Tax structure and macroeconomic performance

Giampaolo Arachi, Università del Salento and Dondena Centre for Research on Social Dynamics and Public Policy, Italy

Valeria Bucci, Università del Salento, Italy

Alessandra Casarico, Università Bocconi and Dondena Centre for Research on Social Dynamics and Public Policy, Italy; CESifo, Germany

Abstract

This paper reassesses the relationship between tax structure and long run income, using as indicators of tax structure both a new series of implicit tax rates based on Mendoza et al. (1997) and tax ratios, adopting a dynamic panel estimation strategy, and explicitly accounting for cross-section dependence in the panel. When implicit tax rates are used, the paper shows, the link between tax structure and long run income per capita is not robust to the adoption of different assumptions on observable and unobservable heterogeneity across countries. When tax ratios are used, there is some evidence of a negative impact of labour taxation on long run income, but this result is shown to capture non-fiscal effects coming from the evolution of the labour share. Turning to the short run, the research presented here finds strong evidence of a positive effect on per capita income of a tax shift from labour and capital taxation towards consumption taxation, which provides support for fiscal devaluations.

Keywords: long run income, tax structure, fiscal devaluation, cross-section dependence

JEL classification: E62, H30, O43

1. Introduction

The goal of this paper is to reassess the relationship between tax structure and growth in a sample of OECD countries from 1965 to 2011, using as indicators of tax structure both a new series of implicit tax rates based on the methodology developed by Mendoza et al. (1997) and tax ratios.

The academic and policy debate on how taxes and their structure affect economic performance is a long-standing one. The global downturn brought about by the 2008 financial crisis renewed interest in a specific issue, namely, the link between a tax system and growth. Specifically, Arnold et al. (2011b) have recently argued that there is strong empirical evidence of a "tax and growth ranking", with recurrent taxes on immovable property being the least harmful (or most beneficial) in terms of their effect on long run GDP per capita, followed by consumption taxes (and other property taxes), personal income taxes, and corporate income taxes.

These findings had a significant impact on the recent policy debate in Europe on the desirability of carrying out a tax shift from labour income taxation, and especially from social security contributions, to broad-based, general consumption taxes, specifically VAT (for a survey see D'Antoni and Zanardi 2011). The OECD has recently issued many recommendations on the opportunity to introduce growth-oriented tax reforms, e.g., OECD 2008 and 2010, and a tax shift towards consumption is part of the reform package. A similar prescription is proposed by the European Commission (European Commission 2013).

Previous literature does not deliver clear-cut results on the effects of taxes on macroeconomic performance. Mendoza et al. (1997) argue that both theory and empirical evidence corroborate the so-called "Harberger's conjecture": changes in tax policy may affect investment rates and improve welfare through efficiency gains, but do not affect growth. They analyse an OECD country panel of 5-year averaged data and find modest effects of capital and labour income taxes on investment, and negligible effects on GDP growth. Kneller et al. (1999) and Bleaney et al. (2001), though, find that distortionary taxes have a negative and significant impact on growth, whereas non-distortionary taxes do not.

Comparisons across different results in the literature and their reconciliation are quite difficult as different studies are based on different proxies for the relevant tax rates and adopt diverse empirical strategies.

With respect to tax rates, most of the literature relies on aggregate measures of the average tax burden, such as the ratio between tax revenue and GDP (Kneller et al. 1999; Bleaney et al. 2001) or the share of one type of tax in total revenue (Arnold et al. 2011b; Xing 2012). Authors distinguish between personal, corporate, consumption, and property taxes and use their share over total tax revenues as indicators of tax structure.[1] Mendoza et al. 1997 propose an alternative methodology. Following Mendoza et al. 1994, they calculate macro-level effective tax rates (also called "implicit tax rates" by European Commission 2013. See also Martinez-Mongay 2000 and Carey and Tchilinguirian 2000) by taking the ratio between the revenue derived from a particular type of tax and its potential tax base, the latter estimated from national accounts. The advantage of this approach is two-fold. First, effective (or implicit) tax rates can be immediately interpreted as they represent the wedge distorting optimizing behaviour in a representative agent setting. The implicit tax rate on consumption measures the percentage difference between post-tax consumer prices and pre-tax prices at which firms supply consumer goods, whereas the implicit tax rate on labour and on capital corresponds to the percentage difference between post and pre-tax income. Second, compared to tax ratios, they are less directly affected in the long run by the development of factor shares. This can be illustrated by means of a simple decomposition: the share of tax on factor i in total revenue (i.e., the i tax ratio) is equal to the implicit tax rate on i, multiplied by the share of factor i's compensation on GDP, multiplied by GDP over total revenue. Thus, given the total tax burden on GDP and the implicit tax rate on i, the i tax ratio is correlated to the evolution of factor i's share.

Because both implicit tax rates and tax ratios can be (and have been) used to describe tax structure, we conduct the analysis using both indicators. If we use the former, and

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[1] Some studies (Gemmell et al. 2013; Sonedda 2009) also suggest the need to distinguish between average and marginal tax rates and between micro-based tax rates (e.g., statutory or effective tax rates at the individual level) and macro-based tax rates.

for a given total tax-to-GDP ratio, we would say that taxation is uniform when average (effective) tax rates on capital, labour, and consumption are the same, as in a Ramsey-type set up. If we adopt the latter, uniform taxation would be defined by equal revenue shares across capital, labour, and consumption.

