.143***	0.039	-0.027						
	(0.031)	(0.034)	(0.027)						
Consumption taxes				0.105***	-0.010	-0.034			
				(0.033)	(0.036)	(0.029)			
VAT& Sales taxes							0.218***	0.082*	-0.055
							(0.045)	(0.043)	(0.050)
Trade taxes							0.199**	-0.230***	-0.107***
							(0.101)	(0.070)	(0.039)
Other consumption taxes							0.025	-0.006	0.006
							(0.042)	(0.065)	(0.055)
Property taxes				0.275***	0.419***	0.138	0.260***	0.130	0.118
				(0.066)	(0.161)	(0.131)	(0.068)	(0.240)	(0.134)
Observations	778	665	649	778	610	484	698	459	347
Omitted tax variable	Income taxes								

Note: *Significant at 10% level; ** at 5% level; *** at 1% level. Standard errors are in brackets. Overall tax revenue is expressed as a share of GDP, and tax structure variables are expressed as a share of total tax burden. All equations include short-run dynamics, but only the long-run coefficient estimates are reported.

Table 5. Test of Weak Exogeneity, The Number of Countries with Potential Endogeneity Problem

		Income taxes				
		Income	PIT vs. SSC vs. CIT	Con. and prop.	Con. vs. Prop.	VAT & Sales vs. Trade
		(1)	(2)	(3)	(4)	(5)
Full-sample	Endo. #	14	18	9	10	23
	Total #	69	47	69	60	49
HICs	Endo. #	2	4	0	1	10
	Total #	21	20	21	21	21
MICs	Endo. #	1	4	2	2	6
	Total #	23	17	23	21	16
LICs	Endo. #	3	4	4	6	6
	Total #	25	10	25	18	12

Note: First row of each category reports the number of countries in which the coefficient on error correction term is statistically significant at 5 percent level in marginal models.

Table 6. Estimation Results, Full Sample, After Excluding Countries with Potential Endogeneity Problem

Dependant Variable:	Income taxes		Consumption and property taxes		
△ log GDP p.c.	(1)	(2)	(3)	(4)	(5)
Baseline model					
Physical capital	0.028	0.041	0.029	0.008	0.078**
	(0.023)	(0.035)	(0.024)	(0.025)	(0.035)
Human capital	0.027**	0.067***	0.025**	0.001	-0.033
	(0.012)	(0.024)	(0.012)	(0.016)	(0.023)
Population growth	-1.357***	-1.660***	-1.508***	-1.609 ***	-1.695***
	(0.190)	(0.244)	(0.161)	(0.161)	(0.228)
Control variable					
Overall tax burden	-0.034	-0.040	-0.067**	-0.068**	-0.044
	(0.033)	(0.040)	(0.029)	(0.030)	(0.034)
Tax structure variables					
Income taxes	-0.046**				
	(0.021)				
Personal Income taxes		-0.168***			
		(0.038)			
Social Security Contributions		-0.173***			
		(0.046)			
Corporate income taxes		-0.023			
		(0.033)			
Consumption and property taxes			0.036*		
			(0.019)		
Consumption taxes				0.023	
				(0.022)	
VAT& Sales taxes					0.169***
					(0.042)
Trade taxes					0.005
					(0.039)
Other consumption taxes					0.048
					(0.042)
Property taxes				0.201***	0.293***
				(0.059)	(0.091)
Observations	1,628	817	1,813	1,607	796
Omitted tax variable	Consumption and property taxes		Income taxes		

Note: *Significant at 10% level; ** at 5% level; *** at 1% level. Standard errors are in brackets. Overall tax revenue is expressed as a share of GDP, and tax structure variables are expressed as a share of total tax burden. All equations include short-run dynamics, but only the long-run coefficient estimates are reported.

