How is tax policy conducted over the business cycle?*

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Abstract

It is well known by now that government spending has typically been procyclical in developing 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 mostly 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 Vegh (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 economies. 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 lie 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, Vegh, and Vuletin (2012), some emerging economies have switched from being procyclical to countercyclical over the last decade (i.e., have "graduated"), fiscal procyclicality remains a pervasive phenomenon in the developing world, which tends to reinforce – rather than mitigate – the underlying business cycle volatility.

The other pillar of fiscal policy is, of course, taxation. A critical observation on the taxation side is that policymakers control tax *rates*, as opposed to tax revenues which vary endogenously with the tax base. Since we are interested in fiscal *policy*, we therefore want to focus on tax rates, the policy instrument, and not tax revenues.[2]

Unfortunately – and leaving aside a few studies focusing on individual countries such as Barro (1990), Huang and Lin (1993), Strazicich (1997), Barro and Redlick (2011), and Romer and Romer (2012) for the United States and Maihos and Sosa (2000) for Uruguay – there is no systematic international evidence regarding the cyclicality of tax policy (i.e., cyclicality of tax rates). 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 Vegh, 2005; Kaminsky, Reinhart, and Vegh, 2004) or (ii) tax revenues, either in absolute terms or as a proportion of GDP

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

[2] An important clarification on terminology. We will say that tax policy is procyclical (countercyclical) when tax rates are negatively (positively) correlated with GDP suggesting that tax policy is amplifying (smoothing) the underlying business cycle. An acyclical tax policy captures the case of zero correlation (i.e., no systematic relation between tax rate and the business cycle).

(Gavin and Perotti, 1997; Braun, 2001; Sorensen, Wu, and Yosha, 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 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 (2012) 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 commoves positively with the business cycle in most industrial countries while it is, on average, acyclical in developing countries. Hence, if anything, one would conclude that tax 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 Vegh (2004) – the second approach is fundamentally flawed because, as mentioned above, tax revenues constitute an 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 the cyclicality of tax rates 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 policy is procyclical.[3] 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 policy.

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 Vegh (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

[3] Notice that, since tax revenues move positively with the business cycle, negatively-related tax revenues must imply lower tax rates during the booms.

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 simply 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 show systematic international evidence regarding the cyclicality of tax policy based on the use of the policy instrument (tax rate) as opposed to a tax 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. Corporate and personal income tax rates are mainly obtained from the World Development Indicators (World Bank) and World Tax Database (University of Michigan, Ross School of Business). On the other hand, value-added tax rates were obtained from various primary 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). We believe that this significant effort in collecting value-added tax rates is crucial for any study analyzing the developing world as well as Europe, where indirect/value-added taxation is a key and active component of fiscal policy.

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.[4]

We can summarize our main empirical findings as follows:

1. Tax policy is more volatile in developing countries than in industrial economies in the sense that developing countries change their tax rates by larger amounts than industrial economies. In particular, the volatility of tax policy in developing economies is about 25 to 50 percent more volatile than in industrial countries. This pattern matches the one observed on the spending side (Gavin and Perotti, 1997; Singh, 2006). Annual average variation in real government spending is about 60 percent higher in developing countries than in industrial economies.

2. Tax policy is acyclical in industrial countries and mostly procyclical in developing economies. This empirical regularity is robust to a wide set of statistical and econometric methods as well as

[4] 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 Vegh (2008), however, argue that even after addressing endogeneity concerns, there is causality running from the business cycle to government spending.

different ways of assessing the behavior of tax policy over the business cycle (percentage change or cyclical components of tax rates). Our findings also hold when using instrumental variables.

3. Countries with more procyclical spending policy typically have more procyclical tax policy and vice-versa. In other words, tax and spending policies are typically conducted in a symmetric/homogeneous way over the business cycle.

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, Hausmann, Perotti, and Talvi, 1996; Gavin and Perotti, 1997; Riascos and Vegh, 2003; Caballero and Krishnamurthy, 2004).[5] To illustrate this idea, we present the simplest possible model of optimal fiscal policy under incomplete markets. We show that government consumption is procyclical. 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 the cyclical behavior of public versus private spending. 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. Section 2 discusses how to measure tax policy and briefly elaborates on some of the practical pros and cons of focusing on different taxes. Section 3 presents the tax rate data used in the study. It also documents six empirical regularities about the frequency and average magnitude of tax changes and the volatility of tax policy. As background, Section 4 briefly characterizes the tax revenue structure – both in terms of size and composition – of countries around the world. Section 5 presents our main findings about the cyclicality of tax policy using alternative statistical and econometric methods as well as measures to assess the behavior of tax policy over the business cycle. Section 6 addresses endogeneity issues. Section 7 shows some complementary evidence for a small sample of six industrial countries where average marginal personal income tax rate data are available. Section 8 explores the relationship between cyclicality of tax and spending policies. Section 9 develops

[5] The other, not necessarily inconsistent, explanation relies on political distortions (Velasco, 1997; Tornell and Lane, 1999; Talvi and Vegh, 2005). We focus on credit market imperfections because (i) our simple model offers new insights into the conditions needed for this channel to explain the data and (ii) we can match the model's key implications to the data.

a theoretical model of optimal fiscal policy under uncertainty. Final thoughts are presented in Section 10.

2 Measuring tax policy

When analyzing the business cycle properties of spending policy, most papers use government spending or government consumption. These fiscal variables represent the overall policy instrument on the spending side. In contrast, tax policy does not rely on a single tax rate associated with a single activity. Governments typically resort to many different taxes, including, among others, individual and corporate income, social security contributions, property, goods and services as well as taxes on trade and financial transactions. Many of these taxes, especially personal income taxes, have several brackets and an intricate system of deductions. These features complicate the extent to which researchers can unequivocally assess the stance and changes in tax policy. Up to now, most papers relying on tax rates have studied the United States while typically focusing on individual income taxes as well as social security contributions. Barro and Redlick (2011) use United States average annual marginal individual income tax rates from federal and state taxes as well as social security payroll taxes for the period 1913-2006. Romer and Romer (2012) analyze the evolution of individual marginal tax rates as well as corporate tax rates in the United States for the interwar period 1919-1941. Riera-Crichton, Vegh, and Vuletin (2012) focus on value-added tax rates for 14 industrial countries for the period 1980-2009. No approach is completely satisfactory and, most likely, given the intricacies of the taxation system, none will ever be. That said, the profession seems to be moving in the right direction by devoting significant efforts to gather new datasets on tax rates, allowing both researchers' and policymakers' better understanding of tax instruments (such as tax rates) behavior and effect, as opposed to tax outcomes (such as tax revenues).