The differences in the empirical strategies are instead motivated by the adoption of diverse approaches to distinguishing between long run and transitory effects of taxes on GDP. As noted by Arnold et al. (2011b), it is possible that tax changes that encourage innovation and entrepreneurship have a persistent long run impact on income, whereas tax changes that affect investment can have effects that fade out in the long run. The same applies to tax changes affecting labour supply. Early literature (Mendoza et al. 1997; Kneller et al. 1999) tries to extract long run information from annual data by taking averages over a five-year period so as to wash out cyclical fluctuations, and it only estimates current-period effects in a static panel. Bleaney et al. (2001) argue that this approach is inadequate, as they find evidence that fiscal variables in a five-year period have a significant effect in the subsequent five-year period. More recently, Arnold et al. (2011b) rely on an error correction representation that makes full use of the available time-series information and provides estimates of both long run and short run parameters without the need for long lag structures. Xing (2012) shows that the results of the relationship between tax structure and growth are highly sensitive to the method used for estimating the error correction model. She finds evidence that the homogeneity restriction imposed by the PMG estimator is invalid for some of the long run coefficients, and shows that the tax ranking established by Arnold et al. (2011b) cannot be detected in the data, once such a restriction is removed.

A further weakness of the existing literature is that the empirical approach assumes cross-section independence in the panel, i.e., that regression residuals show no systematic patterns of correlation across countries. Such a correlation would arise if there are shocks that affect all countries (albeit to a different extent) and if one observes more localized spillover effects between neighbouring countries. It is well known (Phillips and Sul 2003; Andrews 2005; Pesaran 2006; Bai 2009; Pesaran and Tosetti 2011) that if one does not control for cross-section dependence, estimates based on macro-level cross-country panel data may be biased. This concern is particularly salient in our setting. In the period from 1965 to 2011, on which we focus here, countries considered in our sample were hit by several common economic shocks (e.g., the oil crisis in the 1970s and the recent financial crisis); they experienced waves of reforms affecting their economic environment (e.g., a switch from fixed to flexible exchange rates or vice versa, participation in a free trade area) and their institutional and regulatory framework (e.g., changes in the relationship between the government and the central bank, changes in antitrust policies, and regulation of the labour market). Further, there were fundamental innovations in tax policies (e.g., the introduction of VAT in Europe and the diffusion of tax withholding). Local spillovers related to tax strategies are also pervasive, as emphasized by the tax competition literature.

Starting from an error correction model of the type introduced by Arnold et al. (2011b), we test the robustness of the "tax and growth ranking"—using both implicit tax rates and tax ratios as indicators of tax structure—under different assumptions regarding the heterogeneity in the long run tax-growth nexus across countries and the heterogeneity in the response to unobservable global shocks, or local spillovers. Following Eberhardt and Presbitero (2013), we adopt standard linear regression models, albeit of a fashion that accounts for both observed and unobserved heterogeneity. Specifically, we account for the presence of unobserved heterogeneity by using the Pesaran (2006) common correlated effects (CCE) estimator, adjusted to the dynamic setup following the suggestions by Chudik and Pesaran (2013). We thus contribute to the existing literature in three respects: first, we analyze tax structure by classifying taxes according to the margin they affect rather than the formal definition of their bases and categories of taxpayers; second, we complement the analysis based on tax ratios with the one based on implicit tax rates; third, our estimation strategy does not rely on the long run homogeneity assumption and it addresses the issue of cross-section dependence.

When we use implicit tax rates as indicators of tax structure, we find evidence of a positive effect of a revenue-neutral shift towards consumption taxation only by imposing the restriction that the long run coefficients are homogeneous across countries and by neglecting the distorting impact of cross-section dependence in the form of unobserved global shocks and local spillover effects. Once observed and unobserved heterogeneity are properly accounted for, we cannot detect any significant effect of the tax structure on long run income. There is, though, strong evidence of a positive short run effect on income from a tax shift from labour and capital towards consumption. When we use tax ratios rather than implicit tax rates as indicators of tax structure, we find that the labour tax ratio negatively affects long run output. However, this result seems to be driven by changes in the wage share of GDP, rather than by changes in the labour tax wedge.

The next section describes the model specification, Section 3 presents the data and discusses regression results, and Section 4 provides some concluding remarks.

