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ABSTRACT

It is well known by now that government spending has typically been procyclical in emerging economies but acyclical or countercyclical in industrial countries. Little, if any, is known, however, about the cyclical behavior of tax rates (as opposed to tax revenues, which are endogenous to the business cycle and hence cannot shed light on the cyclicality of tax policy). We build a novel dataset on tax rates for 62 countries for the period 1960-2009 that comprises corporate income, personal income, and value-added tax rates. We find that, by and large, tax policy is acyclical in industrial countries but procyclical in developing countries. We show that the evidence is consistent with a model of optimal fiscal policy under uncertainty.

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1 Introduction

There is by now a strong consensus in the literature that fiscal policy, or more precisely government spending, has been typically procyclical in developing countries and countercyclical or acyclical in industrial economies.[1] Figure 1, which updates evidence presented in Kaminsky, Reinhart, and Végh (2004), illustrates this phenomenon by plotting the correlation between the cyclical components of output and government spending for 94 countries during the period 1960-2009. Yellow bars depict developing countries and black bars denote industrial countries. The visual impression is striking: while a majority of black bars lie to the left of the figure (indicating countercyclical government spending in industrial countries), the majority of yellow bars lies to the right (indicating procyclical government spending in developing countries). In fact, the average correlation is -0.17 for industrial countries and 0.35 for developing countries.

Several hypothesis have been put forth in the literature to explain the procyclical behavior of government spending in developing countries, ranging from limited access to international credit markets to political distortions that tend to encourage public spending during boom periods. While, as argued by Frankel, Végh, and Vuletin (2011), some emerging economies seem to have been able to graduate from procyclical fiscal policy over the last decade or so, fiscal procyclicality remains a pervasive phenomenon in the developing world and reinforces – instead of mitigating – the underlying business cycle volatility.

The other pillar of fiscal policy is, of course, taxation. Hence, one would like to analyze the cyclical behavior of tax *rates,* which are the policy instrument (as opposed to tax revenues, which are a policy outcome).[2] Unfortunately – and leaving aside a few studies focusing on individual countries such as Barro (1990), Huang and Lin (1993), and Strazicich (1997) for the United States and Maihos and Sosa (2000) for Uruguay – there is no systematic international evidence regarding the cyclicality of tax rate policy. The main reason is, of course, the absence of readily-available cross-country data on tax rates. To get around this limitation, the literature has relied on the use of (i) the inflation tax (Talvi and Végh, 2005; Kaminsky, Reinhart, and Végh, 2004) or (ii) tax revenues, either in absolute terms or as a proportion of GDP (Gavin and Perotti, 1997; Braun, 2001; Sturzenegger and Wernek, 2006). Both approaches, however, have severe limitations.

The problem with the first approach is that there is simply no consensus on whether the inflation

[1] See, for example, Ilzetzki and Végh (2008) and the references therein.

[2] A note on terminology is important at this point. We will define procyclical (countercyclical) tax rate policy when tax rates are negatively (positively) correlated with the business cycle; that is tax rates tend to fall (increase) in booms and increase (fall) in recessions. An acyclical tax rate policy captures the case of zero correlation (i.e., no systematic relation between tax rate and the business cycle).

tax should be thought of as "just another tax." While there is, of course, a theoretical basis for doing so that dates back to Phelps (1973) and has been greatly refined ever since (see, for example, Chari and Kehoe (1999)), there is little, if any, empirical support (Roubini and Sachs, 1989; Poterba and Rotemberg, 1990; Edwards and Tabellini, 1991; Roubini, 1991). Indeed, Delhy Nolivos and Vuletin (2011) show that the inflation tax can be thought of as "just another tax" only when central bank independence is low in which case the fiscal authority effectively controls monetary policy and uses inflation according to revenue needs. When central bank independence is high, however, inflation is set by the central bank and is essentially divorced from fiscal considerations. For whatever is worth, Figure 2 suggests and Table 1, columns 1 and 2 confirm that the inflation tax is countercyclical in most industrial countries while it is, on average, acyclical in developing countries. Hence, if anything, one would conclude that tax rate policy in developing countries is not procylical which, as will become clear below, would be the incorrect conclusion to draw.

On the other hand – and as argued by Kaminsky, Reinhart, and Végh (2004) – the second approach is fundamentally flawed because tax revenues constitute a policy outcome (as opposed to a policy instrument) that endogenously responds to the business cycle. Indeed, tax revenues almost always increase during booms and fall in recessions as the tax base (be it income or consumption) moves positively with the business cycle. Therefore, if tax revenues are positively related to the business cycle, there is little that we can infer regarding tax rate policy since positively related tax revenues are consistent with higher, unchanged, and even lower tax rates during good times. It is only when tax revenues are negatively related to the business cycle that we can conclude that tax rate policy is procyclical. Since, as shown in Figure 3 and Table 1, columns 3 and 4, tax revenues tend to be positively related to the business cycle, there is little that we can infer regarding the cyclicality of tax rates.

In an attempt to correct for the endogenous fluctuations in the tax base, some authors have used revenues as a ratio of GDP, referring to it as an "average tax burden." As discussed in Kaminsky, Reinhart, and Végh (2004), however, nothing can be inferred from such an indicator regarding the cyclical properties of the policy instrument (i.e., the tax rate). For these reasons, this fiscal indicator is completely uninformative regarding tax policy cyclicality. To show the practical relevance of this point, Figure 4 and Table 1, columns 5 and 6 show the correlation between the cyclical components of government revenue to GDP ratio and real GDP. Based on this, one would (erroneously!) conclude that tax policy is acyclical in industrial economies and countercyclical in developing countries. As we will show in this paper, tax policy is actually procyclical in most developing countries.

In sum, there is really no good substitute for having data on tax rates when it comes to evaluating the cyclical properties of tax policy. This is precisely the purpose of this paper. To our knowledge, this is the first paper to systematically study the cyclical properties of tax policy based on the use of the policy instrument (tax rate) as opposed to outcome (tax revenues). To this end, we build a novel annual dataset that comprises value-added, corporate, and personal income tax rates for 62 countries, 20 industrial and 42 developing, for the period 1960-2009. Using these tax rates, we compute the degree of cyclicality of each tax and of a tax index. From an identification point of view, we also control for endogeneity concerns using instrumental variables.[3]

We can summarize our main empirical findings as follows:

1. Tax policy is more volatile in developing countries than in industrial countries in the sense that developing countries change their tax rates by larger amounts than industrial economies. This is particularly the case for personal income and value-added taxes.

2. Tax policy is mostly acyclical in industrial countries, with the corporate income tax policy being weakly countercyclical. On the other hand, developing economies pursue procyclical tax policies.

Why would the cyclical properties of fiscal policy differ across industrial and developing countries? One compelling explanation is the presence of imperfections in international credit markets (Gavin and Perotti, 1997; Riascos and Végh, 2003). To illustrate this idea, we present the simplest possible model of optimal fiscal policy under incomplete markets. We show that government consumption is procyclical regardless of preferences. Intuitively, government consumption acts much like private consumption and is higher (lower) in the good (bad) state of nature. Interestingly enough, however, the cyclical properties of tax policy depend on preferences. Under the most realistic parameterization in which the ratio of government spending to private consumption (which is the tax base) is higher (lower) in the bad (good) state of nature, tax rate policy is procyclical. Intuitively, if government spending is high relative to the tax base in bad times, the tax rate will need to be also high in order to satisfy the budget constraint. In good times, government spending will be low relative to the tax base, which calls for a lower tax rate. Further, the degree of procyclicality varies directly with output volatility. We show that this prediction of the model is consistent with the data.

The paper proceeds as follows. As background, Section 2 briefly characterizes the tax revenue structure – both in terms of size and composition – of countries around the world. Section 3 presents the tax rate data used in the study. It also shows some basic statistics relevant for our study of

[3] See Rigobon (2004) and Jaimovich and Panizza (2007) who challenge the idea that fiscal policy is proclical in developing countries based on endogeneity problems. Ilzetzki and Végh (2008), however, argue that even after addressing endogeneity concerns, there is causality running from the business cycle to government spending.

cyclicality of taxation; namely the frequency and magnitude of changes in tax rates. Section 4 presents a preliminary analysis of cyclicality of tax policy using average tax rate changes in good and bad times, cross-country correlation plots, and basic panel regression analysis. Section 5 addresses endogeneity issues. Section 6 develops our theoretical model of optimal fiscal policy under incomplete markets. Final thoughts are presented in Section 7.

2 Tax revenue structure

The tax burden, defined as government revenue expressed as percentage of GDP, varies significatively across countries, ranging from 42.1 percent for Norway to 7.3 percent for the Democratic Republic of Congo.[4] The average tax burden in industrial countries is 25.5 percent of GDP, compared to 18.8 percent for developing countries (Table 2, panel A).

The relative importance of income – both corporate and personal – and value-added taxes varies significatively across countries and groups of countries. Generally speaking, industrial countries rely heavily on direct taxation, particularly on personal income taxation. In contrast, developing economies rely more on indirect taxation, particularly the value-added tax (Table 2, panel B).[5]

Compared to corporate and personal income taxation, value-added taxation is fairly modern. The first value-added tax dates back to France in 1948. Beginning in the late 1960s, the value-added tax spread rapidly (Figure 5). Denmark was the first European country to introduce a value-added tax in 1967. Brazil also introduced it in 1967, and it quickly spread in South America. The widespread adoption observed since the early 1990s is mainly explained by developing countries, particularly in Africa, Asia, and transition economies.[6]

3 Tax rate data

Part of this paper's contribution is the creation of a novel tax rate database. Our annual data consist of corporate and personal income tax rates as well as value-added tax rates for 62 countries – 20 industrial and 42 developing – for the period 1960-2009.[7,8] For corporate and personal income data we use top marginal tax rates. Most of the corporate and personal income tax data was obtained from the World

[4] See Appendix 4, Table 1A, column 1 for corresponding country statistics.

[5] See Appendix 4, Table 1A, columns 2-6 for individual country statistics.

[6] Appendix 3 reports the year in which the value-added tax was introduced in each country included in our study.

[7] See Appendix 2 for the list of countries.

[8] We excluded from our analysis major oil-producer countries such as Algeria, Angola, Azerbaijan, Bahrain, Ecuador, Gabon, Iran, Kuwait, Libya, Nigeria, Oman, Qatar, Saudi Arabia, Sudan, United Arab Emirates, Venezuela, and Yemen. For this group of countries oil revenues typically represent more than 60 percent of fiscal revenues. These revenues are raised in different ways; directly via state own enterprises and indirectly trough various specific taxes and royalties.

Development Indicators (WDI-World Bank) and World Tax Database (University of Michigan, Ross School of Business). Our data comprise, on average, about 30 and 40 years of personal and corporate income tax rate data, respectively.[9] Value-added data consist of a single standard rate.[10] Value-added data were obtained from various sources, including countries' revenue agencies, countries' national libraries, books, newspapers, tax law experts, as well as research and policy papers. We should note that for 55 out of the 62 countries included in the sample, we were able to gather the complete time series of the value-added tax rate (i.e., since its introduction).[11] We later use all of these tax rates to calculate an index of cyclicality of tax policy.

Needless to say, while fairly comprehensive, our dataset does not come free of limitations. First, it does not include all available tax rates such as social security, trade, property, alcohol, and tobacco, among others. Having said that, we should note that value-added and corporate and personal income taxes represent around 65 percent of total tax revenues in developing countries and almost 80 percent in industrial countries. Second, personal and corporate income taxes have several brackets and marginal rates associated with them. They also carry an intricate system of deductions and exemptions that complicate the calculation of average marginal tax rates. While some average marginal tax rates are available for some countries, they have been typically calculated for very short periods of time making them unsuitable for our kind of study.[12]

The five most important features of the tax rate data regarding cyclicality issues are as follows:

1. About two thirds of personal and corporate income tax rates changes are negative, both in industrial and developing countries. The opposite occurs with value-added rates; about two thirds of such changes are positive (Table 3). These patterns reflect a slow and moderate downward trend of personal and corporate income tax rates and an upward trend of value-added tax rates. Individual tax rates fell from about 50 percent in the early 1980s to 30 percent in the late 2000s. Similarly, corporate tax rates decreased from about 40 percent in the early 1980s to 25 percent in the late 2000s. On the other hand, value-added tax rates moderately increased from 15 percent in the early 1980s to about 17 percent in the late 2000s.

2. In spite of the above-mentioned differences in long-run trends across personal, corporate and value-added rates, tax rates changes are moderately synchronized in the short-run. In other words, they tend to comove together in the short-run in spite of showing, generally speaking,

[9] Appendix 3 describes the period of coverage for each tax in each country.

[10] We should note that while countries usually have a reduced value-added rate, it typically applies to particular goods such as some foodstuffs and child and elderly care.

[11] Appendix 3 describes each country year of introduction of value-added tax rate as well as its period of coverage.

[12] Appendix 5 show some evidence regarding the cyclicality of average marginal personal and corporate income tax rates for six industrial economies for the period 1981-2008.

different long-run patterns. Table 4 shows that we cannot reject that tax rates changes are positively correlated across different taxes.

3. A key difference between government spending and tax rates is that the latter rarely vary every year. While government spending occurs more or less continuously throughout the budget cycle, changes in tax rates do not occur every year presumably because they typically require explicit approval from congress/parliament. Indeed, the overall sample frequency of tax rate changes are 0.19, 0.18, and 0.10 for personal, corporate, and value-added taxes, respectively. Put differently, tax rates change, on average, about every 5 years for income taxes and every 10 years for value-added tax.

   Table 5, panel A shows that with the exception of the personal income tax, which varies more frequently in industrial countries, the frequency of tax rate changes is quite similar across industrial and developing countries.