The main practical advantage of the VAT rate is that it consists of a single standard rate.[6] On the contrary, personal income taxes have several rates for different income brackets and an intricate system of deductions. The single rate allows the researcher to clearly assess the stance of tax policy. As discussed in great detail in Barro and Redlick (2011), changes in the average marginal individual tax rates (AMITR) may be triggered by shifts in the underlying distribution of marginal tax rates in a manner correlated with differences in labor-supply elasticities (e.g., the 1948 tax cut). Moreover, increases in the AMITR, such as the one observed from 1971 to 1978, may reflect the shift of households

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

into higher brackets due to high inflation in the context of an unindexed tax system. This concern seems to be particularly relevant in the case of the developing world as well as industrial countries with a long history of moderate/high and persistent levels of inflation, such as Greece, Italy, Portugal, and Spain. A second identification advantage of the VAT relates to the lag between the change in tax legislation and the household learning about it. As pointed out by Barro and Redlick (2011), information regarding changes in tax rates, tax brackets, and deductions in the AMITR are arguably gradually learned by households throughout the year. This is indeed the main reason why Barro and Redlick (2011) use annual frequency data. In contrast, changes in VAT rate are arguably internalized promptly by households, since consumption is performed on a more continuos and frequent manner.

Given the above – and as described in the next section – we put a great deal of effort in complementing existing databases on corporate and personal income with a novel database on VAT taxes.

3 Tax rate data

Part of this paper's contribution is the creation of a novel tax rate database that combines existing data on corporate and personal income tax rates with newly collected data on VAT taxes. Our database covers 62 countries – 20 industrial and 42 developing – for the period 1960-2009.[7]

Corporate tax rates generally are the same for differing types and levels of profits. When this is not the case, we use the top marginal tax rate. For personal income data, we use the top marginal tax rate. While the average marginal personal income tax rate is the preferred measure (subject to the caveats mentioned in the previous section), it is only available for a limited number of countries and, even in those cases, just for a short period of time. Later, in Section 7, we will complement our personal income tax rate analysis using average marginal personal income tax rates for six industrial economies for which there exists long time series covering between 18 and 28 years. It is worth noting that the top marginal and average marginal personal income tax rates are positively and significantly related for these six countries, thus supporting the use of top marginal rates as a proxy for average marginal ones. Most of the corporate and personal income tax data were obtained from the World 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

[7] See Appendix 2 for the list of countries. 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-owned enterprises and indirectly trough various specific taxes and royalties.

income tax rate data, respectively.[8]

Additionally, we collected new data on value-added tax rates. These data were obtained from various primary sources, including countries' revenue agencies, countries' national libraries, books, newspapers, tax law experts, as well as research and policy papers.[9] 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).[10] We believe that this significant effort in collecting value-added tax rates is crucial for any study analyzing the developing world as well as Europe, where indirect/value-added taxation is a critical component of fiscal policy.

Needless to say, while fairly comprehensive, our dataset does not come free of limitations. In particular – and as is the case for most studies up to date – it does not include all available tax rates such as social security, trade, property, alcohol, and tobacco, among others. We should note, however, 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. The following subsections briefly characterize six basic empirical regularities about our tax rate data.

3.1 Long-run trends

Long-run tax rate trends differ across taxes. About two thirds of personal and corporate income tax rates changes are negative, both in industrial and developing countries (Table 2, columns 1 to 4). The opposite occurs with value-added rates; about two thirds of such changes are positive (Table 2, columns 5 and 6). These changes 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.

3.2 Short-run patterns

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

[8] Appendix 1.2 describes the data sources and Appendix 3 describes the period of coverage for each tax in each country.

[9] Appendix 1.2 describes the data sources.

[10] Appendix 3 contains the year in which the value-added tax rate was introduced in each country as well as the coverage period.

run trends. Table 3 shows that we cannot reject that tax rates changes are positively correlated across different taxes.

3.3 Frequency of changes

A key difference between government spending – and for that matter most macroeconomic variables – and tax rates is that the latter rarely vary every year.[11] 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 is 0.19, 0.18, and 0.11 for personal, corporate, and value-added taxes, respectively. Put differently, tax rates change, on average, about every 5 years for corporate and personal income taxes and every 9 years for value-added taxes.

Table 4, panel A shows that with the exception of the personal income tax rates, which vary more frequently in industrial countries, the frequency of tax rate changes is quite similar across industrial and developing countries.

3.4 Average magnitude of changes

Both industrial and developing countries share some common average variation in tax rates (Table 4, 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.[12]

3.5 Tax policy volatility

The similarity across groups of countries regarding the *average* magnitude of tax rate changes described in the previous subsection hides important differences about the intensity/magnitude of tax

[11] In this sense, tax rates fluctuations resemble more the profile observed in price changes for individual goods; see, for instance, Bils and Klenow (2004). .

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

rate changes. When focusing only on tax rate changes different from zero (i.e., when tax policy is active), developing economies show larger magnitude of tax rate changes than industrial countries across the board (Table 4, panel C). The percentage change in tax rates in developing countries is almost 50 percent higher for personal income and value-added taxes and about 25 percent for the corporate tax than that of industrial economies. In other words, tax policy is more volatile in developing countries than in 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 percent (February 1, 1988), from 17 to 16 percent (March 24, 1992), from 16 to 17 percent (January 1, 1995), from 17 to 19 percent (June 5, 2002), from 19 to 21 percent (July 1, 2005), and from 21 to 20 percent (July 1, 2008). That is to say, Portugal's average absolute percentage change was 7.57 percent. On the other hand, since its introduction on January 1, 1980, Mexico changed its VAT rate three times: from 10 to 15 percent (December 31, 1982), from 15 to 10 percent (November 21, 1991), and from 10 to 15 percent (March 27, 1995). In other words, Mexico's average absolute percentage change was 44.44 percent; about 5 times that of Portugal.

This regularity regarding tax policy volatility is consistent with the one observed on the government consumption side; developing countries show more volatile spending policy than industrial economies (Gavin and Perotti, 1997; Singh, 2006). Indeed, annual average variation in real government spending is about 60 percent higher in developing countries than in industrial economies included in our sample.

3.6 Frequency of change versus tax policy volatility

Figures 5, 6, and 7 plot country frequency of change and tax policy volatility measured as the percentage absolute change in tax rates without including zero changes. The figures strongly support a negative relationship between the frequency of tax rate changes and tax policy volatility. Countries where changes in tax rates are relatively infrequent (i.e., low frequency of change) typically show high tax policy volatility (i.e., high intensity/magnitude of tax rate changes). In other words, frequency and magnitude of changes seems to act as substitutes: in countries where tax rates change regularly (infrequently), taxes vary by small magnitudes (large).

4 Tax revenue structure

In this section, we briefly characterize the tax revenue structure – both in terms of size and composition – of countries around the world. The tax burden, defined as government revenue expressed as percentage of GDP, varies significantly across countries, ranging from 42.1 percent for Norway to 7.3

percent for the Democratic Republic of Congo.[13] The average tax burden in industrial countries is 25.5 percent of GDP, compared to 18.8 percent for developing countries (Table 5, panel A).