2. Empirical model specification

Following recent literature (Arnold et al. 2011b; Xing 2012; Eberhardt and Presbitero 2013), the empirical analysis is performed by estimating an Error Correction Model (ECM) specified as:

$$\Delta \ln y_{it} = -\varphi_i \left(lny_{it-1} - \sum_j \beta_i^j X_{it}^j - \sum_m \beta_i^m T_{it}^m \right) + \sum_j b_i^j \Delta X_{it}^j + \sum_m b_i^m \Delta T_{it}^m + \gamma_i z_t + \delta_i + \varepsilon_{it} \quad (1)$$

where $\ln y_{it}$ is the log of GDP per capita in country *i* and at time *t* calculated as the ratio between GDP at constant prices and constant PPPs (in millions of US dollars) and the size of the working-age population (in thousands). The vector of non-fiscal variables, X_{it}^j, includes physical capital investment, human capital, and population growth. In particular, physical capital investment is the total gross fixed capital formation as a percentage of GDP; human capital is measured by the average years of schooling of the working-age population; population growth is the annual growth rate of the working-age population. The vector of fiscal variables T_{it}^m includes total revenue over GDP and the implicit tax rates as proxies of tax wedges on consumption, labour, and capital or, alternatively, tax revenues from consumption, labour, and capital, respectively, over total tax revenues (i.e., tax ratios). The variable z_t represents a country-specific time effect, δ_i is a country-specific intercept, and ε_{it} is the error term.[2]

The parameters $!_i^j$ and $!_i^m$ in equation (1) represent the long run equilibrium relationship between the log of GDP per capita and the vectors of non-fiscal and fiscal variables, respectively, whereas the parameters b_i^j and b_i^m capture the short run relationships of the log of GDP per capita with non-fiscal and fiscal variables. The parameter $!_i$ indicates the speed of convergence of the economy to its long run equilibrium. The term in round brackets represents the candidate cointegrating relationship we seek to identify in our panel time series approach. By relaxing the "common factor restriction" implicit in the nonlinear relationship between parameters in equation (1), the model can be reparameterized as follows:

$$\Delta \ln y_{it} = \pi_i^c lny_{it-1} + \sum_j \pi_i^j X_{it}^j + \sum_m \pi_i^m T_{it}^m + \sum_j b_i^j \Delta X_{it}^j + \sum_m b_i^m \Delta T_{it}^m + \gamma_i z_t + \delta_i + \varepsilon_{it} \quad (2)$$

Long run parameters can be calculated from the coefficients on the terms in levels, $!_i^j$ and $!_i^m$, since $\beta_i^j = \# \frac{!_i^j}{!_i^c}$ and $\beta_i^m = \# \frac{!_i^m}{!_i^c}$

The coefficient $\pi_i^c = -\varphi_i$ measures the speed at which the economy returns to the long run equilibrium. As highlighted by Eberhardt and Presbitero (2013), inference on this parameter will provide insights into the presence of a long run equilibrium relationship: if $!_i^c = 0$ ($!_i = 0$), there is no cointegration and the model reduces to a regression with variables in first differences. If $\pi_i^c \neq 0$ ($\varphi_i \neq 0$) variables in round brackets in equation

[2] In both exogenous and endogenous growth models, taxes may affect the long run GDP level through two different channels: by affecting productivity and by altering factors' accumulation. As shown in Arnold et al. (2011a), the empirical specification in (1) is compatible with both exogenous and endogenous growth models. However, the presence of standard factors of production (labour, physical and human capital) among the controls implies that the estimated coefficients of the fiscal variables would only capture the impact of the tax structure through the first channel (i.e., factor productivity). As a consequence, the analysis may over- or underestimate the effect of tax structure on the long run GDP level. This limitation is shared by most of the existing literature. An analysis of the effect of changes in tax structure on long run GDP via the investment in physical and human capital is beyond the scope of this paper and is left for future research.

(1) are cointegrated and, after a shock, the economy returns to the long run equilibrium path.

In order to control for unobservables as well as for omitted elements of the cointegration relationship, we follow the Common Correlated Effects (CCE) approach suggested by Pesaran (2006) and include in the regression cross-section averages of all variables in the model:

$$\Delta lny_{it} = \pi_i^c lny_{it-1} + \sum_j \pi_i^j X_{it}^j + \sum_m \pi_i^m T_{it}^m + \sum_j b_i^j \Delta X_{it}^j + \sum_m b_i^m \Delta T_{it}^m + \sigma_i^c \overline{lny}_{t-1} + \sum_j \sigma_i^j \bar{X}_t^j + \sum_m \sigma_i^m \bar{T}_t^m + s_i \overline{\Delta lny}_t + \sum_j s_i^j \overline{\Delta X}_t^j + \sum_m s_i^m \overline{\Delta T}_t^m + \gamma_i z_t + \delta_i + \varepsilon_{it} \quad (3)$$

This specification allows each country to have its own slope coefficients both on the observed explanatory variables and on the unobserved common factors. This formulation can also be regarded as a way of introducing flexible trends.

The CCE method has been shown to be robust to different types of cross-section dependence of errors, possible unit roots in explanatory variables, and slope heterogeneity (Kapetanios et al. 2011; Pesaran and Tosetti 2011; Chudik et al. 2011). However, the CCE approach may be invalid when the panel includes a lagged dependent variable and/or weakly exogenous variables as regressors, as is the case in our model. Chudik and Pesaran (2013) show that the CCE approach continues to be valid if a sufficient number of lags of cross-section averages, as well as cross-section averages of one or more additional covariates, are included in equation (3). We therefore also run regressions to correct the CCE approach, according to the indications of Chudik and Pesaran (2013).