4. Both industrial and developing countries share some common average variation in tax rates (Table 5, panel B). For personal and corporate income taxes, tax rates change about 3 percent annually for each group. This figure is about 2 percent for value-added taxes. Naturally, the annual average change in tax rates varies significantly across countries and taxes. For example, Norway's annual average change in personal income tax rate is about 6 percent. This is the result of frequent changes in this tax rate, which has fluctuated from values close to 70 percent during the 1970s to about 25 percent during the 1980s, and back up again to the 40 percent range in the early 2000s. At the other side of the spectrum, Korea has never changed its VAT tax rate (of 10 percent) since its introduction in January 1977.[13]

5. The similarity across groups of countries described above hides important differences regarding the magnitude of tax rate changes. When focusing only on tax rate changes different from zero, developing countries show larger magnitude of tax rate changes than industrial countries (Table 5, panel C). With the exception of corporate tax rates, the percentage change in tax rates is much higher – about 50 percent – for developing countries than industrial economies. For example, since its introduction in January 1, 1986 Portugal has changed its VAT rate by relatively small amounts: from 16 to 17 (February 1, 1988), from 17 to 16 (March 24, 1992), from 16 to 17 (January 1, 1995), from 17 to 19 (June 5, 2002), from 19 to 21 (July 1, 2005), and from 21 to 20 (July 1, 2008). At the other side of the spectrum, since its introduction on January 1, 1985, Turkey changed its VAT rate on May 15, 2001 from 10 to 18 percent; that is to say, a one time

[13] See Appendix 4, Table 4A, columns 1-3 for corresponding country statistics.

increase of 80 percent.

These findings regarding taxation policy (i.e., based on tax rates) are consistent with the regularities observed on the government consumption side; developing countries show more volatile fiscal policy than industrial economies. Indeed, annual average variation in real government spending is about 60 percent higher in developing countries than in industrial economies included in our sample.

4 Cyclicality of tax policy: Preliminary analysis

In this section we perform a first analysis of the cyclicality of tax policy. First we use tax rate changes. In particular, we calculate the average percentage tax rate changes in good, normal, and bad times. Later we focus on the cyclical component of tax rates; using both cross-country correlation plots and panel regression analysis. In each case we analyze the behavior of each tax rate as well as that of a tax index that weights the behavior of each tax rate by its relative importance. Specifically, the tax rate index is given by

$$c_{it}^{tax\ index} = w_i^{PIT} \times c_{it}^{PIT} + w_i^{CIT} \times c_{it}^{CIT} + w_i^{VAT} \times c_{it}^{VAT}, \tag{1}$$

where c_{it}^{PIT}, c_{it}^{CIT}, and c_{it}^{VAT} are the percentage changes or cyclical components of the personal income tax rate, corporate income tax rate, and value-added tax rate, respectively. The weights w_i^{PIT}, w_i^{CIT}, and w_i^{VAT} capture the country's average importance of each tax as a proportion of total tax revenues. This weighting structure aims at capturing the relative relevance of each tax in the tax system.

Table 6 shows the average tax rate change evaluated at different stances of the business cycle. While industrial countries reduce personal income tax rates both in good and bad times, developing economies strongly decrease them in good times. This suggests that personal income tax policy is acyclical in industrial countries and procyclical in developing ones. Corporate income tax rates increase in good times in industrial countries but increase in bad times in developing economies. This suggests that corporate income tax policy is countercyclical in industrial countries and procyclical in developing ones. Value-added tax rates decrease in good times in industrial countries and increase in bad times in developing economies. Therefore, both industrial and developing countries appear to be procyclical. The tax index, as defined in equation (1), decreases both in good and bad times in industrial countries. On the other hand, the tax index falls in good times and increases in bad times in developing economies. Tax policy thus appears to be acyclical in industrial countries and procyclical in developing countries.

We now focus on the behavior of the cyclical components of tax rates. Figure 6 shows country correlations between the cyclical components of personal income tax rate and real GDP. Industrial countries are evenly distributed: nine countries have countercyclical tax policy (i.e., positive correlation) and eleven countries show procyclicality (i.e., negative correlation). In sharp contrast, the number of developing economies pursuing procyclical tax policy is more than twice as many as the ones showing countercyclical tax policy. Panel regression analysis indeed supports acyclicality in industrial countries and weak procyclicality in developing countries (Table 7, columns 1 and 2).[14]

Figure 7 reports analogous results for the case of the corporate income tax. Once again, the distribution of industrial countries is about even: eleven countries have countercyclical tax policy (i.e., positive correlation) and nine countries show procyclical tax policy (i.e., negative correlation). In contrast, the number of developing countries pursuing procyclical policies is more than twice as many as the ones showing countercyclical policy. Panel regression analysis supports these findings (Table 7, columns 3 and 4).

Figure 8 shows country correlations between the cyclical components of value-added tax rate and real GDP. Unlike the pattern observed in Figures 6 and 7, about half of both industrial and developing countries show procyclical policy and less than a third show countercyclicality. Table 7, columns 5 and 6 support these findings; procyclical tax policy seems to be fairly common across the board.

Figure 9 shows country correlations between the cyclical tax index, as defined in equation (1), and real GDP. In some cases, a country's tax policy cyclicality reflects similar behavior of different types of tax rates over the business cycle. For example, personal and corporate income as well as value-added tax rates are procyclical in Bulgaria, Mexico and Peru. Conversely, taxes are countercyclical in Germany and Switzerland. In some other cases, the cyclicality of the tax rates varies across types of taxes; however, the overall behavior of the tax index mainly reflects that of the key taxes. For example, on the whole Turkey shows a procyclical tax policy. While personal income and value-added taxes are strongly procyclical, corporate income tax is countercyclical. The procyclicality of the tax system captured by the tax index reflects that while personal income and value-added taxes represent almost two thirds of revenues, corporate tax collection correspond to less than ten percent. In a similar vein, on the whole New Zealand exhibits a countercyclical tax policy. While personal and corporate income are countercyclical, the value-added tax is procyclical. The procyclicality of the tax system captured by the tax index reflects that while direct taxation represent almost two thirds of revenues, value-added tax collection corresponds to only around 20 percent.

[14] Throughout the paper we use the term "weak" to indicate coefficients that are significant only at the 15 percent level.

Figure 9 shows that industrial countries are evenly distributed: nine countries have countercyclical tax policy (i.e., positive correlation) while eleven countries show procyclical tax policy (i.e., negative correlation). Interestingly, but not surprisingly, United Kingdom, United States, Norway, and Switzerland pursue the most countercyclical tax policies among the industrial countries. At the other side of the spectrum, Spain, Italy, and Greece's tax policies are procyclical with correlation levels close to that of Mexico and Turkey. The number of developing countries pursuing procyclical policies is almost three times as many as those showing countercyclical tax policy. Panel regression analysis supports these findings (Table 7, columns 7 and 8).

In sum, our preliminary analysis supports the idea that tax rate policy is, broadly speaking, acyclical in developed countries and mostly procyclical in developing countries. Of course, correlations do not imply any particular direction of causation and it could well be that real GDP is responding to changes in tax policy rather than the other way around. The next section addresses such endogeneity issues.

5 Cyclicality of tax policy: Endogeneity issues

The panel data regression analysis of the previous section characterized the degree of pro/counter cyclicality of tax policy – both at the individual tax level and aggregate tax index – exploiting the comovements between the cyclical components of tax rates and real GDP. This implicitly assumes that there is no reverse causality; that is, causality runs from business cycle fluctuations to tax policy changes and not the other way around. While this has been the traditional approach in the literature, more recent studies (Rigobon, 2004; Jaimovich and Panizza, 2007; Ilzetzki and Végh, 2008) have shown that ignoring the problem of endogeneity can potentially lead to a misleading picture. In other words, the alleged procyclicality of tax policy identified in Section 4 could just reflect the effect of tax multipliers: when tax rates increase (decrease) output decreases (increases).

This section addresses endogeneity concerns by using instrumental variables. We use three instruments that have already been used in the literature. First, we use an instrument suggested by Jaimovich and Panizza (2007):

$$ShockJP_{it} = \frac{X_i}{GDP_i} \sum_j \phi_{ij,t-1} RGDPGR_{j,t}, \tag{2}$$

where $RGDPGR_j$ measures real GDP growth rate in country j, ϕ_{ij} is the fraction of exports from country i to country j, and X_i/GDP_i measures country's i's average exports expressed as share of

GDP.[15] This index of weighted real GDP growth of trading partners attempts to capture an external shock.[16]

Second, we use another external shock: changes in price of exports. This terms of trade based variable has been commonly suggested as a driver of business cycles (Mendoza, 1995; Ilzetzki and Végh, 2008). The effective change of prices of exports is measured as follows:

$$ShockPX_{it} = \frac{X_i}{GDP_i} PXGR_{it}, \tag{3}$$

where $PXGR_i$ measures price of exports growth rate in country i. This variable aims to capture the effective change of prices of exports. Lastly, we use an instrument proposed by Ilzetzki and Végh (2008) who suggest to use the change of real returns on U.S. Treasury bills to capture global liquidity conditions.[17]

In this section we also account for concerns regarding the structure of errors assumptions in the regression analysis. We allow errors to present arbitrary heteroskedasticity and arbitrary intra-country correlation (i.e., clustered by country). The relaxation of the non-autocorrelation assumption is important for a study using the cyclical components of both dependent variables and regressors.

Table 8 shows the first stage regression for instrumental variables estimates for each group of countries. For both groups of countries we can reject that instruments are weak (i.e., instruments are good predictors of the business cycle) at standard 5 percent confidence. The index of weighted real GDP growth of trading partners ($ShockJP$) is positive and strongly significant, indicating that an increase in real GDP of main trade partners boosts real GDP. Changes in the price of exportable goods ($ShockPX$) is positive. However, it is only statistically significant for industrial countries. This is mostly due to multicolinearity, especially with $ShockJP$.[18] The global interest rate is negatively related to the business cycle in developing countries but is statistically insignificant.

Table 9 shows the instrumental variables regressions for personal income, corporate income, and value-added tax rates as well as for the tax index. Before analyzing the regression results, two issues are

[15] As discussed in Jaimovich and Panizza (2007, page 13) "a time-invariant measure of exports over GDP is used because a time-variant measure would be affected by real exchange rate fluctuations, and, therefore, by domestic factors. This is not the case for the fraction of exports going to a specific country...because the variation of the exchange rate that is due to domestic factors has an equal effect on both numerator and denominator."

[16] Ilzetzki and Végh (2008, page 20) argue that while it is unlikely that current government spending of smaller economies has an effect on the growth rates of their trading partners, which include mainly larger economies, this could be the true in the case of larger economies in the sample and hence suggest that results for high-income countries should be taken with a grain of salt. Instead, for industrial countries' regressions, we use the lagged year trade partners real GDP growth rates (i.e., $RGDPGR_{j,t-1}$) rather than the current ones to avoid reverse causality concerns.

[17] Since this instrument might be endogenous in the case of the United States, we exclude this country from the instrumental variables analysis. As in Ilzetzki and Végh (2008), results are virtually unchanged when the United States is included.

[18] The spearman correlation coefficient between $ShockJP$ and $ShockPX$ is 0.31 and statistically significant at the 1 percent level.

worth noting. In all cases the over-identification tests cannot reject the null hypothesis that instruments are valid (i.e., uncorrelated with the error term) and correctly excluded from the estimation equation. Moreover, C-statistics validate the exogeneity of each instrument. These two findings, together with the absence of weak instruments described above, strongly support the validity and strength of our instrumental variables estimates.

Table 9, columns 1 and 2, supports the preliminary findings from Table 7, columns 1 and 2. Personal income taxation is acyclical in industrial countries and procyclical in developing economies. Table 9, columns 3 and 4, broadly supports the preliminary findings from Table 7, columns 3 and 4: industrial economies are more countercyclical in their corporate taxation than their developing counterparts. Corporate income taxation is weakly countercyclical in industrial countries and acyclical in developing economies. Findings for value-added tax rates (Table 9, columns 5 and 6) are quite different from those in Table 7, columns 3 and 4. While developing countries pursue procyclical value-added tax policy, industrial countries' procyclicality vanishes once endogeneity concerns are addressed. The latter occurs because (i) there is a shift in the coefficient distribution function to the right (from -0.26 in Table 7 to 0.15 in Table 9) and (ii) there is a widening in the coefficient distribution function (from an absolute t-statistic value of 2.6 in Table 7 to 0.9 in Table 9). The second feature is typical of IV regressions; estimates are less efficient. The first change supports the presumption regarding the relevance of reverse causality. That is to say, an increase (decrease) in value-added tax rates decreases (increases) output in developed countries and not the other way around. This rationale is consistent with Riera-Crichton, Végh, and Vuletin (2011) who find sizable tax multipliers for industrial countries. Table 9, columns 5 and 6, supports the preliminary findings from Table 7, columns 5 and 6. The tax index is acyclical in industrial countries and procyclical in developing economies.

To sum up, after addressing endogeneity concerns, we find that tax policy is acyclical in industrial countries. Such acyclicality is present not only at an aggregate level (i.e., tax index) but also for personal income and value-added taxation. Corporate income taxation is weakly countercyclical. On the other hand, procyclicality dominates the behavior of tax policy in developing countries both at the aggregate and individual tax level, with the exception of corporate taxation.

6 Model

This section develops a simple static model of optimal fiscal policy in the presence of uncertainty and incomplete markets that can generate both procyclical government spending and procyclical tax rate policy in response to fluctuations in output.[19] We will show that while government spending is procyclical regardless of preferences, the cyclicality of the tax rate depends on the cyclical behavior of public versus private spending.