The relative importance of income – both corporate and personal – and value-added taxes varies significantly 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 5, panel B).[14]

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 8). 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.[15]

5 Cyclicality of tax policy

This section presents our main findings on the cyclicality of tax policy. To this end, we use several statistical and econometric methods including computing the behavior of tax rates across different stances of the business cycle, cross-country correlation plots, and panel data regressions. We also use alternative measures to assess the behavior of tax policy over the business cycle such as percentage changes and cyclical components of tax rates. While using the cyclical component of the fiscal variable is the typical approach when focusing on government consumption (which is a "continuos" variable), the choice of this strategy is less obvious when focusing on a fiscal variable, such as tax rate, that changes less frequently, as discussed in Subsection 3.3). As we will see next, our main findings are robust to all these considerations.

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 change in the tax rate index is given by

$$\Delta tax\ index_{it} = w_i^{PIT} \times \Delta PIT_{it} + w_i^{CIT} \times \Delta CIT_{it} + w_i^{VAT} \times \Delta VAT_{it}, \qquad (1)$$

where ΔPIT, ΔCIT, and ΔVAT are – depending on the variable used to measure the behavior of

[13] See Appendix 4, Table 1A, column 1 for the corresponding country statistics.
[14] See Appendix 4, Table 1A, columns 2-6 for individual country statistics.
[15] Appendix 3 reports the year in which the value-added tax was introduced in each country included in our study.

tax policy – the percentage change 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. The use of a country's average avoids undesired short-term responses of tax bases (and therefore, tax collection and weights) to changes in tax rates.[16]

5.1 Preliminary analysis

We start by performing a preliminary analysis of the cyclicality of tax policy using some simple statistics and cross-country correlation plots. Table 6 shows the average percentage tax rate change evaluated at different stances of the business cycle for industrial and developing countries. While industrial countries reduce personal income tax rates both in good and bad times, developing economies sharply 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, which 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 analyze tax behavior at the country level. For this purpose we show country correlations between the cyclical components of each tax rate and real GDP.[17] Figure 9 shows the correlations for the personal income tax rate. 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

[16] It is important to note that the construction of this tax index does not follow from a theoretical model and, therefore, is not intended to proxy for the overall distortion imposed by the tax system through different taxes. Such an indicator would need to be calibrated to the idiosincracies of each country and, in principle, would also need to be allowed to vary over time. Needless to say, such an indicator would crucially depend upon the specific structure of the theoretical model. Our approach is more modest, yet similar to those frequently used in other empirical areas of international macro-development. For example, Chinn and Ito (2006) build an aggregated index measuring a country's degree of capital account openness based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions. Similarly, Reinhart, Rogoff, and Savastano (2003) build a composite index of dollarization.

[17] We use the Hodrick-Prescott filter with a smoothing parameter of 6.5 (Ravn and Uhlig, 2002). Similar results are obtained using the Baxter-King filter.

policy is more than twice as many as the ones showing countercyclical tax policy.

Figure 10 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.

Figure 11 shows country correlations between the cyclical components of value-added tax rate and real GDP. Unlike the pattern observed in Figures 9 and 10, about half of both industrial and developing countries show procyclical policy and less than a third show countercyclicality.

Figure 12 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, the tax index of Georgia shows a procyclical tax policy. While the value-added tax is strongly procyclical, corporate and personal income taxes are countercyclical. The procyclicality of the tax system captured by the tax index reflects that value-added tax collection represents almost two thirds of total revenues. 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.

In line with Figures, 9, 10, and 11, Figure 12 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 end of the spectrum, Spain, Italy, and Greece's tax policies are procyclical with correlation levels close to that of Mexico and Ghana. The number of developing countries pursuing procyclical policies is almost three times as many as those showing countercyclical tax policy.

5.2 Regression analysis

We now exploit the panel nature of our dataset. Table 7 shows panel country fixed-effects regressions both for the percentage change in tax rates (Panel A) as well as for the cyclical component of tax rates (Panel B). Both measures point to similar findings. Tax policy is mostly acyclical for industrial countries. With the exception of the value-added tax (columns 5), acyclicality is supported both for personal (columns 1) and corporate (columns 3) income taxes as well as for the tax index (columns 8). On the contrary, tax policy is mostly procyclical in developing countries. These findings strongly support the ones obtained in Table 6 and Figures 9, 10, 11, and 12. In sum, our analysis strongly supports the idea that tax policy is, broadly speaking, acyclical in industrial countries and 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 concerns.

6 Addressing endogeneity

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 fiscal procyclicality literature, more recent studies (Rigobon, 2004; Jaimovich and Panizza, 2007; Ilzetzki and Vegh, 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 5 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):

$$ShockJP_{it} = \frac{X_i}{GDP_i} \sum\nolimits_j \phi_{ij,t-1} RGDPGR_{j,t}, \qquad (2)$$

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.[18] This index of weighted real GDP growth of trading partners attempts to capture an external shock.[19]

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 Vegh, 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.[20] Lastly, we use an instrument proposed by Ilzetzki and Vegh (2008) who suggest using the change of real returns on U.S. Treasury bills to capture global liquidity conditions.[21,22]

In this section we also account for concerns regarding the structure of errors in the regression analysis. We allow errors to exhibit 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 instrumental variables panel country fixed-effects regressions both for the percentage change in tax rates (Panel A) as well as for the cyclical component of tax rates (Panel B).[23] Before analyzing the regression results, two issues are worth noting. First, 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. Second, 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. These findings strongly support the validity and strength of our instrumental variable estimates.

[18]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."

[19]Ilzetzki and Vegh (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.

[20]Large economies may affect commodity prices due to agregate demand arguments. Therefore, for industrial countries' regressions, we use the lagged year price of exports growth rate (i.e., $PXGR_{i,t-1}$) rather than the current ones to avoid reverse causality concerns.

[21]Since global liquidity conditions may also have direct effects on governments' fiscal decisions, we include our measure of U.S. interest rates as an instrument for output as well as a determinant of the behavior of tax policy.

[22]Since this instrument might be endogenous in the case of the United States, we exclude this country from the instrumental variables analysis.

[23]In order to make appropiate comparisons, we only use observations where all tax rate data are available.