Table 7. Estimation Results, The Income-Tax Share, HICs, MICs, and LICs, After Excluding Countries with Potential Endogeneity Problem

Dependant Variable: Δ log GDP p.c.	Income taxes			PIT / SSC / CIT		
	HICs	MICs	LICs	HICs	MICs	LICs
	(1)	(2)	(3)	(4)	(5)	(6)
Baseline model						
Physical capital	0.033	0.045	0.033	0.094**	-0.074	0.014
	(0.040)	(0.036)	(0.038)	(0.042)	(0.048)	(0.064)
Human capital	0.109***	0.085***	0.002	0.117***	0.070***	-0.059
	(0.035)	(0.029)	(0.016)	(0.033)	(0.024)	(0.052)
Population growth	-1.663***	-2.131***	-0.053	-1.844***	-1.228***	0.318
	(0.223)	(0.359)	(0.341)	(0.204)	(0.321)	(0.760)
Overall tax revenue	-0.037	-0.105*	-0.005	-0.051	0.020	0.155
	(0.043)	(0.063)	(0.069)	(0.035)	(0.072)	(0.146)
Tax structure variables						
Income taxes	-0.119***	-0.089**	0.028			
	(0.036)	(0.036)	(0.034)			
PIT				-0.207***	-0.327***	0.475**
				(0.034)	(0.058)	(0.214)
SSC				-0.221***	-0.180**	-0.077
				(0.035)	(0.077)	(0.200)
CIT				-0.014	-0.084**	0.043
				(0.055)	(0.039)	(0.056)
Observations	702	647	560	608	357	154
Omitted tax variable	Consumption and property taxes					

Note: *Significant at 10% level; ** at 5% level; *** at 1% level. Standard errors are in brackets. Overall tax revenue is expressed as a share of GDP, and tax structure variables are expressed as a share of total tax burden. All equations include short-run dynamics, but only the long-run coefficient estimates are reported.

Table 8. Estimation Results, The Consumption-and-Property-Tax Share, HICs, MICs, LICs, After Excluding Countries with Potential Endogeneity Problem

Dependant Variable: Δ log GDP p.c.	Consumption and Property taxes			Consumption taxes / Property taxes			VAT & Sales / Trade taxes		
	HICs	MICs	LICs	HICs	MICs	LICs	HICs	MICs	LICs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Baseline model									
Physical capital	0.087**	0.014	0.008	0.099***	-0.043	-0.012	0.085**	-0.158**	-0.106
	(0.036)	(0.040)	(0.039)	(0.038)	(0.051)	(0.053)	(0.043)	(0.068)	(0.110)
Human capital	0.061**	0.073**	0.002	0.020	0.070**	-0.030	-0.054	-0.019	-0.035
	(0.031)	(0.030)	(0.017)	(0.031)	(0.032)	(0.043)	(0.040)	(0.035)	(0.054)
Population growth	-1.742***	-0.024***	0.000	-1.994***	-0.020***	0.003	-2.369***	-0.017***	0.011
	(0.192)	(0.004)	(0.003)	(0.199)	(0.004)	(0.004)	(0.250)	(0.005)	(0.010)
Overall tax revenue	-0.034	-0.168***	0.045	-0.029	-0.168**	0.203	-0.061	-0.155	0.201
	(0.035)	(0.064)	(0.072)	(0.036)	(0.066)	(0.135)	(0.041)	(0.097)	(0.239)
Tax composition variables									
Consumption and property taxes	0.143***	0.024	-0.046						
	(0.031)	(0.034)	(0.031)						
Consumption taxes				0.103***	-0.035	-0.021			
				(0.033)	(0.036)	(0.051)			
VAT& Sales taxes							0.257***	0.086	0.018
							(0.057)	(0.080)	(0.087)
Trade taxes							0.076	0.080	-0.020
							(0.111)	(0.095)	(0.074)
Other consumption taxes							-0.002	-0.048	-0.057
							(0.046)	(0.083)	(0.085)
Property taxes				0.278***	0.427**	0.113	0.300***	1.091***	0.092
				(0.067)	(0.173)	(0.172)	(0.092)	(0.304)	(0.232)
Observations	778	629	535	740	564	304	365	317	155
Omitted tax variable	Income taxes								