Consider a one-period small open economy perfectly integrated into goods markets. There is a single tradable good in the world. There is uncertainty regarding the exogenous output path

$$
\begin{aligned}
y_H &= \bar{y} + \gamma, \\
y_L &= \bar{y} - \gamma,
\end{aligned} \tag{4}
$$

where $\bar{y} > 0$, $\gamma > 0$, and H and L denote the high output and low output state of nature, respectively. Output follows a binomial distribution with equal probability for each state of nature. Since $E(y) = \bar{y}$ and $V(y) = \gamma^2$, an increase in γ represents a mean preserving spread.[20]

Preferences follow the standard expected utility approach:

$$
U = \begin{cases} \underset{i=H,L}{E}\left[\alpha \dfrac{c_i^{1-\frac{1}{\sigma_c}} - 1}{1-\frac{1}{\sigma_c}} + (1-\alpha)\dfrac{g_i^{1-\frac{1}{\sigma_g}} - 1}{1-\frac{1}{\sigma_g}}\right], & \sigma_g \neq 1 \text{ and } \sigma_c \neq 1, \\ \underset{i=H,L}{E}\left[\alpha \ln(c_i) + (1-\alpha)\ln(g_i)\right], & \text{otherwise} \end{cases} \tag{5}
$$

where g is government spending, c represents private consumption, and $1 > \alpha > 0$.

The household constraints are given by[21]

$$
y_i = (1+\tau_i)c_i, \qquad i = L, H, \tag{6}
$$

where τ is the consumption tax.[22] The household chooses $\{c_H, c_L\}$ to maximize utility (5) subject to the constraints (6).

The government's constraints are given by

$$
\tau_i c_i = g_i, \qquad i = L, H. \tag{7}
$$

The government chooses $\{g_H, g_L, \tau_H, \tau_L\}$ to maximize utility (5) subject to constraints (7) and the implementability conditions derived from the household's problem.

[19] Due to space limitations we do not solve the complete markets case; see Végh (2011). In the presence of complete markets, there would be acyclicality both in spending and tax policies.

[20] Similar results would hold if the probability of each state of nature were allowed to differ from 0.5. However, the income process would need to be slightly modified for an increase in γ to still capture a mean preserving spread. In particular, $y_H = \bar{y} + (1-p)\gamma$ and $y_L = \bar{y} - p\gamma$, where p is the probability of the high state of nature.

[21] For simplicity, and with no loss of generality, we assume initial assets equal to zero.

[22] Similar results would hold for income taxation.

Combining the household's constraints, given by expressions (6), with the government's, given by equations (7), we obtain the economy's aggregate constraints:

$$c_i + g_i = y_i \qquad i = L, H. \tag{8}$$

For further reference, let us define two measures of cyclicality. The first measure (θ_g) captures the cyclicality of government spending:

$$\theta_g \equiv \ln\left(\frac{g_H}{g_L}\right). \tag{9}$$

A positive value of this measure, which means that $g_H > g_L$, would indicate procyclicality of government spending. Conversely, a negative value would be consistent with countercyclicality. If $g_H = g_L$, then $\theta_g = 0$ implying acyclicality.

By the same token, the second measure (θ_τ) captures the cyclicality of tax rates:

$$\theta_\tau \equiv \ln\left(\frac{\tau_H}{\tau_L}\right). \tag{10}$$

A positive value of this measure, which means that $\tau_H > \tau_L$, would indicate countercyclicality of tax policy. Conversely, a negative value would be consistent with procyclicality. If $\tau_H = \tau_L$, then $\theta_\tau = 0$ implying acyclicality.

Solving the Ramsey's planner problem, which in this case coincides with the planner's problem, we obtain the following four propositions.[23,24]

Proposition 1 *Government spending is procyclical.*

Naturally, the absence of complete markets induces the government to spend more in good times than in bad times. Formally,

$$\theta_g \equiv \ln\left(\frac{g_H}{g_L}\right) = \ln K\left(y_H\right) - \ln K\left(y_L\right) > 0, \tag{11}$$

because $K'(.) > 0$ and $y_H > y_L$.

Proposition 2 *Tax policy may be procyclical, countercyclical, or acyclical depending on the relationship between σ_g and σ_c. For the most realistic parameterization, where $\sigma_c > \sigma_g$, tax policy is procyclical.*

[23] For this simple model, the Ramsey's planner problem coincides with the planner problem because the consumption tax does not distort intertemporally (because it is a static model) and does not distort intratemporally (because households choose only one consumption good and there is no labor/leisure choice).

[24] See Appendix 6 for all derivations.

Formally,

$$\theta_\tau \equiv \ln\left(\frac{\tau_H}{\tau_L}\right) = \left(1 - \frac{\sigma_c}{\sigma_g}\right)\theta_g \gtreqless 0, \tag{12}$$

From proposition 1 $\theta_g > 0$. The first term is positive if $\sigma_c < \sigma_g$, zero if $\sigma_c = \sigma_g$, and negative if $\sigma_c > \sigma_g$. Hence, the tax rate is countercyclical if $\sigma_c < \sigma_g$, acyclical if $\sigma_c = \sigma_g$, and procyclical if $\sigma_c > \sigma_g$.

In order to understand the roles of σ_c and σ_g, it is important to recall that, taking into account (7) and (10), we can re-write (12) as follows

$$\theta_\tau \equiv \ln\left(\frac{\tau_H}{\tau_L}\right) = \ln\left(\frac{g_H/c_H}{g_L/c_L}\right). \tag{13}$$

Therefore, the tax rate cyclicality is tightly linked to the optimal ratio g/c across states of nature:

- If g/c is constant across states of nature (i.e., $g_H/c_H = g_L/c_L$), then $\tau_H = \tau_L$. Since c and g increase proportionately in the good state of nature, the higher tax base allows the Ramsey planner to leave the tax rate unchanged ($\tau_H = \tau_L$; acyclical tax rates). This case results when $\sigma_c = \sigma_g$. Same results are obtain when using CES preferences.[25]

- If $g_H/c_H > g_L/c_L$, then $\tau_H > \tau_L$. Since c increase *less* than proportionately than g in the good state of nature, the lower tax base induces the Ramsey planner to increase the tax rate ($\tau_H > \tau_L$; countercyclical tax rates). This case results when $\sigma_c < \sigma_g$.

- If $g_H/c_H < g_L/c_L$, then $\tau_H < \tau_L$. Since c increase *more* than proportionately than g in the good state of nature, the much higher tax base induces the Ramsey planner to reduce the tax rate ($\tau_H < \tau_L$; procyclical tax rates). This case results when $\sigma_c > \sigma_g$.

The data supports the latter case where the g/c ratio is higher is bad times than in good times. Specifically, panel regressions clustered by country as well as non-parametric statistics such as the Spearman correlation coefficient clearly suggest a negative relationship between the cyclical components of the ratio g/c and real GDP. With all countries included, the panel regression coefficient is -0.639 and statistically significant at the 1 percent level. The Spearman correlation coefficient is -0.294 and statistically significant at the 1 percent level. For industrial economies the panel regression coefficient is -0.972 and statistically significant at the 1 percent level (t-statistic = -8.39). The Spearman correlation coefficient is -0.405 and statistically significant at the 1 percent level. For developing countries the panel regression coefficient is -0.546 and statistically significant at the 1 percent

[25] CES preferences allow the optimal ratio g/c to vary with changes in the elasticity of substition. However, these preferences would imply that the ratio g/c does not vary across states of nature.

level (t-statistic $= -3.51$). The Spearman correlation coefficient is -0.217 and statistically significant at the 1 percent level.

In other words, for the most realistic parameterization where $\sigma_c > \sigma_g$, tax policy is procyclical (i.e., $\theta_\tau < 0$). If the ratio of government spending to private consumption (the tax base) is higher (lower) in the bad (good) state of nature, tax rate policy is procyclical. Intuitively, if government spending is high relative to the tax base in bad times, then the tax rate will need to be high as well in order to satisfy the government budget constraint. In good times, a low level of government spending relative to the tax base calls for a lower tax rate.

Proposition 3 *Government spending procyclicality is increasing in output volatility.*

Proposition 1 shows that the absence of complete markets induces government to spend more in good times than in bad times. Naturally, higher output volatility increases spending procyclicality. Formally, from (11) it is straightforward

$$\frac{d(\theta_g)}{d\gamma} = \frac{1}{2}\left[\frac{1}{K(y_H)}K'(y_H) + \frac{1}{K(y_L)}K'(y_L)\right] > 0, \tag{14}$$

because $K(.) > 0$, $K'(.) > 0$.[26]

Proposition 4 *For the most realistic parameterization, where $\sigma_c > \sigma_g$, tax policy procyclicality is increasing in output volatility.*

Formally, from (12) it is straightforward

$$\frac{d(\theta_\tau)}{d\gamma} = \left(1 - \frac{\sigma_c}{\sigma_g}\right)\frac{d(\theta_g)}{d\gamma} < 0, \tag{15}$$

because from (14) $\frac{d(\theta_g)}{d\gamma} > 0$ and $\sigma_c > \sigma_g$.

Moreover, from (13) and (15) it follows that

$$\frac{d[\ln \tau_H - \ln \tau_L]}{d\gamma} = \frac{d[\ln(g_H/c_H) - \ln(g_L/c_L)]}{d\gamma} = \left(1 - \frac{\sigma_c}{\sigma_g}\right)\frac{d(\theta_g)}{d\gamma} < 0. \tag{16}$$

From proposition 2 we know that, under the most realistic parameterization where $\sigma_c > \sigma_g$, the ratio of government spending to private consumption – which is the tax base – is higher (lower) in the bad (good) state of nature. Therefore, tax rate policy is procyclical. Equations (15) and (16) show that tax policy procyclicality is increasing in output volatility because the difference between the

[26] See Appendix 6 for derivations.

optimal g/c ratio in good and bad states of nature increases with output volatility. In other words, the pressure to collect (i.e., higher tax rates) is more important the larger is the economic downturn and less important during boom periods.

Indeed, propositions 3 and 4 are supported by the data. Figures 10 and 11 show that government spending and tax policy cyclicality are increasing in output volatility. The positive relationship between government spending cyclicality and output volatility shown in Figure 10 has been previously identified in the literature (Lane, 2003; Talvi and Végh, 2005; Frankel, Végh, and Vuletin, 2011). However, the positive relationship between tax policy cyclicality and output volatility (Figure 11) is a novel finding.

7 Conclusions

There is by now a strong consensus in the literature that government spending has been typically procyclical in developing countries and countercyclical or acyclical in industrial economies. The evidence on the taxation side is, however, almost non-existent due to the lack of data on tax rates. To analyze the cyclical properties of tax rate policy, we build a novel dataset on tax rates for 62 countries for the period 1960-2009 that comprises corporate income, personal income, and value-added tax rates.

We find that, by and large, tax policy is acyclical in industrial countries but procyclical in developing countries. We show that the evidence is consistent with a model of optimal fiscal policy under uncertainty. In the model, government spending is always procyclical regardless of preferences. Tax rate policy is procyclical as long as the ratio of public to private consumption is high in bad times and low in good times (the relevant case in practice). The model also predicts that both government spending and tax rates will be more procyclical the larger is output volatility. This prediction of the model is consistent with the evidence.

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Appendix 1. Definition of variables and sources

1.1 Macroeconomic data

Gross Domestic Product

World Economic Outlook (WEO-IMF) and International Financial Statistics (IFS-IMF) were the main data sources. Series NGDP (gross domestic product, current prices) for WEO and 99B for IFS-IMF. For Azerbaijan, Bahrain, Kuwait, Libya, Qatar, and United Arab Emirates data were provided by Middle East Department at the IMF. Data period covers 1960-2009.

Government expenditure

World Economic Outlook (WEO-IMF) was the main data source, series GCENL (central government, total expenditure and net lending). Due to non availability of central government data, general government data were used for Azerbaijan, Ecuador, Kuwait, Libya, Qatar, and United Arab Emirates. For Azerbaijan, Bahrain, Kuwait, Libya, Qatar, and United Arab Emirates data were provided by Middle East Department at the IMF. For Brazil data was from Instituto de Pesquisa Econômica Aplicada (IPEA). Data period covers 1960-2009.

Private consumption

World Economic Outlook (WEO-IMF) was the main data source, series NCP (Private consumption expenditure, current prices). Data period covers 1960-2009.

Government total revenue

World Economic Outlook (WEO-IMF) was the main data source, series GCRG (central government, total revenue and grants). Due to non availability of central government data, general government data were used for Ecuador, Kuwait, Libya, Qatar, and United Arab Emirates. For Azerbaijan, Bahrain, Kuwait, Libya, Qatar, and United Arab Emirates data were provided by Middle East Department at the IMF. Data period covers 1960-2009.

GDP deflator

World Economic Outlook (WEO-IMF) and International Financial Statistics (IFS-IMF) were the main data sources. Series NGDP_D (gross domestic product deflator) for WEO-IMF and 99BIP for IFS-IMF. For Azerbaijan, Bahrain, Kuwait, Libya, Qatar, and United Arab Emirates data were provided by Middle East Department at the IMF. Data period covers 1960-2009.

Consumer price index

World Economic Outlook (WEO-IMF) and International Financial Statistics (IFS-IMF) were the main data sources. Series PCPI (consumer price index) for WEO-IMF and 64 for IFS-IMF. For Azerbaijan and Kuwait data were taken from Global Financial Data (GFD). Data period covers 1960-2009.

Government tax structure data

Government Finance Statistics (GFS-IMF) was the data source for Government tax structure data. Data for Australia were from Australian Government Budget Office.
The variables are defined as follows: tax revenue (Central government, taxes. Series cB_BA_11 and aB_BA_11), tax revenue on income, profits and corporations (Central government, taxes on income, profits and corporations. Series cB_BA_111 and aB_BA_111), personal income tax revenue (Central government, taxes on individuals. Series cB_BA_1111 and aB_BA_1111), corporate income tax revenue (Central government, taxes on corporations. Series cB_BA_1112 and aB_BA_1112), goods and services tax revenue (Central government, taxes on goods and services. Series cB_BA_114 and aB_BA_114), and value added tax revenue (Central government, value added tax. Series cB_BA_11411 and aB_BA_11411). Data period covers 1990-2009.