Our instrumental variable regressions (Table 8) generally support those findings from the previous section (i.e., Table 7). As expected, instrumental variable estimates are less efficient (i.e., standard errors are a little bit larger). Two differences are worth noting. First, while developing countries pursue procyclical value-added tax policy, industrial countries' procyclicality vanishes once endogeneity concerns are addressed (Table 8, columns 5). The latter occurs because (i) there is a shift in the coefficient distribution function to the right (from -0.26 in Table 7 to 0.16 in Table 8) and (ii) there is a widening in the coefficient distribution function (from an absolute t-statistic value of 2.6 in Table 7 to 1.1 in Table 8). The latter 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 industrial countries and not the other way around. This rationale is consistent with Riera-Crichton, Vegh, and Vuletin (2012) who find sizable tax multipliers for industrial countries. The second difference with our findings in the previous section is that developing countries' procyclicality in corporate taxation vanishes once endogeneity concerns are addressed (Table 8, columns 4).

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 and corporate income tax rates as well as value-added taxation. 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.

7 Some evidence from average marginal personal income data

This section performs econometric analysis similar to that of Sections 5.2 and 6 using average marginal personal income tax rates for six industrial economies (Australia, Belgium, France, Germany, United Kingdom, and United States) for which there exists long time series covering between 18 and 28 years.[24] It is worth noting that the Spearman rank correlation between our top personal income marginal tax rate and the average marginal is 0.26. Such relationship is statistically significant at the 1 percent level, supporting the use of top marginal rates as a proxy for average marginal ones.

Columns 1 in Table 9 show analogous basic panel regressions to that of columns 1 in Table 7 using average marginal as opposed to top marginal tax rates. Similarly, columns 2 in Table 9 show similar

[24] We would like to thank Ethan Ilzetzki for sharing this dataset. The data coverage is: 28 years for United States and Australia (1981-2008), 27 years for France (1981-2007), 24 years for the United Kingdom (1985-2008), 22 years for Belgium (1986-2007), and 18 years for Germany (1991-2008).

instrumental variables panel regressions to that of columns 1 Table 8.[25,26] In line with our previous findings, tax rate policy is acyclical even after accounting for endogeneity problems.

8 Cyclicality of fiscal (tax and spending) policies

Up to now, we have focused our analysis on the cyclicality of tax policy. We have found robust evidence that, in line with the behavior of government spending, industrial countries follow acyclical policies while developing countries are mostly procyclical. We now focus on the relationship between the cyclicality of tax policy and that of spending. In particular, we would like to know how strong is the relationship between the behavior of tax and spending policies over the business cycle.

Figure 13 shows the country relationship between the cyclicality of taxation and cyclicality of government spending.[27] While far from perfect, Figure 13 indeed supports the idea that, countries with more procyclical spending policy (i.e., more positive values of Corr(G, RGDP)) typically have more procyclical tax policy (i.e., more negative values of Corr(tax index, RGDP)) and viceversa. In other words, tax and spending policies are typically conducted in a symmetric way over the business cycle.

9 Model

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 (Gavin, Hausmann, Perotti, and Talvi, 1996; Gavin and Perotti, 1997; Riascos and Vegh, 2003; Caballero and Krishnamurthy, 2004) to political distortions that tend to encourage public spending during boom periods (Velasco, 1997; Tornell and Lane, 1999; Talvi and Vegh, 2005).

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.[28] We will show that while government spending is procyclical, the cyclicality of the tax rate depends on the cyclical behavior of public versus private spending.

[25] In order to be able to include the United States in our instrumental variable regressions we do not include our measure of U.S. interest rates in the analisis.

[26] Unfortunately, for this very small sample, instruments are weak for percentage changes in tax rates (Table 9, panel A, column 2).

[27] In order to make appropiate comparisons, we only use observations where both tax index as well as spending data are available.

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

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.[29]

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[30]

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

where τ is the consumption tax.[31] 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.

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

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

[29] 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.

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

[31] Similar results would hold for income taxation.

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 we obtain the following four propositions.[32]

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.*

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 $\sigma_c > \sigma_g$.

[32] See Appendix 5 for all derivations.

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 obtain when using CES preferences.[33]

- 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 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

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

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 $K(.) > 0$, $K'(.) > 0$.

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

Formally, from (12) it follows that

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

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 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.

We now show that propositions 3 and 4 are supported by the data. Indeed, Figures 14 and 15 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 14 has been previously identified in the literature (Lane, 2003; Talvi and Vegh, 2005; Frankel, Vegh, and Vuletin, 2012). However, the positive relationship between tax policy cyclicality and output volatility (Figure 15) is a novel finding. We do not claim that this is the only way to explain procyclicality of spending and, more importantly for the purposes of our paper, tax policy. Having clarified that, it is worth noting that our simple model of optimal fiscal policy under incomplete markets (i) rationalizes why spending and tax policies are more procyclical in developing countries than in industrial economies and (ii) calls attention to the fact that while it is fairly simple to rationalize procyclicality of government spending, explaining the procyclicality of tax policy requires further structure.

10 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. 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. We also find that countries with more procyclical spending policy typically have more procyclical tax policy and vice-versa. In other words, tax and spending policies are typically conducted in a symmetric/homogeneous way over the business cycle.

This novel data also allows us to uncover some new empirical regularities regarding the volatility of tax policy. We find that, similar to the behavior on the spending side, tax policy is more volatile in developing countries than in industrial economies in the sense that developing countries change their tax rates by larger amounts than industrial economies.

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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 the 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 the 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 the 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,

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

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.

1.2. Tax rate data

Personal income tax

Maximum marginal personal income tax rate. World Development Indicators (WDI-World Bank) and World Tax Database (University of Michigan, Ross School of Business). Data period covers 1960-2009.

Corporate income tax

Maximum corporate income tax rate. World Development Indicators (WDI-World Bank) and World Tax Database (University of Michigan, Ross School of Business). Data period covers 1960-2009.

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	Tax revenue on income, profits, and corporations	Personal income tax revenues	Corporate income tax revenues	Good and services tax revenues	Value-added tax revenues
	(as % of GDP)	(as % of total tax revenues)	(as % of total tax revenues)	(as % of total tax revenues)	(as % of total 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	1.12	0.25	0.31	0.09	6.96	25.57	12.69
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	4.20	0.33	0.15	0.25	11.48	28.50	16.81
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	1.98	0.03	0.13	0.20	.	16.90	9.93
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

This appendix solves the Ramsey's planner problem, which in this case coincides with the planner problem, of the model from Section 6.[34] 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 the 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