The analysis focuses on tax structure as measured both by implicit tax rates and by tax ratios, and aims at evaluating the impact of revenue-neutral tax policy changes on the long run level of GDP. For this reason, following Arnold et al. (2011b) and Xing (2012), we control for the overall tax burden and always omit one or more tax indicators in each regression. The omitted tax structure indicators are assumed to adjust to compensate for changes in revenue brought about by changes in the other tax structure indicators that are included in the regression.

3. Data and results

3.1 Data

We combine different data sources to obtain an unbalanced panel data set that includes 15 OECD countries[3] over the period from 1965 to 2011. The growth regression considers GDP as a function of several non-fiscal determinants suggested by the literature (investment into physical capital, human capital, working-age population growth) and a set of fiscal variables. Specifically, non-fiscal data come from OECD National Accounts, OECD Factbook (Economic, Environmental and Social Statistics), OECD Statistical Population, OECD Education at a Glance, and Arnold et al. (2011a).

The implicit tax rate on consumption (ITR_c) is computed as the sum of revenues from consumption taxes on goods and services divided by the sum of private and government consumption. The implicit tax rate on capital (ITR_k) includes corporate profit taxes, taxes on household capital income, and various property taxes. The implicit tax rate on labour (ITR_l) is computed as the sum of taxes on labour income, revenues from social security contributions, and revenues from payroll taxes divided by labour income. Data on potential tax bases are taken from OECD National Accounts and OECD Labour Force Statistics, whereas revenue data are from OECD Revenue Statistics.

The implicit tax rates are calculated using the methodology proposed by Mendoza et al. (1997) as amended by Carey and Tchilinguirian (2000), which allows for overcoming some of the shortcomings of standard calculation of implicit tax rates (e.g., European Commission 2012). In particular, the assumption that all income from self-employment is capital income is dropped in favour of assuming that the self-employed earn both labour and capital income. This adjustment is relevant when comparing countries with significant differences in the share of the self-employed in total employment or when this share changes over time. Furthermore, government consumption is added to the tax base of consumption taxes. This allows us to compare countries with different

[3] The 15 countries are: Australia, Austria, Belgium, Canada, Finland, France, Greece, Italy, Japan, Netherlands, Norway, Spain, Sweden, United Kingdom and United States.

dimensions of the public sector. In the computation of ITR_k and ITR_l, we take into account that in most countries[4] employees' social security contributions are deductible from taxable income. We also make some specific adjustments to account for some peculiar taxes that the OECD classifies in the residual category of "Other taxes", such as *Irap* in Italy. The resulting implicit tax rates and the method used to compute them are described in Appendix A.

Tax ratios TR_c, TR_k, and TR_l are obtained by dividing tax revenues on consumption, capital, and labour, respectively, by total tax revenues. Revenues for each factor are the same as those used to compute the numerator of implicit tax rates.

In order to perform some robustness checks, we include in the empirical model two additional variables: a proxy of trade-openness, computed as the sum of exports and imports as a share of GDP, and a proxy of public expenditure, computed as the ratio of general government final consumption and GDP, taken from OECD International Trade (MEI) and OECD Revenue Statistics.

Appendix B reports descriptive statistics of all variables and graphs describing the evolution of implicit tax rates and of tax ratios. The implicit tax rate on capital displays a more evident short run dynamic, with some sharp spikes. As we detail in Appendix A, the calculation of the implicit tax rate on capital features in the denominator the net operating surplus as a measure of the base on which capital taxes are raised, and in the numerator it includes taxes on property, on income, on profits, and on capital gains of corporations. The main reason for the volatility of the implicit tax rate on capital is the mismatch between the net operating surplus, in the denominator, and the base of all taxes recorded in the numerator. For example, property taxes are often levied on presumed rents rather than on actual rents or capital value, whereas the corporate tax base differs from net operating surplus, because losses are usually carried forward. As a result, property and corporate tax base do not immediately react to a reduction in net operating surplus. This explains why we observe large jumps in the ITR_k during

[4] The countries that do not allow social security contributions to be deducted are Australia, Canada, the United Kingdom, and the United States.

recessions (as those that hit many European countries in the early 1990s) and why in some cases (e.g., Finland during the 1991 financial crisis) the ITR_k rises above 1. Another source of discrepancy in movements of the numerator and the denominator of ITR_k stems from capital gains, which are not included in the net operating surplus in national accounts because they are not related to the production process. During periods of booming asset prices, like the years preceding the 2008 financial crisis, capital gains foster revenue coming from property and corporate taxes, without affecting the net operating surplus, thus increasing the ITR_k. The short term dynamics included in the estimation procedure are meant to capture precisely these kinds of cyclical fluctuations and to avoid inference on the long run relationship between GDP and tax structure being affected by an endogeneity bias.