Exports of goods and services (as % of GDP)

World Economic Outlook (WEO-IMF) and World Development Indicators (WDI-World Bank) were the main data source, series BX and NGDPD (WEO-IMF) and NE.EXP.GNFS.ZS (WDI-World Bank). Data period covers 1960-2009.

Global interest rate

Global interest rate was calculated by deflating the returns on U.S. Treasuries by the CPI inflation rate of the previous year. As Ilzetzki and Végh (2008), we use an adaptive-expectations measure of real interest rates. These variables were obtained from International Financial Statistics (IFS-IMF). Data period covers 1960-2009.

Real external shock (ShockJP)

Following Jaimovich and Panizza (2007) we created an index of weighted GDP growth of trading partners. In particular,

$$ShockJP_{it} = \frac{X_i}{GDP_i} \sum_j \phi_{ij,t-1} RGDPGR_{j,t} ,$$

where $RGDPGR_j$ measures real GDP growth rate in country j, ϕ_{ij} is the fraction of export from country i going to country j, and X_i / GDP_i measures country i's average exports expressed as share of GDP.
Export weights data was from Robert Feenstra and Robert Lipsey, NBER-United Nations Trade Data, 1962-2000 (http://cid.econ.ucdavis.edu/) for period 1962-1985 and from Direction of Trade Statistics database (DOTS-IMF) for the period 1986-2009. Data period covers 1962-2009.

Real external shock (ShockPX)

We created the following index of price of exports,

$$ShockPX_{it} = \frac{X_i}{GDP_i} PEGR_{it} ,$$

where $PEGR_i$ measures price of exports growth rate in country i and X_i / GDP_i measures country i's average exports expressed as share of GDP.
World Economic Outlook (WEO-IMF) and International Financial Statistics (IFS-IMF) were the main data sources for price of exports. Series TXG_D (price deflator for exports of goods) for WEO and 74 for IFS-IMF. Data period covers 1962-2009.

Appendix 2. Countries in the tax rate sample

TABLE 1A

Countries in the tax sample

Industrial countries (20)	Developing countries (42)	
Australia	Argentina	Kenya
Austria	Barbados	Korea
Belgium	Bolivia	Latvia
Canada	Botswana	Lithuania
Denmark	Brazil	Malta
Finland	Bulgaria	Mauritius
France	Chile	Mexico
Germany	China	Namibia
Greece	Colombia	Pakistan
Italy	Costa Rica	Papua New Guinea
Japan	Czech Rep.	Paraguay
Luxembourg	Dominican Rep.	Peru
New Zealand	El Salvador	Philippines
Norway	Ethiopia	Romania
Portugal	Fiji	Russia
Spain	Georgia	South Africa
Sweden	Ghana	Tanzania
Switzerland	Honduras	Thailand
United Kingdom	Hungary	Turkey
United States	India	Uruguay
	Jamaica	Zambia

Notes: Total number of countries is 62.

Appendix 3. Tax period coverage

TABLE 2A

Tax period coverage

	Corporate income tax rate	Personal income tax rate	Value-added tax rate		
	Period of coverage	Period of coverage	Year of introduction	Period of coverage	Period of coverage (as % of maximum potential)
Argentina	1979-2009	1976-2009	1974	1974-2009	100
Australia	1960-2009	1974-2009	2000	2000-2009	100
Austria	1960-2009	1975-2009	1973	1973-2009	100
Barbados	1960-2009	1974-2009	1997	1997-2009	100
Belgium	1960-2009	1975-2009	1971	1971-2009	100
Bolivia	1979-2009	1976-2006	1973	1994-2009	41.7
Botswana	1960-2009	1974-2009	2002	2002-2009	100
Brazil	1979-2009	1974-2009			
Bulgaria	1993-2009	1995-2009	1994	1994-2009	100
Canada	1960-2009	1975-2009	1991	1991-2009	100
Chile	1979-2009	1974-2009	1975	1975-2009	100
China	1980-2009	1981-2009	1994	1994-2009	100
Colombia	1979-2009	1976-2009	1989	1989-2009	100
Costa Rica	1979-2009	1974-2009	1975	1999-2009	29.4
Czech Rep.	1991-2009	1991-2009	1993	1993-2009	100
Denmark	1962-2009	1975-2009	1967	1967-2009	100
Dominican Rep.	1979-2009	1979-2007	1983	1992-2009	65.4
El Salvador	1979-2009	1974-1999	1992	1992-2009	100
Ethiopia	1995-2009	2002-2007	2003	2003-2009	100
Fiji	1960-2009	1976-2007	1992	1992-2009	100
Finland	1960-2009	1974-2009	1995	1995-2009	100
France	1960-2009	1975-2009	1948	1968-2009	67.2
Georgia	1992-2007	1992-2009	1992	1992-2009	100
Germany	1960-2009	1975-2009	1968	1968-2009	100
Ghana	1960-2009	1991-2009	1998	1998-2009	100
Greece	1961-2009	1975-2009	1987	1987-2009	100
Honduras	1979-2009	1979-2007	1976	2000-2009	27.3
Hungary	1990-2009	1990-2009	1988	1988-2009	100
India	1960-2009	1974-2009	2005	2005-2009	100
Italy	1960-2009	1975-2009	1973	1973-2009	100
Jamaica	1960-2009	1974-2009	1991	1991-2009	100
Japan	1960-2009	1972-2009	1989	1989-2009	100
Kenya	1960-2009	1974-2004	1990	2000-2009	47.4
Korea	1980-2009	1974-2009	1978	1978-2009	100
Latvia	1995-2009	1995-2009	1992	1992-2009	100
Lithuania	1993-2009	1994-2009	1994	1994-2009	100
Luxembourg	1963-2009	1974-2009	1970	1970-2009	100
Malta	1960-2009	1981-2009	1995	1995-2009	100
Mauritius	1960-2009	1988-2009	1998	1998-2009	100
Mexico	1980-2009	1974-2009	1980	1980-2009	100
Namibia	1991-2009	1991-2009	2000	2000-2009	100
New Zealand	1960-2009	1974-2009	1987	1987-2009	100
Norway	1960-2009	1974-2009	1970	1970-2009	100
Pakistan	1960-2009	1974-2009	1995	1995-2009	100
Papua New Guinea	1960-2009	1974-2009	1999	1999-2009	100
Paraguay	1979-2009	1974-2009	1991	1991-2009	100
Peru	1979-2009	1976-2009	1973	1982-2009	75
Philippines	1980-2009	1974-2009	1988	1988-2009	100
Portugal	1964-2009	1976-2009	1986	1986-2009	100

TABLE 2A cont.

Tax period coverage

	Corporate income tax rate	Personal income tax rate	Value-added tax rate		
	Period of coverage	Period of coverage	Year of introduction	Period of coverage	Period of coverage (as % of maximum potential)
Romania	1993-2009	1994-2009	1994	1994-2009	100
Russia	1990-2009	1990-2009	1992	1992-2009	100
South Africa	1960-2009	1974-2009	1992	1992-2009	100
Spain	1965-2009	1975-2009	1986	1986-2009	100
Sweden	1960-2009	1974-2009	1969	1969-2009	100
Switzerland	1960-2009	1975-2009	1995	1995-2009	100
Tanzania	1960-2009	1988-2009	1998	1998-2009	100
Thailand	1975-2009	1974-2009	1992	1992-2009	100
Turkey	1983-2009	1975-2009	1985	1985-2009	100
United Kingdom	1978-2009	1975-2009	1973	1973-2009	100
United States	1960-2009	1960-2009			
Uruguay	1979-2009	1976-2009	1969	1969-2009	100
Zambia	1963-2009	1974-2004	1995	1995-2009	100

Notes: Total number of countries is 62. The value-added tax in Brazil is levied by states (for goods) and by municipalities (for services). The United States does not have a value-added tax. The sales tax in the United States is levied by states.

Appendix 4. Individual country revenue and tax statistics

TABLE 3A

Tax revenue structure: Country tax burden and tax revenue composition

	Revenues (as % of GDP)	Tax revenue on income, profits, and corporations (as % of total tax revenues)	Personal income tax revenues (as % of total tax revenues)	Corporate income tax revenues (as % of total tax revenues)	Good and services tax revenues (as % of total tax revenues)	Value-added tax revenues (as % of total tax revenues)
	(1)	(2)	(3)	(4)	(5)	(6)
Argentina	15.50	21.44	6.73	14.70	61.88	44.55
Australia	23.86	72.87	44.06	22.63	27.13	15.50
Austria	23.42	46.35	36.18	8.74	45.19	27.84
Bangladesh	8.08	18.27	9.99	8.28	37.29	35.50
Barbados	37.10	36.15	17.52	16.45	45.19	32.04
Belgium	31.38	59.54	47.13	12.16	38.04	26.15
Benin	16.17	22.48	9.89	12.18	43.02	41.33
Bolivia	16.55	12.86	0.00	12.86	66.33	35.74
Botswana	33.28	57.98	7.60	44.95	6.98	6.45
Brazil	14.28	42.00	2.74	11.30	52.41	17.49
Bulgaria	35.64	23.78	11.43	11.62	73.19	47.93
Cambodia	8.24	10.83	2.51	8.32	53.55	33.85
Cameroon	15.49	27.76	12.91	14.86	31.08	.
Canada	16.82	74.80	55.00	16.93	23.40	17.89
Cape Verde	28.83	29.82	16.95	12.87	54.15	36.98
Central African Rep.	14.62	22.62	13.39	8.66	38.82	29.42
Chad	22.45	.	.	.	.	.
Chile	22.51	36.75	12.25	24.50	55.02	44.94

TABLE 3A cont.

Tax revenue structure: Country tax burden and tax revenue composition

	Revenues (as % of GDP) (1)	Tax revenue on income, profits, and corporations (as % of total tax revenues) (2)	Personal income tax revenues (as % of total tax revenues) (3)	Corporate income tax revenues (as % of total tax revenues) (4)	Good and services tax revenues (as % of total tax revenues) (5)	Value-added tax revenues (as % of total tax revenues) (6)
China	21.47	25.92	7.18	18.73	77.73	62.54
Colombia	9.58	40.45	2.19	38.25	49.35	43.50
Congo, Dem. Rep. of	7.30	27.63	12.05	15.17	23.50	.
Congo, Rep. of	26.42	12.84	6.57	6.27	62.70	18.15
Costa Rica	11.39	20.03	6.02	14.02	56.57	34.46
Cyprus	37.94	39.75	16.95	22.12	50.03	29.39
Czech Rep.	32.05	42.25	20.30	21.95	55.51	31.65
Côte d'Ivoire	25.00	27.32	12.86	14.46	13.80	6.97
Denmark	36.82	43.75	35.06	8.69	48.54	30.98
Dominican Rep.	12.06	22.06	5.70	10.86	53.82	28.85
Egypt	27.64	41.54	10.19	31.35	39.09	28.28
El Salvador	14.64	31.77	15.27	16.50	58.27	53.04
Estonia	32.06	27.15	17.82	9.33	72.73	50.47
Ethiopia	14.29	30.65	8.67	19.72	25.09	2.73
Fiji	25.08	33.40	16.88	13.21	45.46	38.25
Finland	25.23	37.23	25.65	11.39	59.87	35.87
France	19.49	36.42	22.15	14.27	55.61	39.95
Gambia	22.52	14.00	5.28	8.62	40.29	.
Georgia	15.21	11.55	4.97	6.58	80.52	62.76
Germany	14.11	44.45	38.63	5.17	55.55	27.59
Ghana	15.74	26.64	11.16	13.89	41.45	19.28
Greece	30.82	37.59	22.48	14.25	57.02	32.94
Guatemala	10.53	27.15	2.11	17.68	60.28	46.34
Haiti	10.26	.	.	.	.	.
Honduras	13.09	27.59	14.12	13.47	62.78	36.77
Hong Kong	15.84	.	.	.	.	.
Hungary	38.14	34.61	24.36	10.25	58.15	36.82
India	9.44	34.85	14.69	19.72	38.89	0.21
Indonesia	14.65	57.25	21.17	34.76	35.22	.
Ireland	34.68	49.48	35.62	13.81	41.11	27.41
Israel	38.87	47.18	31.87	13.43	44.14	29.95
Italy	27.66	55.55	43.24	12.29	35.83	23.45
Jamaica	23.00	40.22	15.65	17.39	39.68	33.78
Japan	11.76	67.40	41.34	26.06	22.17	10.48
Jordan	25.88	15.86	4.46	11.06	42.36	0.00
Kenya	17.94	39.59	21.29	18.33	47.78	28.56
Korea	18.81	39.97	20.46	19.51	42.51	27.31
Laos	11.90	25.39	.	.	60.44	.
Latvia	26.73	25.24	9.61	15.64	73.00	49.64
Lithuania	27.70	28.23	15.33	12.90	71.17	47.31
Luxembourg	38.56	46.34	28.30	18.04	47.47	22.39
Madagascar	14.25	17.62	5.49	9.17	26.99	.
Malaysia	26.82	57.51	14.11	43.20	30.55	.
Mali	16.64	20.85	6.39	13.60	54.17	40.47
Malta	38.29	43.01	23.47	19.28	50.00	27.65
Mauritius	21.53	17.53	7.37	9.94	52.09	35.78

TABLE 3A cont.