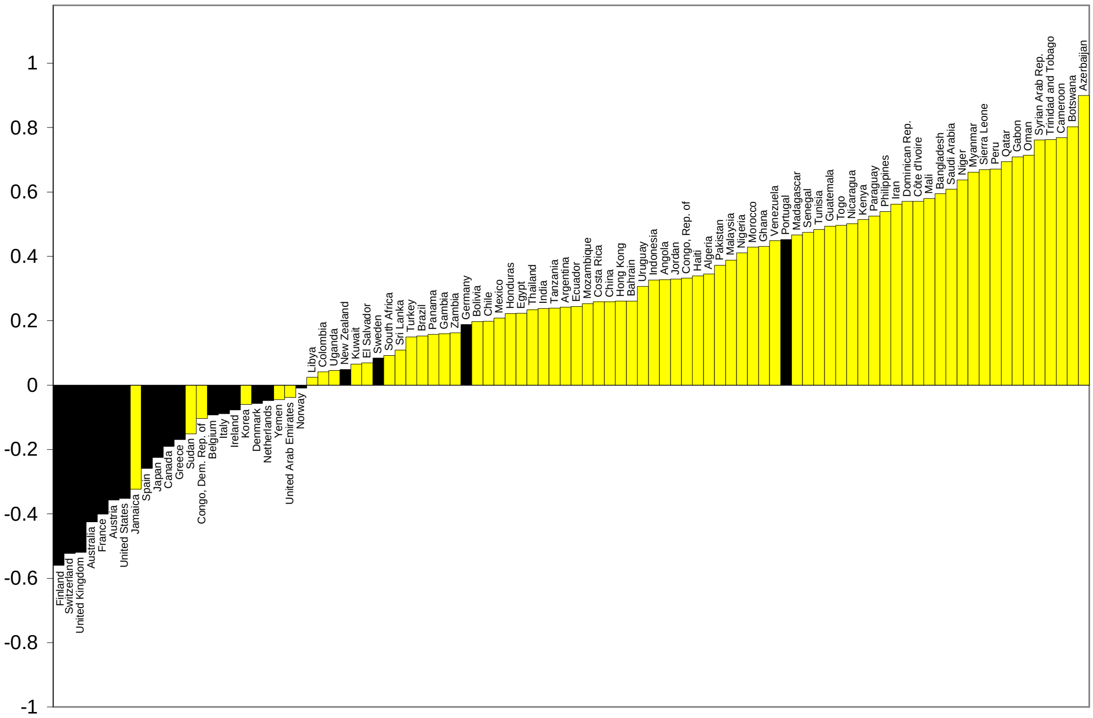
$$\tau_i = g_i^{1-\frac{\sigma_c}{\sigma_g}} \left(\frac{1-\alpha}{\alpha}\right)^{\sigma_c} \qquad i = L, H. \tag{22}$$

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

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

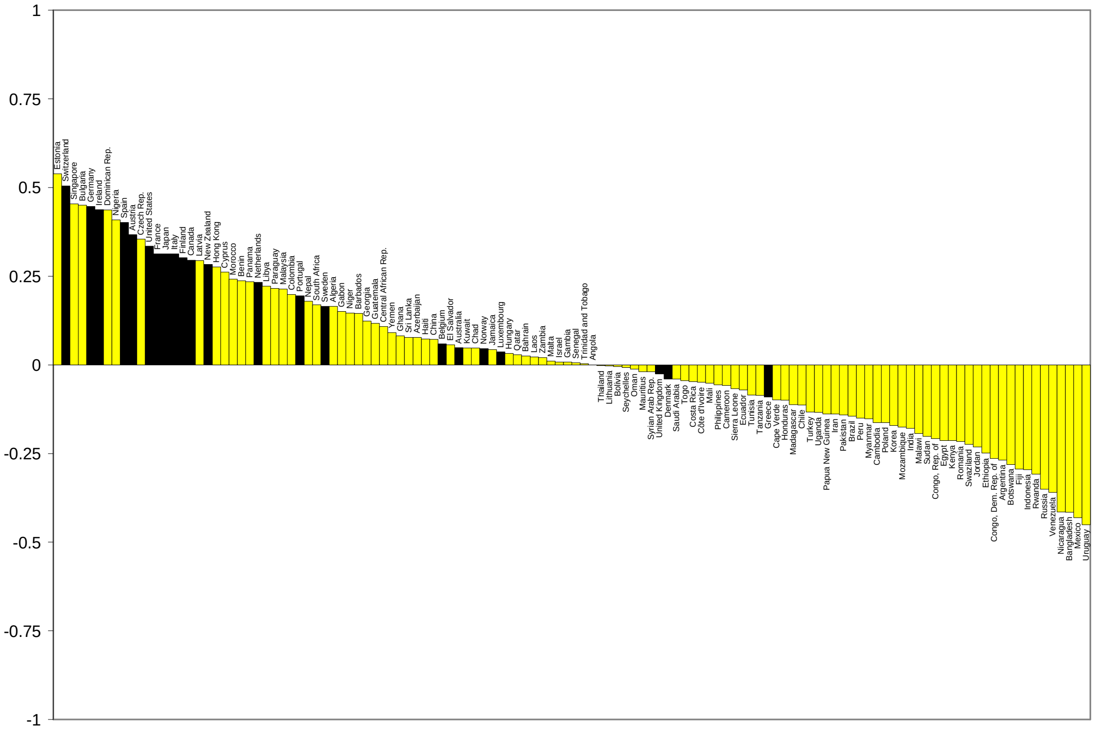
[34] For this simple model, the Ramsey's planner problem coincides with the planner problem because the consumption tax does not distort intertemporally (because it is a static model) and does not distort intratemporally (because households choose only one consumption good and there is no labor/leisure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

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



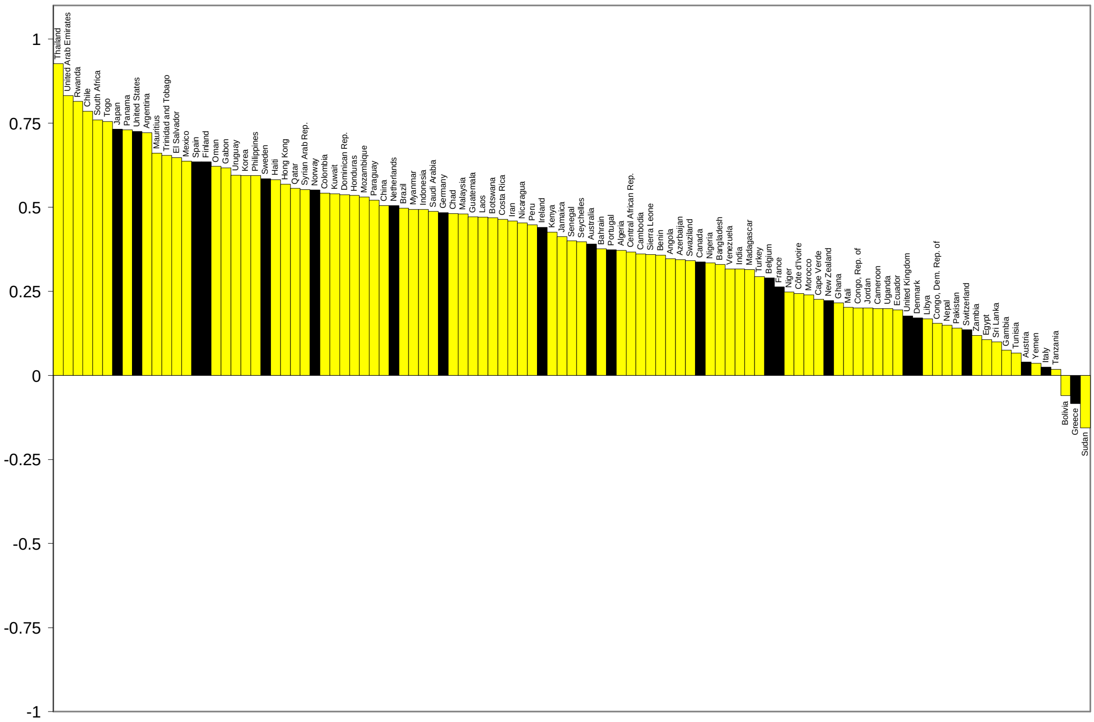
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. Real government expenditure is defined as central government expenditure and net lending deflated by the GDP deflator. A positive (negative) correlation indicates procyclical (countercyclical) fiscal policy. Source: Frankel, Vegh and Vuletin (2012).