ANNEX I. CONSTRUCTION OF THE GFS DATASET

The GFS dataset for the whole 1970-2009 period is compiled according to the following steps in combination with a number of simplifying assumptions, as described below:

- All historical data available in both GFSM1986 and GFSM2001 methodologies starting in 1970 through 2010 were retrieved, both for expenditure and revenue, for all countries that reported data to the IMF's GFS yearbook during that period.[33]
- The conversion guideline stated in Wickens (2002) was applied to 'map' the different public finance concepts under the two methodologies.[34] With these mapping rules in hand the different expenditure and revenue items of the GFSM1986 classification were re-classified according to the GFSM2001 nomenclature.
- Given differences in data reporting—mostly accrual in GFSM2001 yet only cash basis in GFSM1986—the following rules were applied: whenever an observation was reported in accrual basis that data point was included. Otherwise, information in cash basis was taken when available.
- Since GFSM1986 reports information for the CCG level but not for the CGG level, the newly-created GFS dataset refers only to the CCG level.
- The remaining macroeconomic variables used in compiling the dataset–e.g., GDP and exchange rates–were taken from either the World Economic Outlook (WEO) or the International Financial Statistics (IFS) databases of the IMF.
- In raw form, the dataset covers 149 countries that reported at least five years of data on total revenue and expenditure for the whole 1970-2010 period.[35]

[33] Although information is generally available from 1972 onwards, for advanced economies different key variables have been reported starting in 1970.

[34] For instance, in the case of the functional classification of expenditure the GFSM1986 methodology provides 14 categories whereas the GFSM2001 methodology provides only 10 categories. In this case IMF (2002) guidelines provide the basis to 'map' these 14 GFSM1986 functional categories into the 10 GFSM2001 categories.

[35] The number of countries decreases to 91 when considering only those that reported data for more than 20 years.

ANNEX II. DEFINITION OF TAX VARIABLES

The tax variables used in the regressions are defined as follows—GFSM2001 classification codes in parenthesis:

- Total tax revenue: total tax revenue (11) is included in regression as a percent of GDP.
- Income taxes: this includes taxes on income, profits, and capital gains (111), Taxes on payroll and workforce (112), and social contributions (12).
- Personal income taxes (PIT): this includes taxes on income, profits, and capital gains payable by individuals (1111).
- Corporate income taxes (CIT): this is taxes on income, profits, and capital gains payable by corporations and other enterprises (1112).
- Social security contributions: this includes social contributions (12) and taxes on payroll and workforce (112).
- Consumption and property taxes: this includes taxes on property (113), taxes on goods and services (114), taxes on international trade and transactions (115), and other taxes (116)
- Consumption taxes: this includes taxes on goods and services (114), taxes on international trade and transactions (115), and other taxes (116). Taxes on goods and services include general taxes on goods and services (1141), excises (1142), profits on fiscal monopolies (1143), taxes on specific services (1144), and taxes on use of goods and on permission to use goods or perform activities (1145).
- VAT and sales taxes: this includes general taxes on goods and services (1141), which include value-added-taxes (11411), sales taxes (11412), and turnover and other general taxes on goods and services (11413).
- Property taxes: this includes taxes on property (113).