Tax revenue structure: Country tax burden and tax revenue composition

	Revenues (as % of GDP)	Tax revenue on income, profits, and corporations (as % of total tax revenues)	Personal income tax revenues (as % of total tax revenues)	Corporate income tax revenues (as % of total tax revenues)	Good and services tax revenues (as % of total tax revenues)	Value-added tax revenues (as % of total tax revenues)
	(1)	(2)	(3)	(4)	(5)	(6)
Mexico	13.79	43.26	14.42	28.84	73.18	27.59
Morocco	20.75	37.11	18.78	18.01	44.07	29.55
Mozambique	16.62	31.42	16.47	14.79	58.36	38.34
Myanmar	9.33	30.11	30.11	0.00	49.77	.
Namibia	31.21	39.27	23.90	15.37	21.92	21.15
Nepal	10.66	18.46	1.33	14.19	46.60	34.91
Netherlands	30.24	46.68	29.66	17.02	47.77	30.04
New Zealand	34.80	66.33	51.26	15.07	30.29	21.80
Nicaragua	21.62	27.93	.	.	65.54	41.58
Niger	21.48	17.84	6.20	10.90	27.17	19.78
Norway	42.13	53.55	18.25	35.20	44.24	29.54
Pakistan	13.73	24.28	4.21	22.10	39.97	26.51
Panama	19.15	38.02	1.84	12.27	33.07	.
Papua New Guinea	23.68	54.14	26.56	26.86	12.41	12.41
Paraguay	12.70	18.52	0.00	18.52	59.06	42.94
Peru	13.68	29.91	9.57	20.34	54.40	40.74
Philippines	15.13	45.32	15.73	23.37	29.95	14.29
Poland	31.66	27.82	17.07	10.75	70.49	43.69
Portugal	20.70	40.13	26.02	14.11	55.90	33.26
Romania	25.68	28.88	5.99	22.62	66.26	40.19
Russia	29.94	10.75	0.03	10.56	60.64	49.19
Rwanda	13.87	19.49	9.40	4.81	39.04	.
Senegal	18.98	23.21	12.27	7.94	32.03	32.03
Seychelles	36.01	19.95	1.24	18.71	26.99	31.23
Sierra Leone	17.22	25.11	11.15	13.23	26.81	0.00
Singapore	.	46.59	.	.	32.52	12.32
South Africa	20.75	57.29	30.75	26.54	35.16	26.70
Spain	18.53	58.75	37.09	21.66	40.76	26.79
Sri Lanka	18.70	16.09	5.33	8.72	60.43	34.89
Swaziland	24.68	27.68	16.74	9.95	17.00	.
Sweden	31.65	24.44	11.47	12.97	56.48	37.39
Switzerland	9.48	33.53	22.30	11.23	59.66	38.48
Syrian Arab Rep.	23.28	33.99	.	.	42.42	.
Tanzania	15.96	24.00	12.00	7.00	65.00	36.00
Thailand	16.55	45.93	12.74	33.20	46.11	22.10
Togo	23.81	22.21	6.68	11.28	50.42	40.86
Trinidad and Tobago	32.51	54.36	23.00	26.48	34.41	.
Tunisia	24.37	28.86	15.87	11.95	42.41	31.58
Turkey	15.98	44.48	34.20	9.19	46.10	29.85
Uganda	12.77	22.16	8.53	11.44	55.45	31.83
United Kingdom	33.82	49.82	37.58	12.24	40.54	22.88
United States	18.66	89.80	73.96	15.85	6.03	0.00
Uruguay	20.22	17.40	6.28	10.48	60.65	39.97
Zambia	29.51	43.46	34.17	9.29	43.96	29.71

TABLE 4A

Tax rate data: Country characteristics

	Percentual absolute change in tax rates. Including zero changes			Frequency of tax rate changes			Percentual absolute change in tax rates. Without including zero changes		
	PIT (1)	CIT (2)	VAT (3)	PIT (4)	CIT (5)	VAT (6)	PIT (7)	CIT (8)	VAT (9)
Argentina	1.75	3.40	4.87	0.13	0.13	0.26	13.14	26.36	18.92
Australia	1.00	2.11	0.00	0.20	0.24	0.00	4.99	8.84	.
Austria	0.57	2.30	0.66	0.03	0.09	0.06	19.35	24.72	11.81
Barbados	1.65	1.85	1.19	0.13	0.14	0.07	12.40	13.23	16.67
Belgium	1.05	2.39	1.03	0.15	0.17	0.16	6.81	14.36	6.55
Bolivia	4.20	0.00	0.00	0.09	0.00	0.00	48.33	.	.
Botswana	2.58	2.25	2.50	0.16	0.10	0.13	16.02	22.52	20.00
Brazil	6.28	2.29	0.00	0.23	0.10	0.00	26.90	23.65	.
Bulgaria	8.38	9.07	2.09	0.33	0.47	0.13	25.14	19.28	15.66
Canada	1.33	3.28	1.72	0.08	0.23	0.11	17.28	14.32	15.48
Chile	1.74	7.87	0.46	0.25	0.31	0.06	6.96	25.57	7.78
China	0.00	2.31	0.00	0.00	0.10	0.00	.	23.07	.
Colombia	2.86	2.51	2.83	0.18	0.31	0.10	16.01	8.09	28.33
Costa Rica	3.00	1.65	6.25	0.07	0.06	0.10	45.00	25.56	62.50
Czech Rep.	5.95	4.99	1.12	0.36	0.63	0.13	16.66	7.91	8.99
Denmark	12.76	2.96	2.49	0.37	0.27	0.12	34.44	11.11	20.96
Dominican Rep.	3.30	3.55	4.90	0.14	0.23	0.12	24.22	15.72	41.67
El Salvador	2.58	1.54	1.76	0.09	0.10	0.06	28.33	15.87	30.00
Ethiopia	0.00	3.12	0.00	0.00	0.20	0.00	.	15.60	.
Fiji	1.48	1.30	1.47	0.15	0.16	0.06	9.62	8.14	25.00
Finland	3.52	3.40	0.00	0.44	0.24	0.00	8.05	14.15	.
France	2.40	0.79	1.73	0.30	0.18	0.17	7.88	4.37	10.11
Georgia	2.94	2.86	2.94	0.06	0.07	0.11	50.00	42.86	26.43
Germany	0.82	3.40	1.65	0.13	0.16	0.17	6.60	21.24	9.67
Ghana	3.17	3.09	2.27	0.13	0.25	0.09	25.32	12.34	25.00
Greece	2.26	3.23	1.33	0.15	0.29	0.14	14.67	11.29	9.72
Honduras	1.49	5.04	0.00	0.07	0.13	0.00	20.83	39.08	.
Hungary	3.51	6.86	0.95	0.37	0.25	0.05	9.52	27.45	20.00
India	2.79	6.58	0.00	0.15	0.34	0.00	18.13	19.35	.
Italy	1.38	4.73	1.55	0.20	0.16	0.11	6.88	29.57	13.95
Jamaica	2.39	1.93	3.06	0.07	0.12	0.17	33.51	16.05	18.33
Japan	2.67	1.30	3.33	0.14	0.22	0.05	19.75	5.91	66.67
Kenya	2.65	7.87	1.11	0.22	0.20	0.10	11.92	39.33	11.11
Korea	1.51	1.84	0.00	0.21	0.23	0.00	7.24	7.87	.
Latvia	2.61	3.11	3.92	0.14	0.20	0.12	18.29	15.56	33.33
Lithuania	5.24	3.22	0.37	0.33	0.12	0.07	15.71	27.37	5.56
Luxembourg	0.99	1.74	1.79	0.24	0.22	0.08	4.13	7.84	23.33
Malta	1.65	1.42	1.43	0.04	0.06	0.07	46.15	23.68	20.00
Mauritius	4.26	2.19	4.09	0.16	0.10	0.18	26.98	23.05	22.50
Mexico	2.99	2.08	4.60	0.30	0.40	0.10	9.97	5.21	44.44
Namibia	2.80	0.68	0.00	0.39	0.11	0.00	7.20	6.45	.
New Zealand	2.69	2.25	1.14	0.20	0.14	0.05	13.47	16.09	25.00
Norway	6.12	0.35	0.59	0.55	0.06	0.10	11.22	5.76	5.76
Pakistan	3.39	4.11	0.00	0.14	0.26	0.00	23.71	15.82	.
Papua New Guinea	3.58	2.41	0.00	0.21	0.18	0.00	16.89	13.40	.
Paraguay	9.09	2.69	0.00	0.06	0.06	0.00	100.00	41.67	.
Peru	3.69	2.42	9.07	0.23	0.16	0.41	16.35	15.03	22.27
Philippines	1.84	1.08	0.95	0.13	0.17	0.05	14.71	6.50	20.00
Portugal	2.15	4.88	1.98	0.15	0.30	0.26	13.99	16.51	7.57
Romania	6.41	5.05	2.39	0.20	0.18	0.13	32.04	28.59	17.93
Russia	8.89	3.30	3.95	0.26	0.25	0.29	33.79	13.18	13.41
South Africa	0.74	2.44	2.35	0.15	0.26	0.06	4.79	9.57	40.00
Spain	4.12	1.09	1.32	0.38	0.11	0.13	10.70	9.85	10.13
Sweden	7.28	2.87	2.84	0.63	0.12	0.15	11.65	23.89	18.90
Switzerland	0.90	7.32	1.19	0.14	0.07	0.14	6.27	104.92	8.36
Tanzania	5.32	9.21	0.00	0.29	0.16	0.00	18.62	57.87	.
Thailand	1.46	0.43	4.29	0.06	0.03	0.12	24.06	14.29	36.43
Turkey	3.83	4.22	3.33	0.33	0.15	0.04	11.48	28.50	80.00
United Kingdom	1.04	1.85	3.85	0.03	0.25	0.11	33.33	7.39	34.61
United States	3.53	1.25	0.00	0.31	0.18	0.00	11.54	6.92	.
Uruguay	0.00	2.18	2.49	0.03	0.13	0.15	.	16.90	16.60
Zambia	3.21	2.22	1.40	0.13	0.21	0.13	24.62	10.42	10.54

Notes: PIT, CIT and VAT stand for personal income tax, corporate income tax and value-added tax respectively.

Appendix 5

In this section we perform analyses similar to that of Sections 4 and 5 using average marginal personal and corporate income tax rates for six industrial economies (Australia, Belgium, France, Germany, United Kingdom, and United States) for the period 1981-2008.[27] It is worth noting that the Spearman rank correlations between our top marginal tax rates and the average marginal ones are 0.26 and 0.54 for personal and corporate income taxes. For both taxes, such relationship is statistically significant at the 1 percent level; supporting the use of top marginal rates as proxy for average marginal ones.

Columns 1 and 2 in Table 5A show analogous basic panel regressions to that of columns 1 and 3 in Table 7 using average marginal as opposed to top marginal tax rates. Similarly, columns 3 and 4 in Table 5A show similar instrumental variables panel regressions to that of columns 1 and 3 in Table 9. Like our findings, acyclicality in tax rates are supported even after considering potential endogeneity concerns.

TABLE 5A

Cyclicality of tax policy: Average marginal tax rates

	Basic panel regressions		Instrumental variables regressions	
	Personal income tax	Corporate income tax	Personal income tax	Corporate income tax
	(1)	(2)	(3)	(4)
RGDP cycle	-0.51 [-1.1]	-0.05 [-0.3]	-1.19 [-1.2]	-0.10 [-0.2]
STATISTICS				
Weak-identification test (p-value)			0.016	0.001
Over-identification test (p-value)			0.57	0.22
Exogeneity of ShockPX (p-value)			0.29	0.31
Exogeneity of ShockJP (p-value)			0.88	0.12
Exogeneity of Global int. rate (p-value)			0.79	0.39
Number of observattions	147	168	135	151
Number of countries	6	6	6	6

[27] We would like to thank Ethan Ilzetzki for sharing this dataset.

Appendix 6

This appendix solves the Ramsey's planner problem, which in this case coincides with the planner problem, of the model from Section 6.[28] The planner chooses an allocation $\{c_H, c_L, g_H, g_L\}$ to maximize the households' utility (8) subject to the economy's aggregate constraints (given by (8)). From first order conditions we obtain

$$c_i = g_i^{\frac{\sigma_c}{\sigma_g}} \left(\frac{\alpha}{1-\alpha}\right)^{\sigma_c} \qquad i = L, H. \tag{17}$$

Replacing (17) in (8) we obtain

$$g_i + g_i^{\frac{\sigma_c}{\sigma_g}} \left(\frac{\alpha}{1-\alpha}\right)^{\sigma_c} = y_i \qquad i = L, H. \tag{18}$$

While we cannot obtain a reduced-form solution for g_i from (18) for the general case when $\sigma_c \neq \sigma_g$, we can still characterize its relationship with y_i. Defining $k(g_i) \equiv g_i + g_i^{\frac{\sigma_c}{\sigma_g}} \left(\frac{\alpha}{1-\alpha}\right)^{\sigma_c}$, we can write (18) as follows

$$k(g_i) = y_i, \tag{19}$$

where $k'(g_i) = 1 + \left(\frac{\alpha}{1-\alpha}\right)^{\sigma_c} \frac{\sigma_c}{\sigma_g} g_i^{\frac{\sigma_c}{\sigma_g}-1} > 0$. Therefore, we can characterize g_i's relationship with y_i as follows

$$g_i = K(y_i), \tag{20}$$

where $K(y_i) > 0$ and $K'(y_i) > 0$. Considering (20) and (9) we show that

$$\theta_g \equiv \ln\left(\frac{g_H}{g_L}\right) = \ln K(y_H) - \ln K(y_L) > 0 \tag{21}$$

because $K'(.) > 0$ and $y_H > y_L$.