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



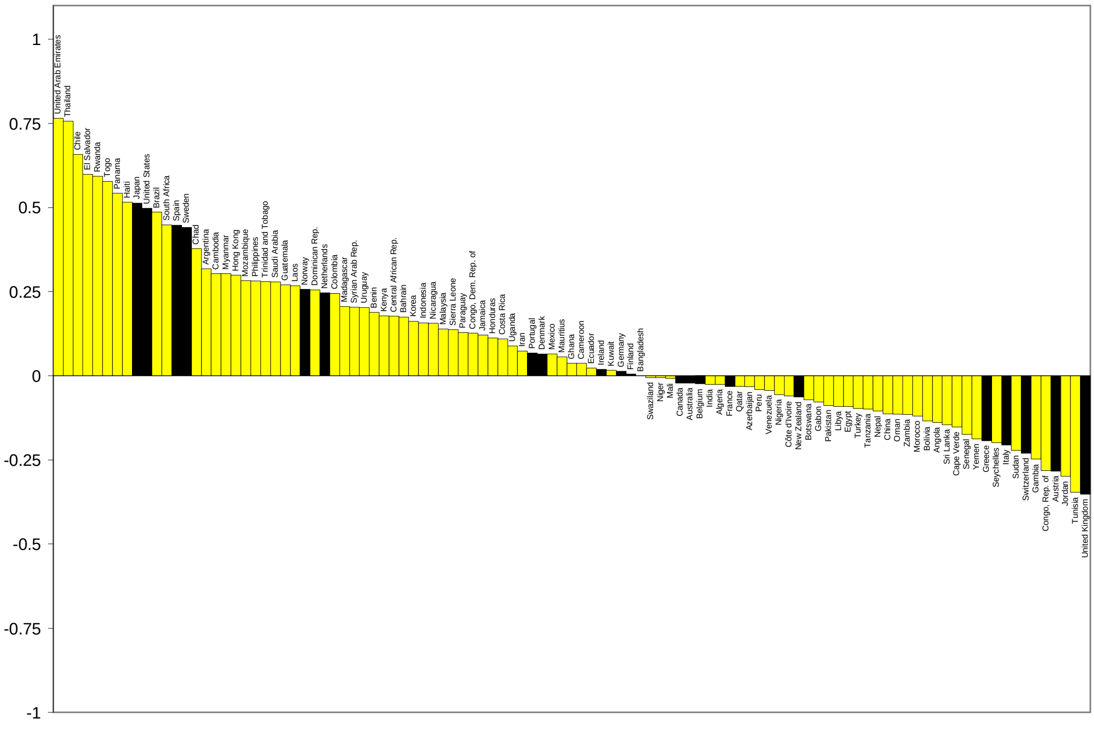
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. Inflation tax is defined as $(\pi/(1+\pi))*100$, where π is inflation. Sample includes 124 countries.

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. Country relationship between the frequency of tax rate changes and percentual absolute change in tax rates (without including zero changes). Personal income tax. 1960-2009

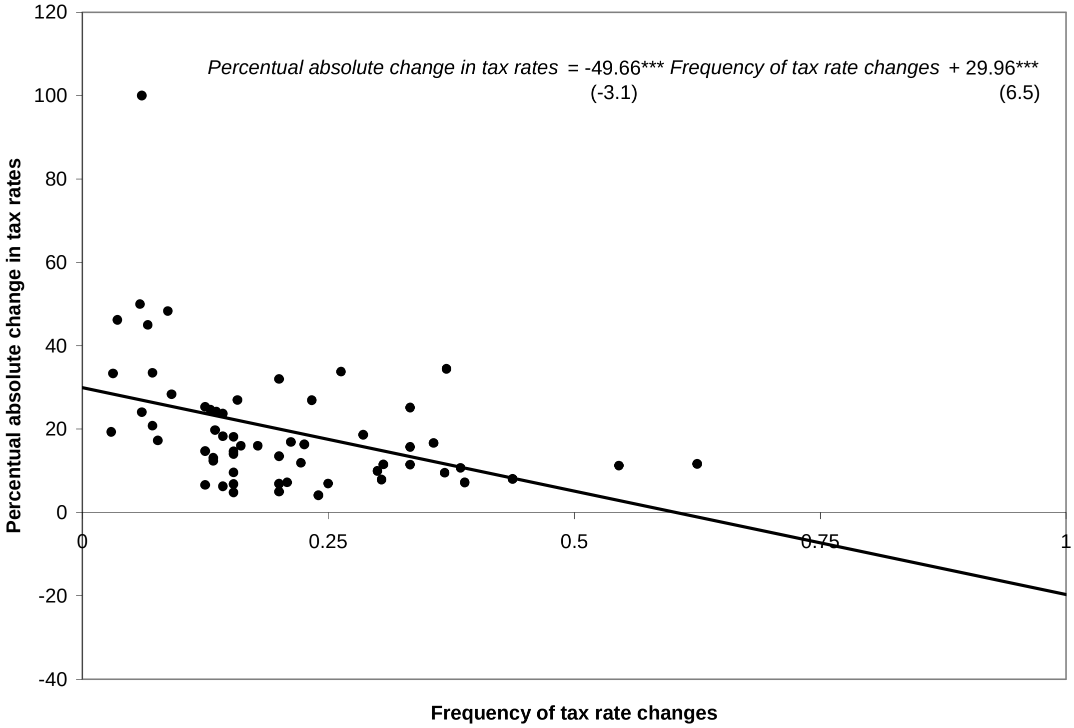


Figure 6. Country relationship between the frequency of tax rate changes and percentual absolute change in tax rates (without including zero changes). Corporate income tax. 1960-2009