ANNEX III. THE UNDERLYING ERROR CORRECTION MODEL

The underlying model of error correction form in equation (1) is an Autoregressive Distributed Lag (ARDL (1,1)) model:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \beta_0 X_t + \beta_1 X_{t-1} + \varepsilon_t, \quad (1)$$

This estimation is motivated by the consideration that current growth rate may be influenced lagged growth and by lagged tax-related variables. Assuming that $|\alpha_1| < 1$, there should be a stable long-run relation between X_t and Y_t at steady states as follows:

$$Y = \alpha_0 + \alpha_1 Y + \beta_0 X + \beta_1 X \quad (2)$$

where X and Y are unconditional expectations of the long-run equilibrium levels. This expression can be further simplified to:

$$Y = \frac{\alpha_0}{1-\alpha_1} + \frac{\beta_0 + \beta_1}{1-\alpha_1} X \quad (3)$$

where the long-run effect of X on Y is captured by the coefficient $\frac{\beta_0 + \beta_1}{1-\alpha_1}$. We can then derive the Error Correction Model (ECM) form directly from equation (3):

$$\Delta Y_t = \alpha_0 + (\alpha_1 - 1) Y_{t-1} + (\beta_0 + \beta_1) X_{t-1} + \beta_0 X_t - \beta_0 X_{t-1} + \varepsilon_t$$

$$\Leftrightarrow \Delta Y_t = (\alpha_1 - 1)\left(Y_{t-1} - \frac{\alpha_0}{1-\alpha_1} - \frac{(\beta_0 + \beta_1)}{1-\alpha_1} X_{t-1} \right) + \beta_0 \Delta X_t + \varepsilon_t \quad (4)$$

Therefore, the ECM is a simple reparameterization of the ARDL (1,1) model. It thus contains the same information as the original ARDL (1,1) form and can be easily estimated with OLS.[36] While the error-correction form in (4) is equivalent to (1) in essence, the advantages of using ECM are as follow:

- An error-correction form readily estimates the long-run equilibrium coefficients as a coefficient on X_{t-1}, without having to derive them as in the ARDL model.
- The error-correction form simultaneously and separately estimates short-term and long-term coefficients and the speed of adjustment to equilibrium ($\alpha_1 - 1$). This is particularly helpful when making different assumptions on short-term and long-rum coefficients. For instance, the error-correction form explicitly models the possibility that some fiscal variables have only short-run effects while others have log-run growth effects (Gemmell et al, 2011).
- Because the dependent variable and the short-run dynamics of the model are taken in first-differences, spurious-regression type of concerns are excluded.

[36] This point is elaborated in Keele and De Boef (2008), in which they argue that the appropriateness of ECMs need not necessarily be linked to cointegration analysis, and thus they may be used with stationary data to a great advantage as well.

ANNEX IV. REGRESSION ANALYSIS CONSIDERING THE OUTPUT LEVEL

Arnold et al (2011) examine the effects of changes in the tax mix on output inspecting 21 OECD countries for the period 1970-2004 using OECD data. Their main findings are:

- An increase in consumption and property taxes, while reducing income taxes, has a positive effect on the long-run GDP level.
- Tax and growth ranking: recurrent taxes on immovable property are the least harmful taxes for the long-run GDP level, followed by consumption taxes, personal income taxes, and corporate income taxes.

In our paper we explicitly modeled the effect of changes in the tax composition on the long-run GDP per capita growth rate. In this annex we estimate how these changes affect the GDP per capita level for the same set of 21 OECD countries examined by Arnold et al (2011), to determine whether their results are robust to different specifications and data sources. Table I in this annex reports the results. We obtain similar findings at the most aggregate level, but we did not find some of their 'tax and growth ranking' results to be robust. There are several possible explanations. First, we extend the sample to the period 1970-2009. Second, instead of using non-linear time control variables (5-year time dummies), we use a linear time trend. Finally, the source of the data is different—whereas we use WDI data for GDP, physical investment and population, and Barro and Lee (2010) for the associated human capital variable, Arnold et al (2011) consider only data provided by the OECD.

Our main findings are summarized below:

- At the aggregate level we find that a shift from consumption and property taxes to income taxes negatively affects the long-run output level, as suggested by the negative coefficient on income taxes in column (2) and the positive coefficient on consumption and property taxes in column (6). This result is similar to Arnold et al (2011)'s result.
- However, we did not find that CIT is the most detrimental tax to long-run output.
- In addition, we did not find that recurrent taxes on immovable property are the least harmful taxes for the level of output. We rather find that the positive effect of property taxes is driven by the other property taxes category. A similar result is found in Xing (2012).