Considering (7) and (17) we can show that

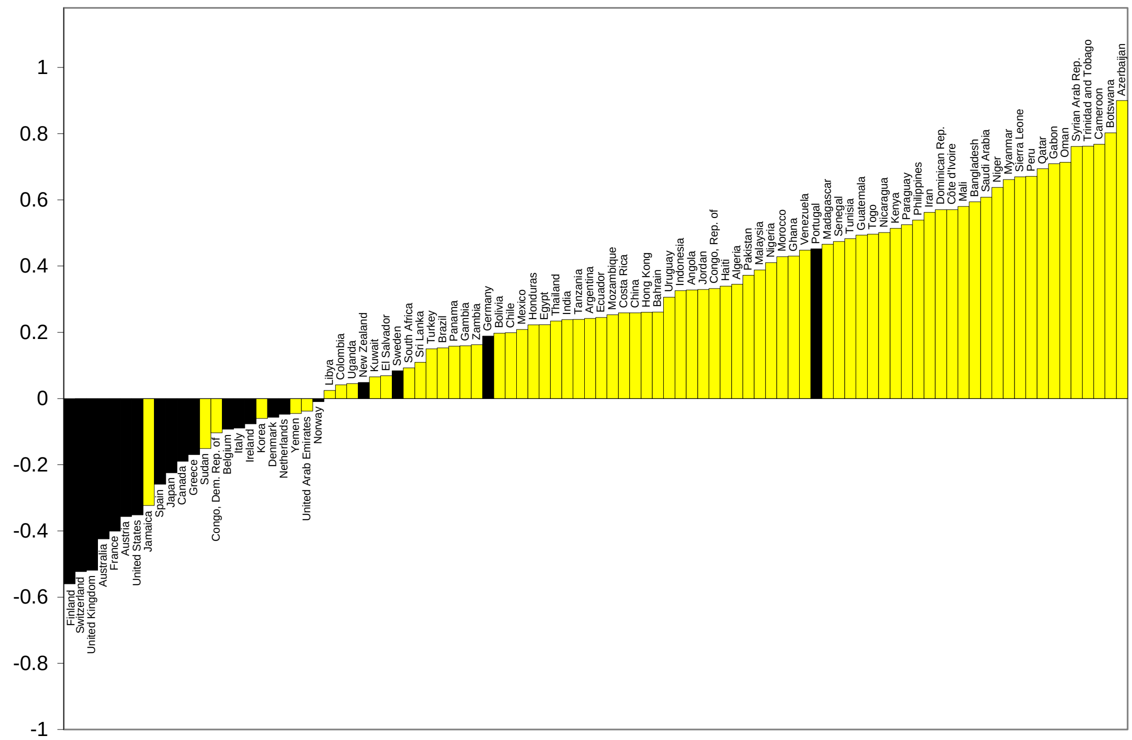
$$\tau_i = g_i^{1-\frac{\sigma_c}{\sigma_g}} \left(\frac{1-\alpha}{\alpha}\right)^{\sigma_c} \qquad i = L, H. \tag{22}$$

Combining (10), (21), and (22) we obtain

$$\theta_\tau \equiv \ln\left(\frac{\tau_H}{\tau_L}\right) = \left(1 - \frac{\sigma_c}{\sigma_g}\right)\theta_g \gtrless 0 \tag{23}$$

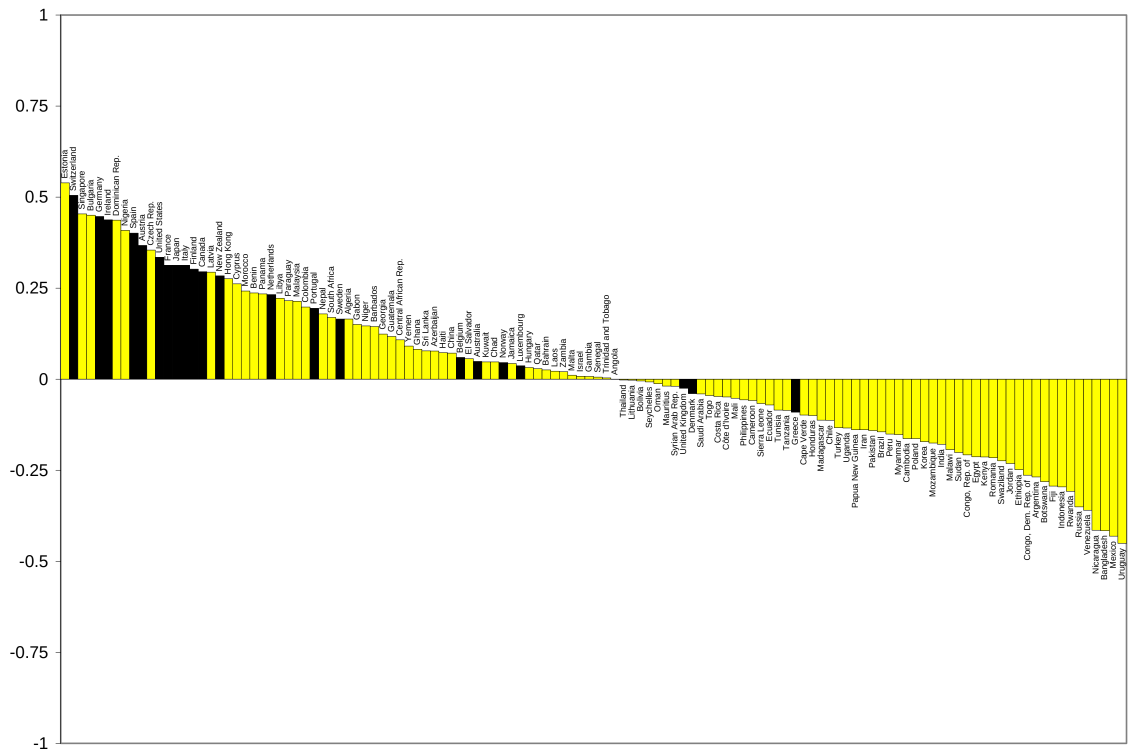
[28] For this simple model the Ramsey's planner problem coincides with the planner problem because taxes are non-distortive. Since output is assumed exogenous there is no distortion originated from labor-leisure decisions.

Figure 1. Country correlations between the cyclical components of real government expenditure and real GDP. 1960-2009



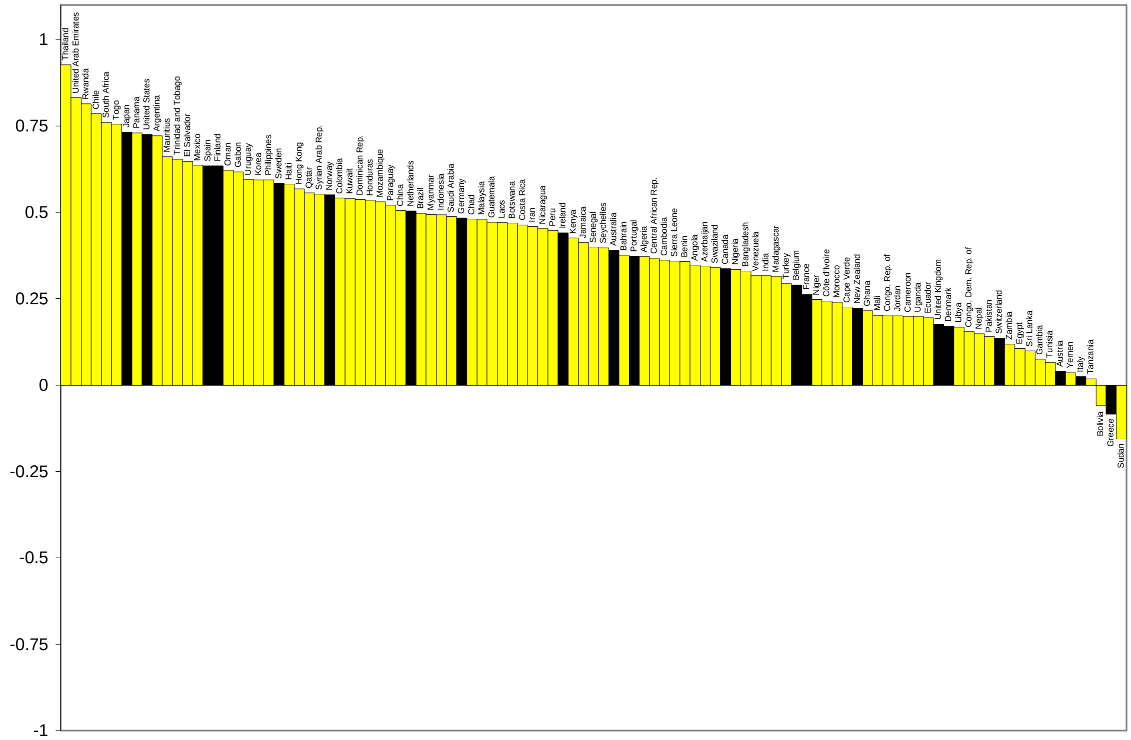
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. Real government expenditure is defined as central government expenditure and net lending deflated by the GDP deflator. A positive (negative) correlation indicates procyclical (countercyclical) fiscal policy. Source: Frankel, Végh and Vuletin (2011).

Figure 2. Country correlations between the cyclical components of the inflation tax and real GDP. 1960-2009



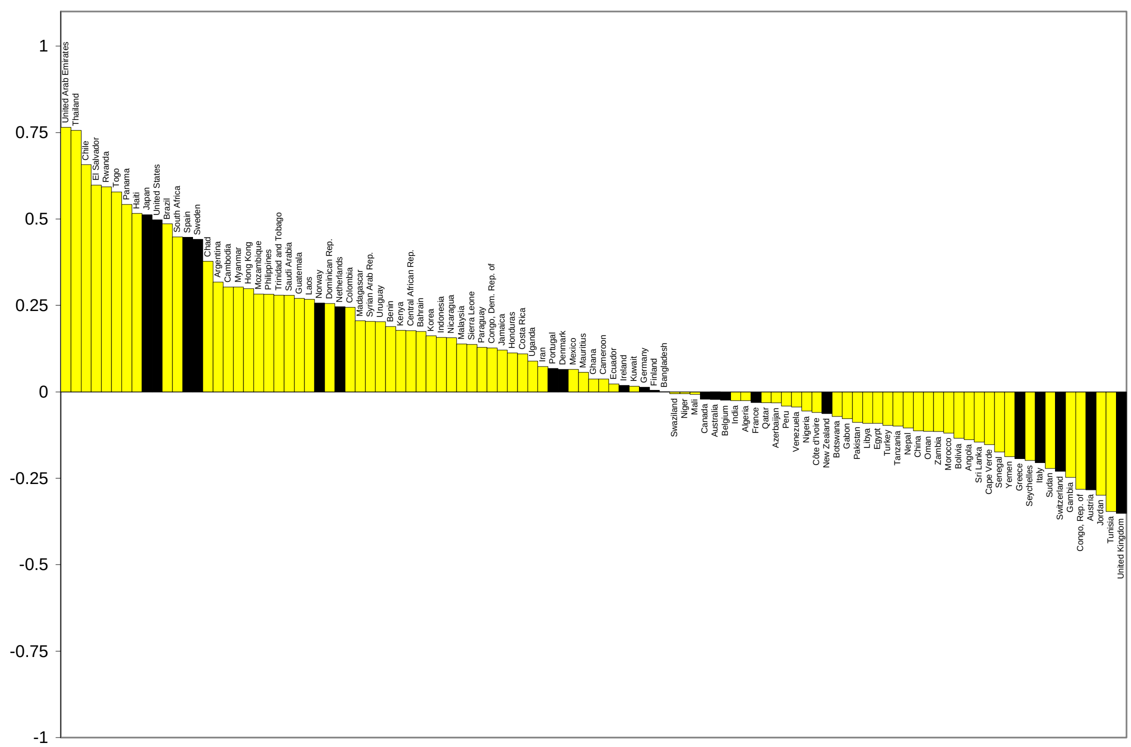
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. Inflation tax is defined as $(\pi/(1+\pi))*100$, where π is inflation. Sample includes 124 countries.

Figure 3. Country correlations between the cyclical components of the real government revenue and real GDP. 1960-2009



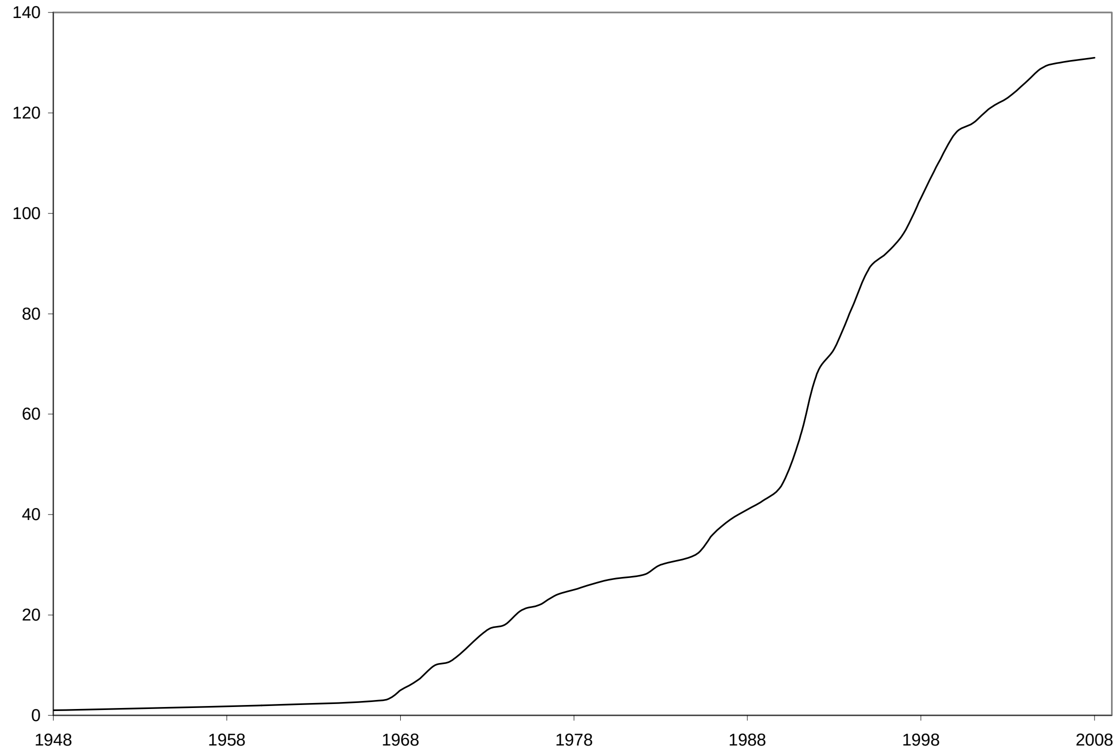
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. Real government revenue is defined as central government total revenue and grants deflated by the GDP deflator. Sample includes 105 countries.