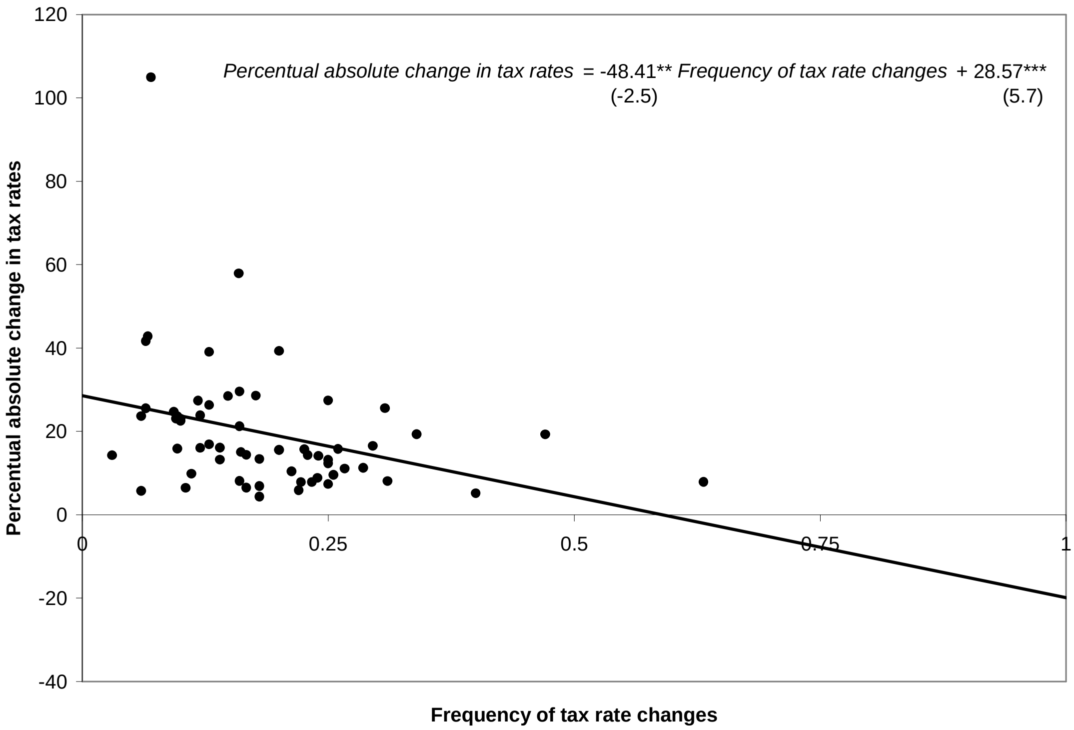


Figure 7. Country relationship between the frequency of tax rate changes and percentual absolute change in tax rates (without including zero changes). Value-added tax. 1960-2009

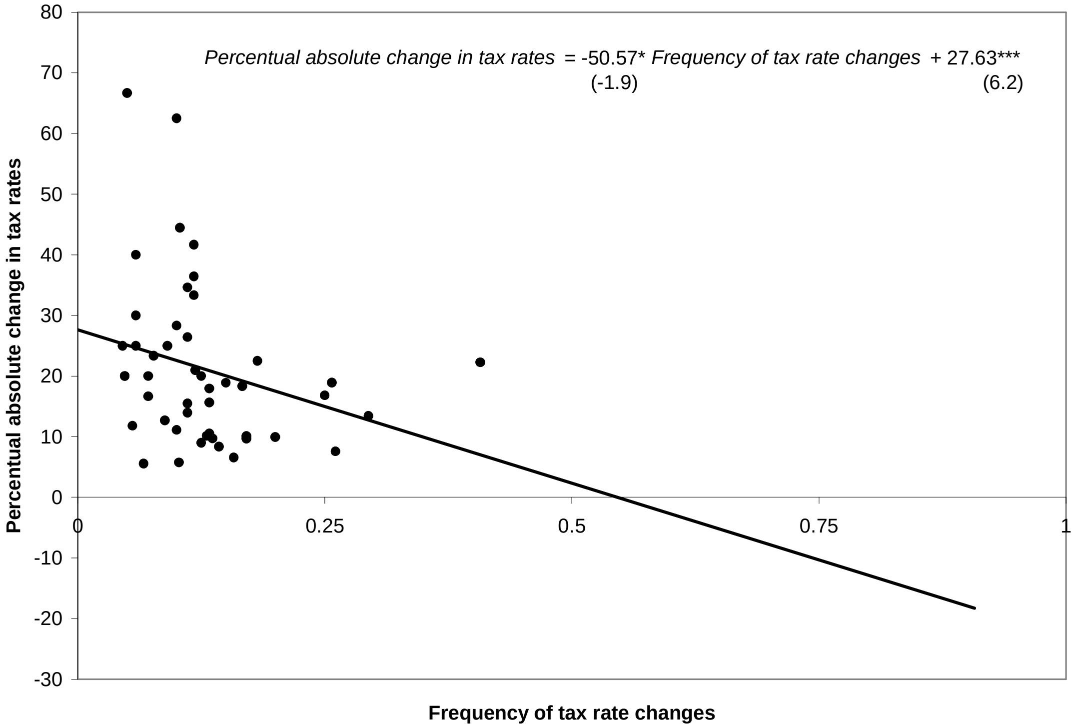
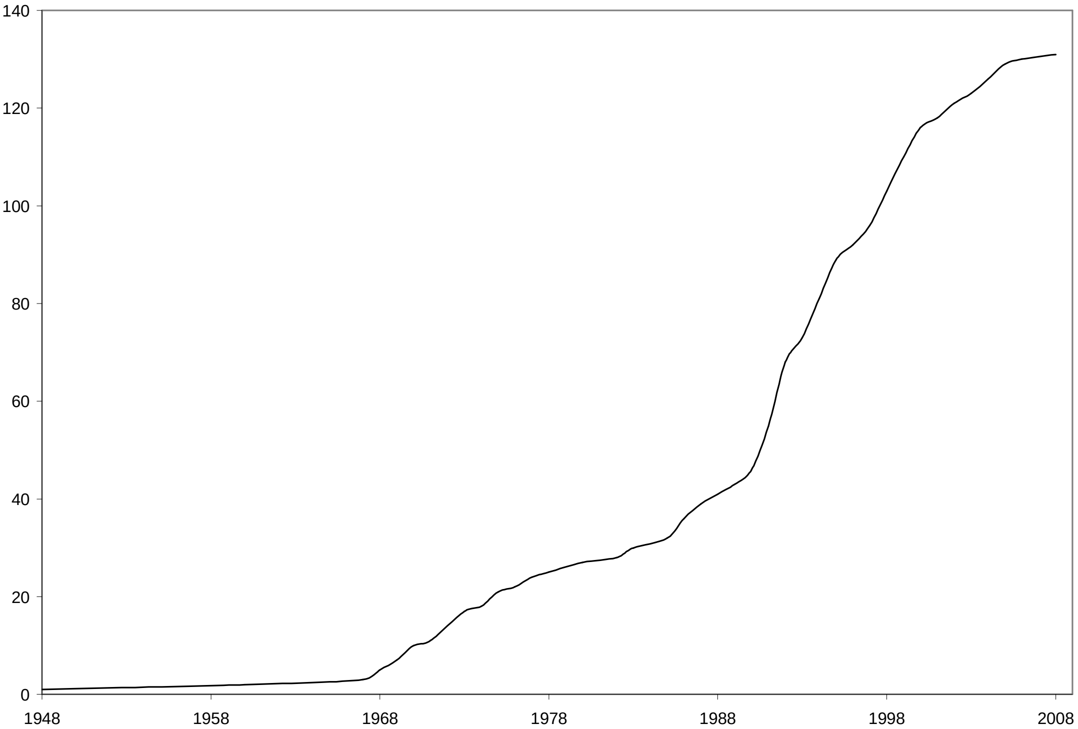
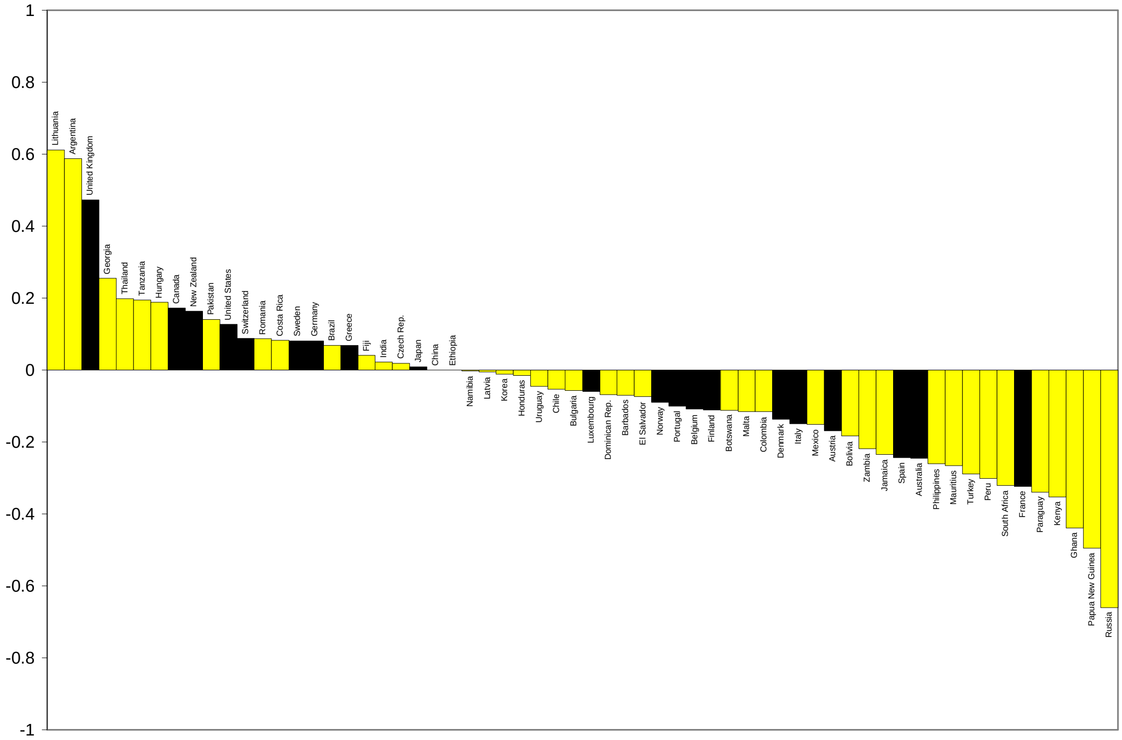