Annex Table 1. Tax Composition and Income Level, in Comparison with Arnold et al (2011)

Dependant Variable: log GDP p.c.	Arnold et al (1)	Updates (2)	Arnold et al (3)	Updates (4)	Arnold et al (5)	Updates (6)	Arnold et al (7)	Updates (8)	Arnold et al (9)	Updates (10)
Baseline model										
Physical capital	0.18***	0.15***	0.25***	0.26***	0.18***	0.15***	0.16***	0.17***	0.21	0.19***
	(0.05)	(0.036)	(0.05)	(0.032)	(0.05)	(0.036)	(0.05)	(0.040)	(0.45)	(0.037)
Human capital	1.19***	0.55***	1.30***	0.51***	1.18***	0.52***	1.4***	0.49***	1.57***	0.42**
	(0.13)	(0.175)	(0.12)	(0.149)	(0.13)	(0.174)	(0.11)	(0.182)	(0.11)	(0.172)
Population growth	-0.08***	-0.11***	-0.08***	-0.04***	-0.07***	-0.11***	-0.07***	-0.11***	-0.07***	-0.12***
	(0.01	(0.022)	(0.01)	(0.009)	(0.01)	(0.022)	(0.01)	(0.023)	(0.01)	(0.024)
Overall tax burden	-0.27***	0.10	-0.24***	-0.32**	-0.26***	0.10	-0.22***	0.15	-0.14***	0.48**
	(0.05)	(0.199)	(0.05)	(0.143)	(0.05)	(0.200)	(0.04)	(0.214)	(0.04)	(0.192)
Tax composition variables										
Income taxes	-0.98***	-1.05***								
	(0.20)	(0.224)								
PIT & SSC			-1.13***	-0.24						
			(0.19)	(0.144)						
CIT			-2.01***	1.05***						
			(0.32)	(0.271)						
Consumption and property taxes					0.93***	1.01***				
					(0.02)	(0.221)				
Consumption taxes							0.74***	0.92***	0.72***	0.80*
							(0.18)	(0.252)	(0.19)	(0.432)
Property taxes							1.45***	1.22**		
							(0.43)	(0.550)		
Immovable property taxes									2.47***	-2.59***
									(0.84)	(0.982)
Other property taxes									-0.34	8.17***
									(0.51)	(1.714)
Observations	696	799	675	780	696	799	696	799	698	764
Omitted tax variable	Consumption and Property taxes				Income taxes					

Note: *Significant at 10% level; ** at 5% level; *** at 1% level. Standard errors are in brackets.