Figure 4. Country correlations between the cyclical components of the government revenue/GDP and real GDP. 1960-2009



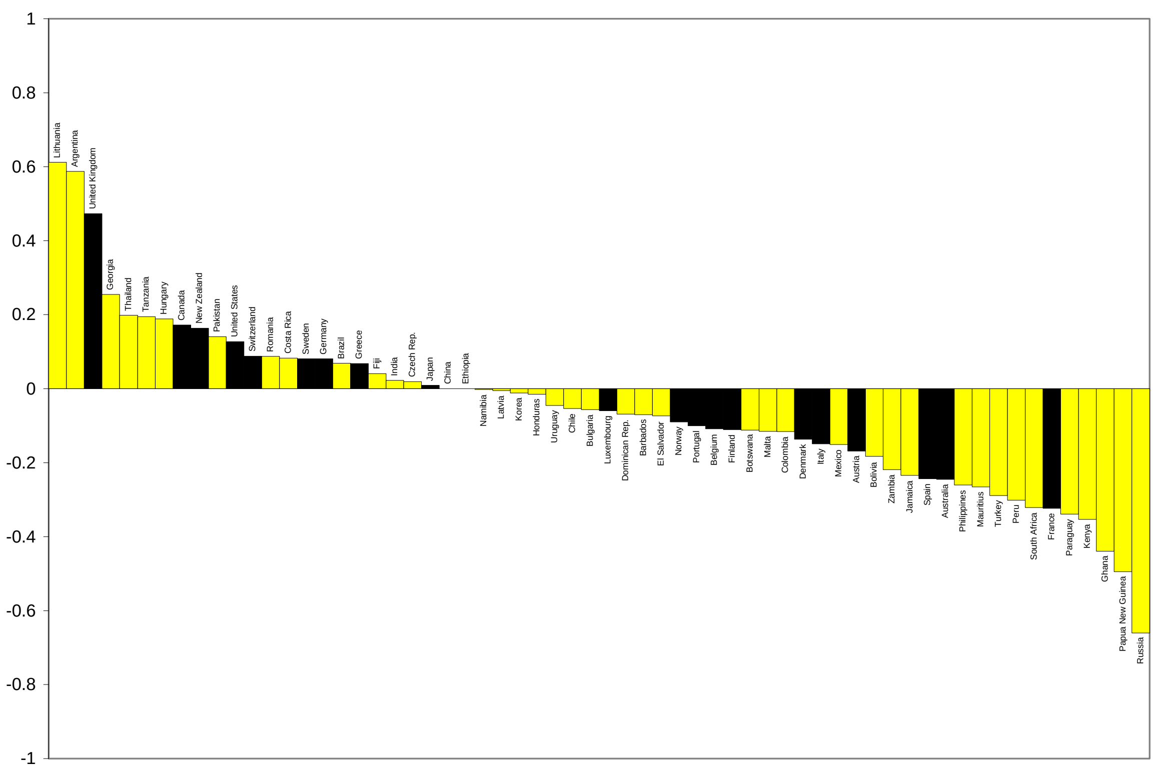
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. Real government revenue is defined as central government total revenue and grants deflated by the GDP deflator. Sample includes 105 countries.

Figure 5. Number of countries with value-added tax. 1948-2009



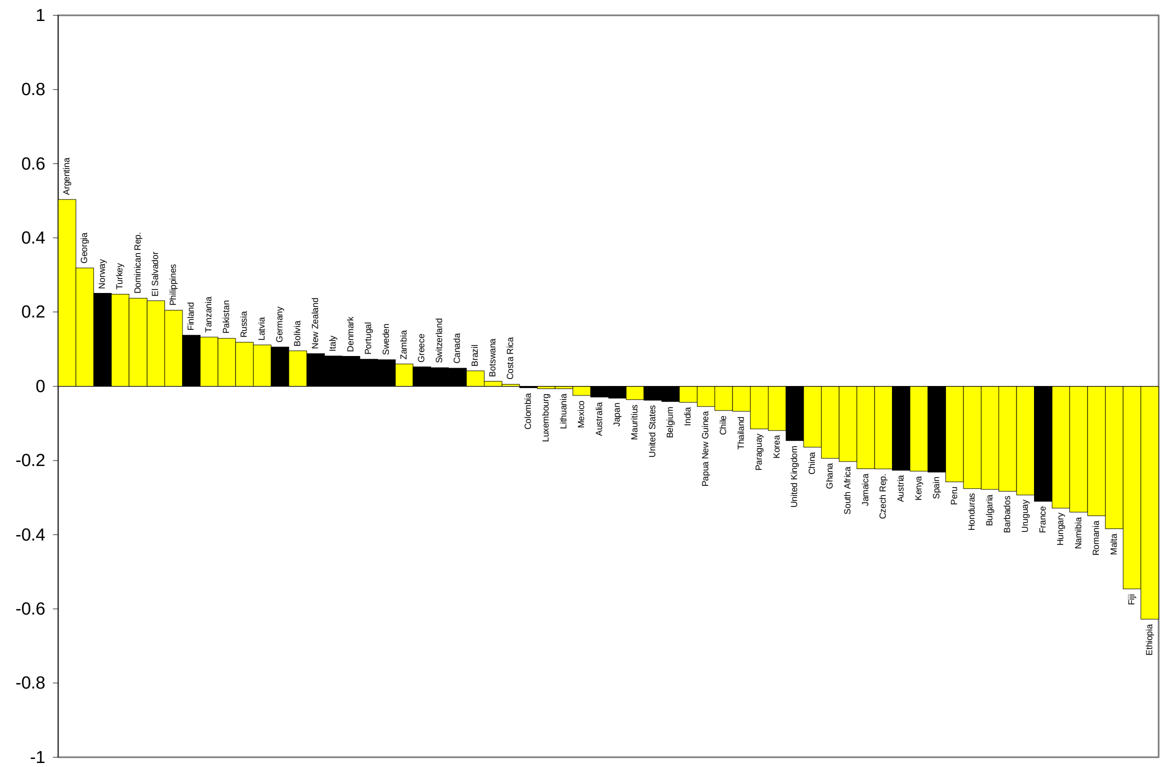
Source: Oldman and Schenk (2007) and authors' sources.

Figure 6. Country correlations between the cyclical components of the personal income tax rate and real GDP. 1960-2009



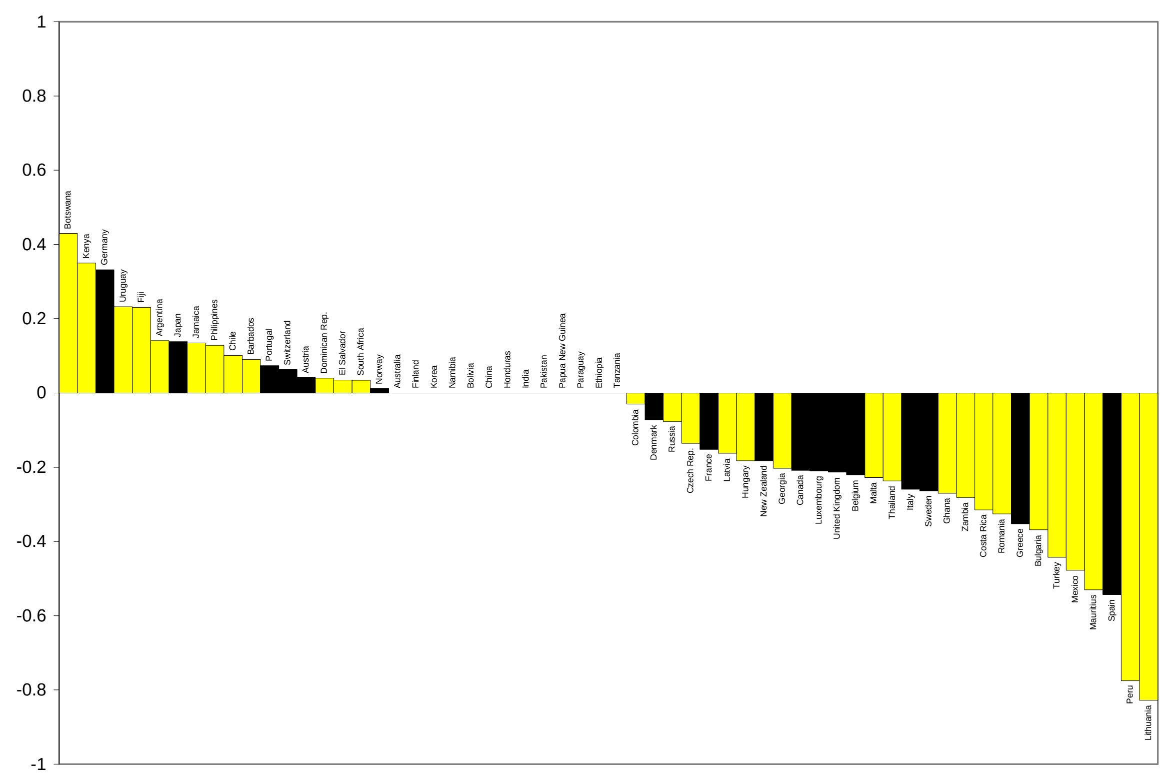
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 62 countries.

Figure 7. Country correlations between the cyclical components of the corporate income tax and real GDP. 1960-2009



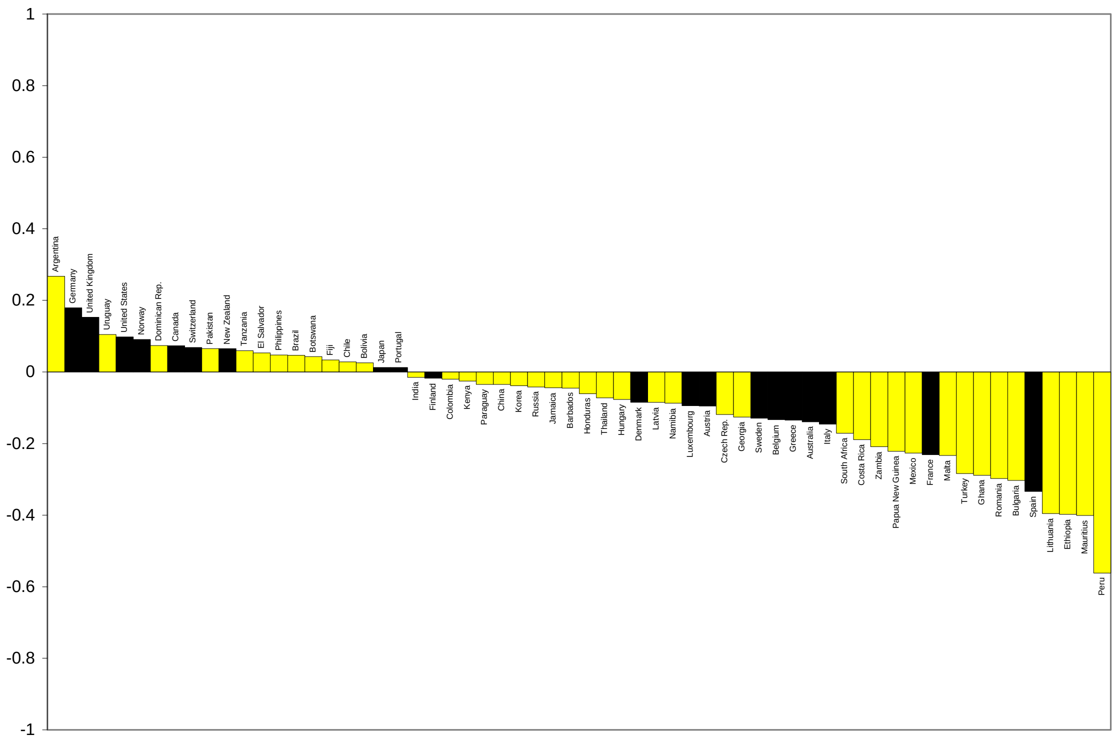
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 62 countries.