Before running our regressions, we perform a preliminary analysis and carry out a series of panel unit root tests and the Pesaran (2004) CD test for cross-sectional dependence. These tests indicate that the level variables series are integrated of order 1 and subject to considerable cross-section dependence.[5]

3.2 Results

In terms of methodology adopted, in order to compare our results with those in Arnold et al. 2011b, Gemmell et al. 2013, and Xing 2012, we first estimate equation (1) using the pooled mean group (PMG) estimator (Pesaran et al. 1999), which assumes homogeneous long run coefficients across countries (i.e. $!_i^j = !^j$ and $!_i^m = !^m$) but allows for heterogeneous speed of convergence and short run dynamics. Time effects are captured by country-specific time trends and a dummy variable for the economic crisis (it assumes value 1 for the years 2008 through 2011). We also include country fixed effects to control for unobserved time invariant heterogeneity. Table 1 summarizes the PMG estimates of the long run and short run coefficients and the estimated speed of convergence across countries under different model specifications. In column 1 we regress the log of GDP per capita on measures of physical and human

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[5] Results are available upon request.

capital and on population growth. In columns 2 through 7 we include fiscal variables. In columns 2 through 4 tax structure is measured by implicit tax rates; in columns 5 through 7 we adopt tax ratios. In each regression, we always control for total tax revenues over GDP in order to focus on revenue-neutral tax changes.[6] Relying more on revenues coming from a given tax instrument changes the amount to be raised via the other tax instruments: this outcome is achieved by always omitting from the regressions one tax structure indicator.[7] Column 2 (5) considers the effect of an increase in the tax wedge (tax ratio) on consumption and on labour, compensated by a change in the tax wedge (tax ratio) on capital. Column 3 (6) estimates the impact of an increase of implicit tax rates (tax ratios) on labour and on capital, compensated by a change in the implicit tax rate (tax ratio) on consumption, whereas column 4 (7) refers to an increase in the implicit tax rates (tax ratios) on consumption and on capital, compensated by a change in the labour tax wedge (tax ratio).[8]

The sign of the estimated long run coefficients of the non-fiscal control variables is consistent with the findings of previous literature. There is evidence of error correction as the convergence rate is highly statistically significant.

Overall, when we use implicit tax rates as indicators of tax structure, the PMG estimates in columns 2 through 4 seem to provide evidence that a revenue-neutral tax shift from labour and capital to consumption has a positive effect on the long run level of income

[6] We include this control variable to avoid the bias that could result from a correlation between the tax mix and the overall tax burden. However, the value of the coefficient of this variable cannot be interpreted as an estimate of the effect of the overall tax burden on GDP for a given tax structure. Since we always omit from the regressions at least one tax structure indicator, the coefficient of tax revenues over GDP represents the impact on long run GDP of an increase in the overall tax burden achieved by a change in the omitted indicator(s). This implies that the sign and the significance of the estimated coefficient may vary across the different regressions we run to evaluate revenue-neutral tax changes. Furthermore, as highlighted by Arnold et al. (2011b), our regressions cannot provide an accurate estimate of this coefficient because we do not take into account how any additional tax revenue is spent.

[7] When tax structure is measured by tax ratios, the increase in one tax ratio—given the share of total revenues in GDP—necessarily delivers a reduction in one or more of the others. When we measure tax structure by implicit tax rates, the increase in one of them—again, given the share of total revenues in GDP—causes a change in one or more of the others. The sign of the change is not known a priori as it depends on the elasticity of the tax base.

[8] Given the error-correction specification, it is important to check that the residuals from the long run equation are stationary to avoid spurious correlations. The errors of the regression equation have been tested for non-stationarity using panel unit root tests based on Im et al. (2003). Non-stationarity of the residuals was rejected at the 1% level. Results are available upon request.

per capita: the coefficient of the implicit tax rate on consumption is positive and statistically significant when the implicit tax on capital or on labour (columns 2 and 4, respectively) is changed to keep the total amount of revenues constant. The coefficient of the implicit tax rate on labour and on capital are both negative and statistically significant when these taxes are increased to compensate for a change in the implicit tax rate on consumption (column 3). In contrast, there is no clear evidence of a positive effect on long run income per capita of a tax shift from capital to labour or from labour to capital (the coefficients in columns 2 and 4 are both negative and not, or only mildly, significant). These results suggest that taxation on consumption is most favourable to growth, whereas capital and labour taxation cannot be ranked in terms of their effect on GDP.

The results partly change when we measure tax structure adopting tax ratios. The effect of taxes on consumption remains positive and highly significant in all regressions, as we highlighted for the implicit tax rate. However, we obtain a ranking as well for capital taxation and labour taxation, with the latter being the most harmful for growth.

Xing (2012) has shown that the homogeneity restriction imposed by the pooled mean group (PMG) estimator is invalid for some of the long run coefficients. It is well known that inference based on the PMG estimator may be unreliable in this instance. In Table 2 we compare PMG (columns 1 and 4) and mean group (MG) estimates (columns 2-3 and 4-5) for a specification in which we include only the tax structure measures that have the largest impact on GDP, namely, the implicit tax rate on consumption on the one side (columns 1-3) and consumption and labour tax ratios (columns 4-6) on the other. Differently from the PMG, the MG estimation yields country-specific long run tax coefficients that are then averaged across the panel. In columns 3 and 6 we also employ robust regression to weigh down outliers in the computation of the averages (see Eberhardt and Presbitero 2013). PMG and MG bring about very similar estimates for all long and short run coefficients, with the exception of the implicit tax rate on consumption and the consumption tax ratio, which are no longer significant in the MG estimation. The coefficient on the labour tax ratio remains negative and significant in the MG estimation as well.