ANNEX V. SUMMARY STATISTICS

Annex Table 2. Summary Statistics of Tax Variables

		Obs	Mean	Std.Dev.	Min	Max	Corr. w/ GDP p.c.	Corr. w/ GDP p.c. growth
Total tax revenue	LICs	739	14.64	5.31	2.50	42.04	0.35***	0.02
	MICs	727	20.11	9.11	4.38	54.63	0.55***	0.05
	HICs	821	34.75	7.84	15.92	52.26	0.36***	-0.06
Income taxes	LICs	739	4.94	3.36	0.21	30.57	0.26***	-0.01
	MICs	727	9.63	6.13	1.29	29.49	0.53***	0.01
	HICs	821	22.16	6.01	7.81	37.49	0.47***	-0.10**
Corporate income taxes	LICs	651	2.36	1.97	0.09	13.76	0.13**	-0.02
	MICs	658	2.82	2.36	0.01	15.59	-0.03	-0.05
	HICs	802	2.80	1.45	0.27	12.76	0.39***	0.06
Personal income taxes	LICs	682	2.37	2.05	0.03	9.85	0.33***	-0.02
	MICs	704	6.55	5.29	0.01	23.93	0.63***	-0.05
	HICs	802	19.47	5.81	7.17	35.65	0.31***	-0.09**
Social security contributions	LICs	451	1.23	1.43	0.00	6.05	0.31***	0.03
	MICs	665	3.77	3.39	0.01	15.47	0.37***	-0.02
	HICs	781	9.20	4.79	0.19	20.61	0.04	-0.07*
Consumption taxes	LICs	739	9.08	3.19	1.74	21.17	0.24***	0.03
	MICs	727	9.69	4.20	1.56	29.45	0.33***	0.07
	HICs	821	10.59	3.24	3.64	17.22	-0.08	0.06
VAT and sales taxes	LICs	581	2.78	1.97	0.01	10.76	0.37***	-0.01
	MICs	649	4.84	3.24	0.00	13.86	0.53***	0.02
	HICs	802	5.77	2.33	0.98	10.36	0.13***	0.04
Trade taxes	LICs	739	3.96	2.47	0.41	14.84	0.087*	0.07
	MICs	700	2.44	2.43	0.00	13.59	-0.34***	0.16***
	HICs	750	0.51	0.48	0.00	5.46	-0.50***	0.07*
Other consumption taxes	LICs	581	2.91	1.56	0.00	8.54	0.05	-0.04
	MICs	622	3.11	2.01	0.05	14.72	0.35***	-0.01
	HICs	731	4.42	1.48	0.41	9.97	-0.21***	0.11**
Property taxes	LICs	647	0.36	0.40	0.00	2.30	0.05	0.01
	MICs	706	0.74	0.70	0.00	3.40	0.44***	0.10*
	HICs	821	1.96	1.00	0.30	7.75	0.27***	-0.07*
Recurrent taxes on immovable property	LICs	98	0.07	0.13	0.00	0.64	0.04	0.00
	MICs	230	0.26	0.24	0.00	1.27	0.10	0.27***
	HICs	788	1.11	1.03	0.00	4.38	0.15***	-0.07
Other property taxes	LICs	163	0.38	0.46	0.00	1.82	0.14	-0.06
	MICs	328	0.72	0.63	0.02	2.87	0.43***	0.21***
	HICs	821	0.90	0.53	0.04	7.55	0.12***	0.03

Note:***p<0.001; general government data for OECD countries, Argentina and Brazil; central government data for remaining countries

Annex Table 3. Summary Statistics of Other Variables

		Obs	Mean	Std.Dev.	Min	Max	Corr. w/ GDP p.c.	Corr. w/ GDP p.c. growth
log(GDP per capita, 2000 constant USD prices)	LICs	739	7.19	0.75	5.39	8.67		
	MICs	727	8.93	0.86	6.97	11.33		
	HICs	821	10.21	0.41	8.87	11.06		
GDP growth rate (percent)	LICs	700	0.01	0.04	-0.21	0.19		
	MICs	701	0.02	0.04	-0.18	0.20		
	HICs	800	0.02	0.02	-0.09	0.11		
Gross fixed capital formation (percent of GDP)	LICs	722	0.21	0.07	0.03	0.49	0.36***	0.32***
	MICs	716	0.22	0.06	0.07	0.46	-0.02	0.25***
	HICs	820	0.21	0.04	0.12	0.32	-0.25***	0.18***
Average years of schooling (pop. aged 25-64)	LICs	739	4.15	2.14	0.35	10.52	0.46***	0.03
	MICs	727	7.23	2.48	1.31	12.32	0.63***	0.09
	HICs	821	9.64	2.06	3.72	13.45	0.65***	-0.14***
Population growth rate	LICs	739	0.03	0.01	-0.01	0.14	0.13***	-0.07
	MICs	727	0.02	0.01	0.00	0.07	-0.35***	-0.08*
	HICs	821	0.01	0.01	-0.04	0.04	-0.17***	-0.09**

Note:***p<0.001