Figure 8. Country correlations between the cyclical components of the value-added tax and real GDP. 1960-2009



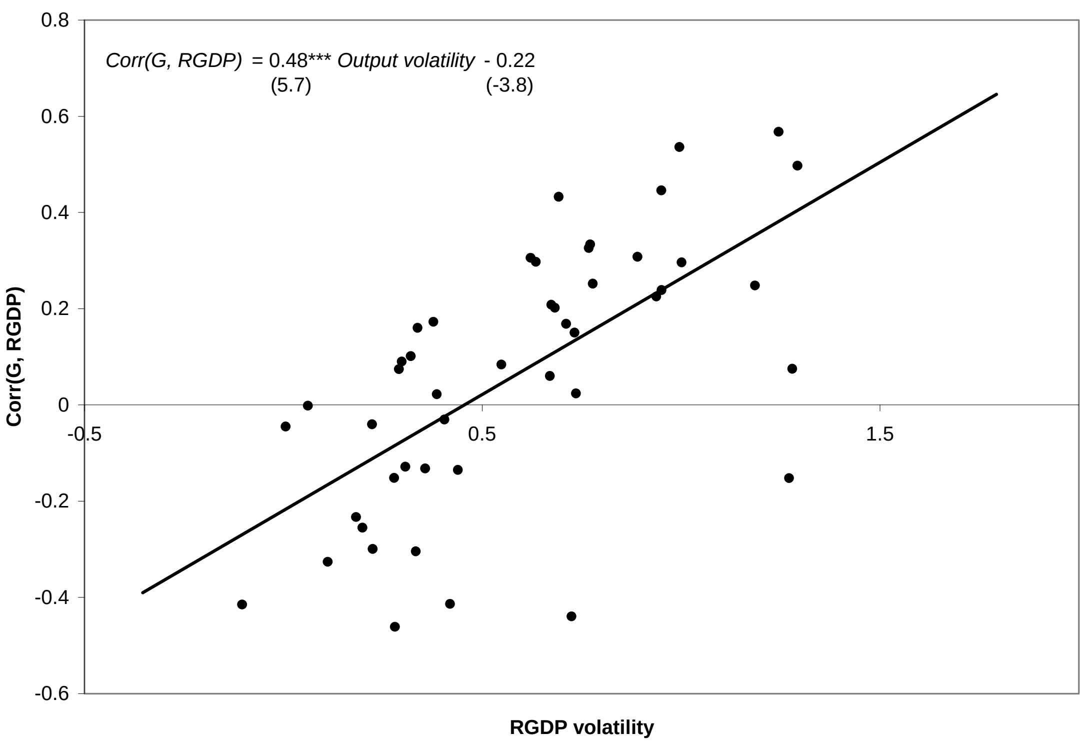
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 60 countries.

Figure 9. Country correlations between the cyclical components of the tax index and real GDP. 1960-2009



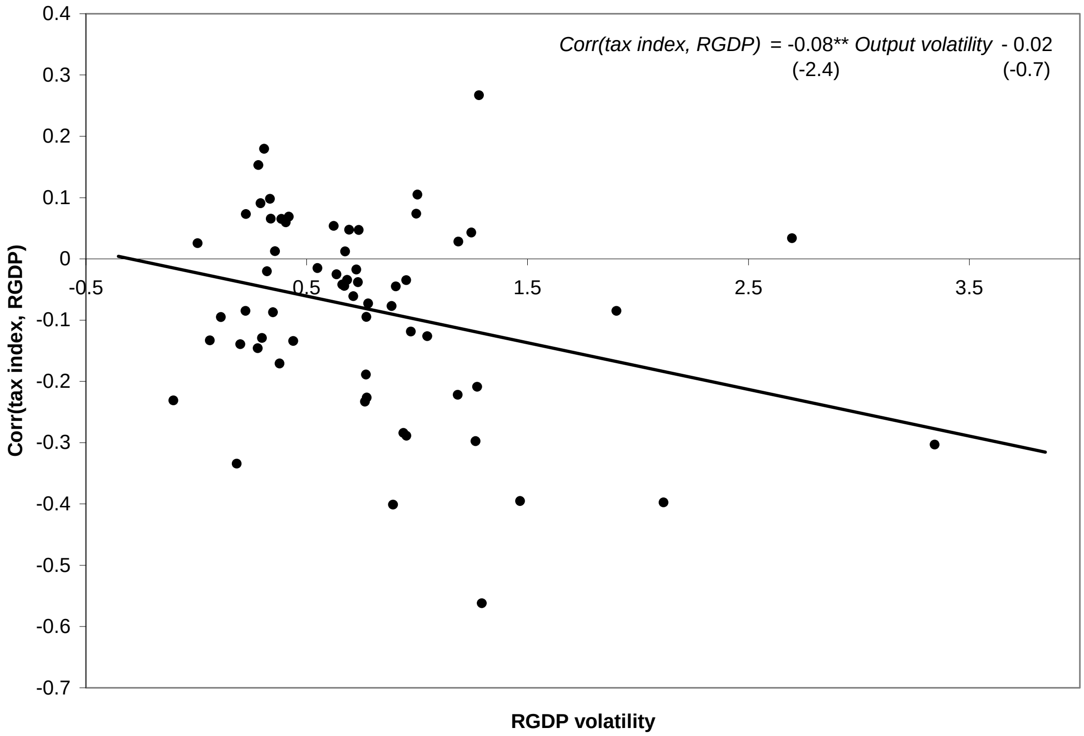
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 62 countries.

Figure 10. Country relationship between the cyclicality of real government expenditure and real GDP volatility. 1960-2009



Notes: The cyclical components have been estimated using the Hodrick-Prescott Filter. A positive (negative) correlation indicates procyclical (countercyclical) fiscal policy. Real GDP volatility is calculated as the logarithm of the standard deviation of the cyclical component of real RGDP. Sample includes 47 countries.

Figure 11. Country relationship between the cyclicality of the tax index and real GDP volatility. 1960-2009



Notes: The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Real GDP volatility is calculated as the logarithm of the standard deviation of the cyclical component of real RGDP. Sample includes 62 countries.

TABLE 1

Cyclicality of tax policy: Alternative tax indicators frequently used in the literature

	Inflation tax		Revenues		Revenues/GDP	
	Industrial	Developing	Industrial	Developing	Industrial	Developing
	(1)	(2)	(3)	(4)	(5)	(6)
RGDP cycle	10.48***	1.87	0.98***	1.50***	0.02	0.59***
	[6.0]	[0.3]	[7.5]	[16.8]	[0.1]	[6.2]
Number of observations	1030	3666	901	3008	901	3008
Number of countries	22	86	21	67	21	67

Notes: The dependent variable is the cyclical component of each tax indicator: inflation tax, revenues, and revenues/GDP. Inflation tax is defined as (π/(1+ π))*100, where π is inflation. Real government revenue is defined as central government total revenue and grants deflated by the GDP deflator. The regressor is the cyclical component of real GDP. Estimations are performed using country-fixed-effects. t-statistics are in square brackets. Constant term is not reported. ˣ, *, ** and *** indicate statistically significant at the 15%, 10%, 5% and 1% levels, respectively.

TABLE 2

Tax revenue structure: Tax burden and tax revenue composition

	Industrial (1)	Developing (2)	Difference ≡ (1) - (2) (3)
PANEL A: Tax burden			
Tax revenues (as % of GDP)	25.5	18.8	6.7***
PANEL B: Tax revenue composition (as % of total tax revenues)			
1. Tax revenue on income, profits, and corporations	50.1	31.0	19.1***
1.1. Personal income tax revenues	35.4	12.6	22.8***
2.2. Corporate income tax revenues	14.4	16.3	-1.9***
2. Good and services tax revenues	44.2	46.5	-2.3**
2.1. Value-added tax revenues	28.8	31.6	-2.8***
3. Others	5.7	22.5	-16.8***

Notes: The mean test is a t-test on the equality of means for two groups; the null hypothesis is that both groups have the same mean.
*, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.

TABLE 3

Direction of tax rates changes

	Personal income tax		Corporate income tax		Value-added tax	
	Industrial (1)	Developing (2)	Industrial (3)	Developing (4)	Industrial (5)	Developing (6)
Tax rate increases	34	21	52	72	53	42
Tax rate decreases	101	134	114	161	13	25
Total tax rate changes	135	155	166	233	66	67

TABLE 4

Correlation between tax rates changes

	Personal income tax	Corporate income tax	Value-added tax
Personal income tax	1		
Corporate income tax	0.15***	1	
Value-added tax	0.07**	0.05*	1

Notes: Spearman's rank correlation coefficients are reported.
*, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.

TABLE 5

Frequency and magnitude of tax rate changes

	Industrial (1)	Developing (2)	Difference ≡ (1) - (2) (3)
PANEL A: Frequency of tax rate changes			
Personal income tax	0.23	0.16	0.07***
Corporate income tax	0.11	0.18	-0.07
Value-added tax	0.11	0.09	0.02
PANEL B: Percentual absolute change in tax rates. Including zero changes			
Personal income tax	2.86	3.08	-0.22
Corporate income tax	2.65	3.23	-0.58
Value-added tax	1.57	2.18	-0.61
PANEL C: Percentual absolute change in tax rates. Without including zero changes			
Personal income tax	12.24	18.23	-5.99***
Corporate income tax	14.52	17.98	-3.46
Value-added tax	14.41	22.85	-8.44***

Notes: The mean test is a t-test on the equality of means for two groups; the null hypothesis is that both groups have the same mean. *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.

TABLE 6

Percentage tax rate changes across different stances of the business cycle

	Personal income tax		Corporate income tax		Value-added tax		Tax index	
	Industrial	Developing	Industrial	Developing	Industrial	Developing	Industrial	Developing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Good times	-0.29	-1.19	0.74	0.09	-0.64	-0.17	-0.01	-0.25
Normal times	0.16	0.34	-0.08	-0.81	0.23	-0.28	0.12	0.04
Bad times	-0.11	0.42	-0.55	1.54	0.13	0.89	-0.29	0.15

Notes: Percentage tax rate changes are reported as difference with respect to the overall (i.e., not distinguishing across stances of the business cycle) mean. Therefore, positive (negative) values indicate tax rate changes above (below) the mean. Good (bad) times are defined as those years for which the real GDP cycles are in the first higher (lower) quartile for each country. Normal times are defined as those years for which the real GDP cycles are in the second and third quartile for each country.

TABLE 7

Cyclicality of tax policy: Basic panel regressions

	Personal income tax		Corporate income tax		Value-added tax		Tax index	
	Industrial	Developing	Industrial	Developing	Industrial	Developing	Industrial	Developing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RGDP cycle	0.03	-0.39ˣ	0.14	-0.11**	-0.26**	-0.35***	-0.09	-0.24***
	[0.2]	[-1.6]	[0.9]	[-2.2]	[-2.6]	[-5.5]	[-0.9]	[-3.6]
Number of observations	639	1089	900	1323	614	764	509	662
Number of countries	20	42	20	42	20	42	20	42

Notes: The dependent variable is the cyclical component of each tax indicator: personal income tax rate, corporate income tax rate, value-added tax rate, and the cycle of tax index. The regressor is the cyclical component of real GDP. Estimations are performed using country-fixed-effects. t-statistics are in square brackets. Constant term is not reported.
ˣ, *, ** and *** indicate statistically significant at the 15%, 10%, 5% and 1% levels, respectively.

TABLE 8

First stage regression for instrumental variables regressions

	Industrial (1)	Developing (2)
ShockPX	0.05* [2.0]	0.02 [0.6]
ShockJP	1.14*** [3.9]	1.04** [2.7]
Global interest rate	0.05ˣ [1.5]	-0.04 [-0.5]
STATISTICS		
Weak-identification test (p-value)	0.005	0.042
Number of observattions	397	451
Number of countries	17	26

Notes: The dependent variable is the cyclical component of real GDP. The regressors in the first stage regressions (i.e., the excluded instruments) are ShockPX, ShockJP, and Global interest rate. Estimations are performed using two-step efficient GMM country-fixed-effects, allowing errors to present arbitrary heteroskedasticity and arbitrary intra-country correlation (i.e., clustered by country). t-statistics are in square brackets. Constant terms are not reported. The weak-identification test is Kleibergen-Paap Wald rk F statistic; the null hypothesis is that the model is weakly identified (i.e., the excluded instruments have a nonzero correlation with the endogenous regressors but small).
ˣ, *, ** and *** indicate statistically significant at the 15%, 10%, 5% and 1% levels, respectively.

TABLE 9

Cyclicality of tax policy: Instrumental variables regressions

	Personal income tax		Corporate income tax		Value-added tax		Tax index	
	Industrial (1)	Developing (2)	Industrial (3)	Developing (4)	Industrial (5)	Developing (6)	Industrial (7)	Developing (8)
RGDP cycle	-0.20 [-0.3]	-11.30ˣ [-1.6]	0.69ˣ [1.6]	-0.88 [-0.8]	0.15 [0.9]	-1.15** [-2.5]	-0.02 [-0.1]	-1.39** [-2.0]
STATISTICS								
Over-identification test (p-value)	0.23	0.51	0.51	0.55	0.32	0.62	0.91	0.54
Exogeneity of ShockPX (p-value)	0.39	0.25	0.47	0.38	0.14	0.81	0.75	0.27
Exogeneity of ShockJP (p-value)	0.75	0.27	0.60	0.78	0.13	0.54	0.88	0.37
Exogeneity of Global int. rate (p-value)	0.09	0.60	0.41	0.71	0.68	0.35	0.73	0.67
Number of observattions	397	451	397	451	397	451	397	451
Number of countries	17	26	17	26	17	26	17	26

Notes: The dependent variable is the cyclical component of each tax indicator: personal income tax rate, corporate income tax rate, value-added tax rate, and the cycle of tax index. The regressor is the cyclical component of real GDP. The excluded instruments are ShockPX, ShockJP, and Global interest rate (see Table 8 for first stage regression estimates). Estimations are performed using two-step efficient GMM country-fixed-effects, allowing errors to present arbitrary heteroskedasticity and arbitrary intra-country correlation (i.e., clustered by country). t-statistics are in square brackets. Constant terms are not reported. The over-identification test is Hansen's J statistic; the null hypothesis is that the instruments are exogenous (i.e., uncorrelated with the error term). The exogeneity test of each excluded instrument is C statistic; the null hypothesis is that the excluded instrument tested is exogenous (i.e., uncorrelated with the error term).
ˣ, *, ** and *** indicate statistically significant at the 15%, 10%, 5% and 1% levels, respectively.