We test the validity of the common long run coefficients restriction using both the Hausman test (Hausman 1978) and an alternative Wald test, as suggested by Xing (2012). We first look at implicit tax rates. The results, reported in Table 3, Panel A, and Table 4, Panel A, are somewhat mixed. The Hausman test that considers all five coefficients jointly does not reject the validity of the homogeneous coefficient hypothesis. However, the same test performed on each of the coefficients separately casts some doubt on the homogeneity restriction on the coefficient of the implicit tax rate on consumption, which is rejected at the 10% level. In contrast, the Wald test in Table 4, Panel A, does not reject the homogeneity restriction for any single coefficient, whereas it rejects the hypothesis of equal long run coefficients for all five variables jointly.

Using in the empirical model tax ratios rather than implicit tax rates does not significantly alter our conclusions (see Panel B of Table 3 and Table 4). The Hausman test that considers all five coefficients jointly, and the one that looks at each of them separately, do not reject the validity of the equal long run coefficient hypothesis. However, the Wald test rejects the homogeneity restriction for human capital and for all five variables jointly. Overall, these results suggest some caution in the interpretation of the coefficients of the PMG estimation.

In both PMG and MG models the CD statistic highlights the presence of residual cross-section dependence. To account for unobserved common factors we use the Pesaran (2006) CCE estimator and some of its variants.

Table 5, Panel A reports the results for the analysis that focuses on the implicit tax rate on consumption. In the first column we adopt the standard CCE estimator in the mean group version (CMG), employing robust regression in the computation of the coefficient averages. The CD statistic drops[9] significantly when we shift from the MG to the CMG estimation, confirming that the use of cross-section averages considerably reduces residual cross-section dependence. The CMG estimator confirms that the

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[9] The CD test decreases from around 10 (columns 2 and 3 of Table 2) in the MG to -1.98 in the CMG model in Table 5, Panel A (column 1).

implicit tax rate on consumption has no statistically significant effect on long run income per capita.

The CCE approach may be invalid in our framework as the model includes a lagged dependent variable and weakly exogenous variables as regressors. Chudik and Pesaran (2013) show that this problem can be overcome by including in the specification lags of all cross section averages of the dependent and of the control variables, as well as a sufficient number of cross-section averages of one or more additional covariates. We cannot fully implement this approach as our time series are not sufficiently long. Nonetheless, in the spirit of Eberhardt and Presbitero (2013), we run some robustness checks by adding lags of the cross-section average of the dependent variable and by including in the model cross-section averages and lags of additional covariates outside the benchmark model. We experiment with proxies of trade-openness and of public expenditure. These variables only enter the empirical model in the form of their cross-section averages with the aim of helping to identify the unobserved common factors, which represent global shocks and local spillover effects. The results are reported in columns 2 through 9. In no specification the implicit tax rate on consumption is significant.

These results highlight the relevance of observable and unobservable heterogeneity in the empirical investigation of the nexus between implicit tax rates and long run growth. The PMG estimation results suggest that a revenue neutral tax shift towards consumption taxation may be associated with a higher steady-state level of income per capita. However, this effect is not robust to account for heterogeneity in the slopes of long run coefficient and in the responses to unobservable common shocks.

Table 5, Panel B replicates the analysis performed in Panel A using the labour tax ratio rather than the implicit tax rate on consumption as an indicator of tax structure. Because in the MG regression with tax ratios only the one on labour was significant, we focus on this variable in the analysis that accounts for cross-sectional dependence. We find some evidence that the negative impact of the labour tax ratio is robust for controlling for cross-sectional dependence.

Thus, the conclusion one can draw about the relationship between tax structure and long run per capita GDP seems to hinge critically on the definition of the tax structure one adopts. To further investigate this point, we resort to the decomposition we described at the outset of the paper and introduce it formally. The labour tax ratio can be written as follows: $TR_l = ITR_l \frac{W}{GDP} \frac{GDP}{T}$, where W indicates the total labour compensation. We thus note that a regression in which we proxy fiscal variables by the labour tax ratio and by total revenues over GDP—as we do in Table 5, Panel B—is equivalent to one in which we include the implicit tax rate on labour and control for the share of wages over GDP. The labour tax ratio could change not only because the labour tax rate changes, but also because the labour tax base changes. In Table 5, Panel C we find that there is a negative and significant relationship between the share of GDP going to wages and the log of GDP per capita, which suggests that the negative impact of the labour tax ratio on GDP may actually be driven by non-fiscal factors, i.e., changes in the tax base of labour.

We conclude that there is no clear evidence supporting the claim that tax structure, either measured by implicit tax rates or by tax ratios, is detrimental for GDP.

Although our analysis focuses on the long run, it is remarkable that in almost all specifications the short run coefficient of the implicit tax rate on consumption is positive and highly significant. This is consistent with the so-called "fiscal devaluation" hypothesis (Alworth and Arachi 2010; De Mooij and Keen 2013; Farhi et al. 2014): a value-added tax increase coupled with a uniform payroll tax reduction may replicate a nominal exchange rate devaluation that fosters exports and growth.[10]

4. Conclusions

In recent years many international organizations, e.g., the European Commission, the International Monetary Fund, and the OECD, have strongly supported tax reforms

[10] The analysis based on tax ratios does not provide any clear evidence on the short run effects. The PMG estimator delivers a negative sign for both an increase in consumption and in labour taxation. The former result is in contrast with the fiscal devaluation hypothesis. However, the short run impacts are not statistically significant when we allow for heterogeneity in the long run relationship and control for cross-section dependence.

aimed at shifting the tax burden away from capital and labour income to broad-based consumption taxes or to property taxes. The existing literature does not provide clear empirical evidence supporting these policy prescriptions. Several studies have reached conflicting conclusions using different datasets, methodologies, and indicators of tax structure.

When measuring tax structure with implicit tax rates, we find evidence of a positive effect of a revenue-neutral shift towards consumption taxation only by imposing the restriction that the long run coefficients are homogeneous across countries and by neglecting the distorting impact of cross-section dependence in the form of unobserved global shocks and local spillover effects. However, diagnostic tests cast some doubts on the validity of the homogeneity restriction and clearly reject cross-section independence. Once observed and unobserved heterogeneity are properly accounted for by using methods suggested by the recent panel econometric literature, we cannot detect any significant effect of the tax structure on long run income.

When we use tax ratios rather than implicit tax rates as indicators of tax structure, we find that the labour tax ratio negatively affects long run output. However, this result seems to be driven by changes in the wage share in GDP, rather than by changes in the labour tax wedge.

Even though this paper is mainly concerned with the long run relationship between taxes and income, our analysis based on the implicit tax rates provides strong evidence of a positive short run effect on income of a tax shift from labour and capital towards consumption. This evidence is in line with the prediction of the literature on fiscal devaluations.

Our analysis can be extended in a few directions. Following the most recent literature, we have estimated a growth regression by controlling for factors' accumulation. The implication is that we have tested whether tax structure has an impact on the long run GDP level via its effect on factor productivity. However, taxes may also affect GDP through their impact on investment in physical and human capital. These effects may be particularly relevant if growth is endogenous (Myles, 2009). Another limitation of the analysis is that we provide insights only regarding the central tendency of the panel. Our approach may mask the presence of within-country nonlinearities, which are washed out when looking at average effects. As recently suggested by Jaimovich and Rebelo (2012), the effects of taxation on growth may be highly non-linear: marginal increases in tax rates have a small growth impact when tax rates are low or moderate, whereas the impact on growth may be large when tax rates are high. The empirical investigation of the link between tax structure and growth via investment in physical and human capital and the study of non-linear effects of taxes are very relevant topics for future research.

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- WSSS Compensation of employees (including private employers' contributions to social security and to pension funds).

The implicit tax rate on consumption ITR_c is computed as:

$$ITR_c = \frac{(5110+5121+5122+5123+5126+5128+5200)}{(CP+CG)}$$

In order to compute implicit tax rates on labour and on capital we first calculate the implicit tax rate on total household income (ITR_{hh}), the wage-bill for the self-employed (WSE), the share of labour income in household income (α), and, correspondingly, the share of capital income in household income ($1-\alpha$):

$$ITR_{hh} = \frac{1100}{(OSPUE+PEI+W)}$$

$$WSE = \frac{ES\cdot(W-2100)}{EE}$$

$$\alpha = \frac{W}{OSPUE+PEI+W}$$

If social security contributions are not deductible, the implicit tax rates on capital and labour are computed as:

$$ITR_l = \frac{(ITR_{hh}\cdot(W+WSE)+2100+2200+2300+\alpha\cdot 2400+3000)}{(WSSS+WSE+2300+3000)}$$

$$ITR_k = \frac{(ITR_{hh}\cdot(OSPUE+PEI-WSE)+\beta\cdot 2400+1200+4000)}{(OS-WSE-2300-3000)}$$

If social security contributions are deductible, they are equal to:

$$ITR_l = \frac{(ITR_{hh}\cdot(W-2100+WSE-2300-\alpha\cdot 2400)+2100+2200+2300+\alpha\cdot 2400+3000)}{(WSSS+WSE+2300+3000)}$$

$$ITR_k = \frac{(ITR_{hh}\cdot(OSPUE+PEI-WSE-\beta\cdot 2400)+\beta\cdot 2400+1200+4000)}{(OS-WSE-2300-3000)}.$$

For France and Italy we make some adjustments to account for peculiar taxes that the OECD classifies in the residual category "Other taxes" and that generate large revenues (i.e., Tax professionelle and IRAP). Because their tax base includes both labour and capital, we split the revenues of these taxes between labour and capital according to the share α we defined before and add them to the numerator of the corresponding implicit tax rate.

Appendix B: Descriptive Statistics

Table B1: Descriptive Statistics

Variables	*Mean*	*Std. Dev.*	*Min*	*Max*
GDP per capita (y_{it})	3.587	0.294	2.548	4.308
Fixed Investments (s_{it})	3.091	0.173	2.646	3.614
Human Capital (h_{it})	2.345	0.175	1.739	2.598
Population Growth (n_{it})	0.740	0.616	-0.981	4.729
Tax Revenue/GDP (T_{it})	0.354	0.079	0.159	0.523
Implicit tax rate on consumption $(ITRc_{it})$	0.135	0.042	0.050	0.232
Implicit tax rate on labour $(ITRl_{it})$	0.290	0.092	0.094	0.503
Implicit tax rate on capital $(ITRk_{it})$	0.507	0.216	0.076	1.615
Consumption tax ratio (TRc_{it})	0.287	0.067	0.123	0.500
Labour tax ratio (TRl_{it})	0.485	0.068	0.260	0.645
Capital tax ratio (TRk_{it})	0.209	0.078	0.074	0.402
Trade Share (TS_{it})	0.031	0.030	0.001	0.216
Public Expenditure (G_{it})	19.116	3.839	9.006	28.987

Notes: GDP per capita is the log of GDP in country *i* and at time *t* calculated as the ratio between GDP at constant prices and constant PPPs (in millions of US dollars) and the size of the working-age population (in thousands); fixed investment is the total gross fixed capital formation as a percentage of GDP; human capital is measured by the average years of schooling of the working-age population; population growth is the annual growth rate of the working-age population; tax revenue/GDP is the total tax revenue as percentage of GDP; implicit tax rates (*ITR*) are the ratios between the revenue derived from a particular type of tax and its potential base; tax ratios (*TR*) are the ratios between the revenue derived from a particular type of tax and total tax revenue; trade share is the ratio between the sum of exports and imports and GDP; public expenditure is the ratio between general government final consumption and GDP. Non fiscal data come from OECD National Accounts, OECD Factbook (Economic, Environmental and Social Statistics), OECD Statistical Population, OECD Education at a Glance, Arnold et al. 2011a, OECD International Trade (MEI), and OECD Revenue Statistics; tax data come from OECD National Accounts, OECD Labour Force Statistics, and OECD Revenue Statistics. The 15 countries included in the panel data set are: Australia, Austria, Belgium, Canada, Finland, France, Greece, Italy, Japan, Netherlands, Norway, Spain, Sweden, the United Kingdom, and the United States. The observation period is 1965-2011.

Figure B.1: Evolution of implicit tax rates

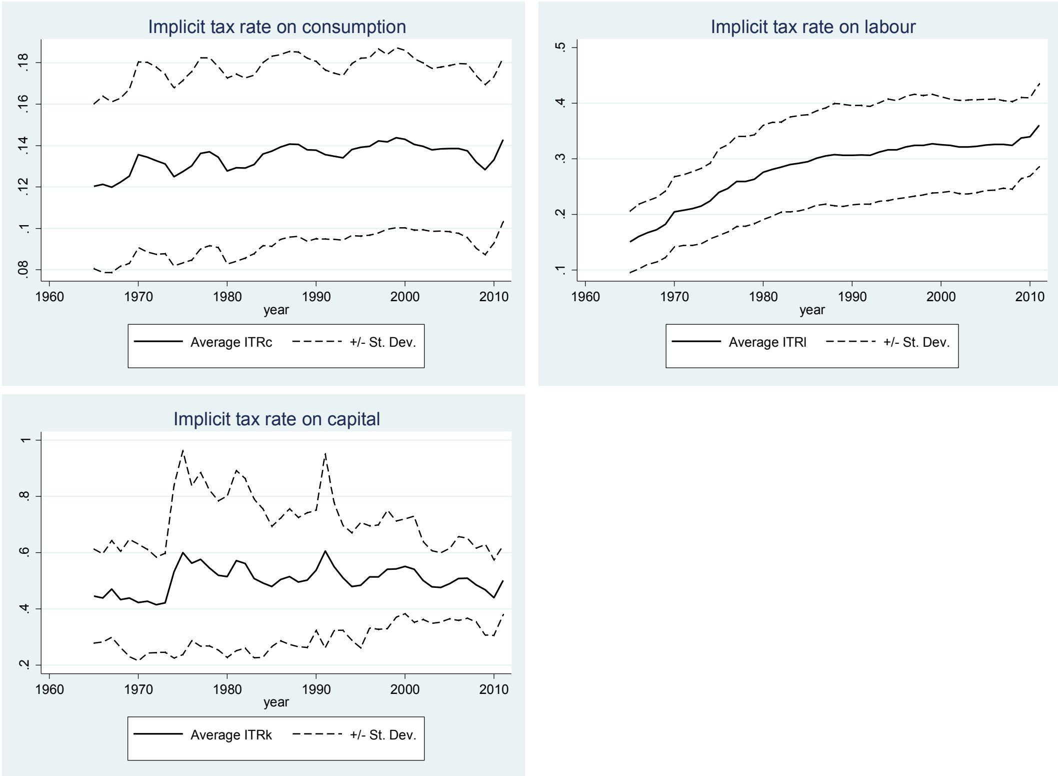

Figure B.2: Evolution of tax ratios