Figure 8. Number of countries with value-added tax. 1948-2009



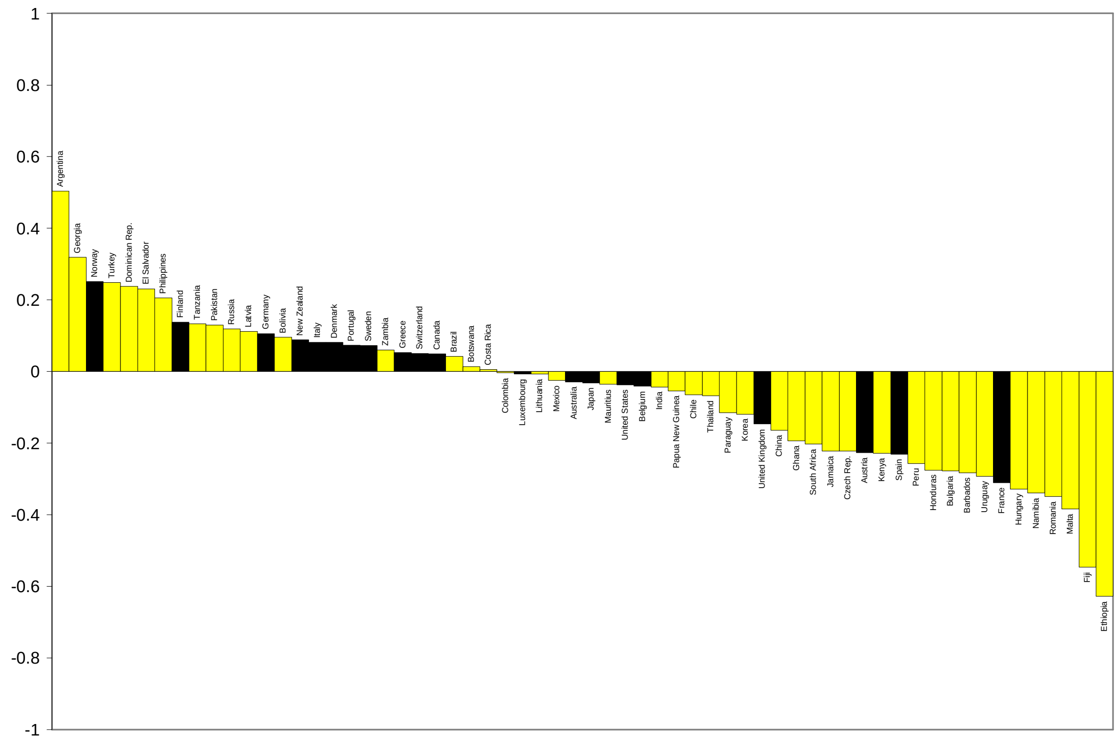
Source: Oldman and Schenk (2007) and authors' sources.

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



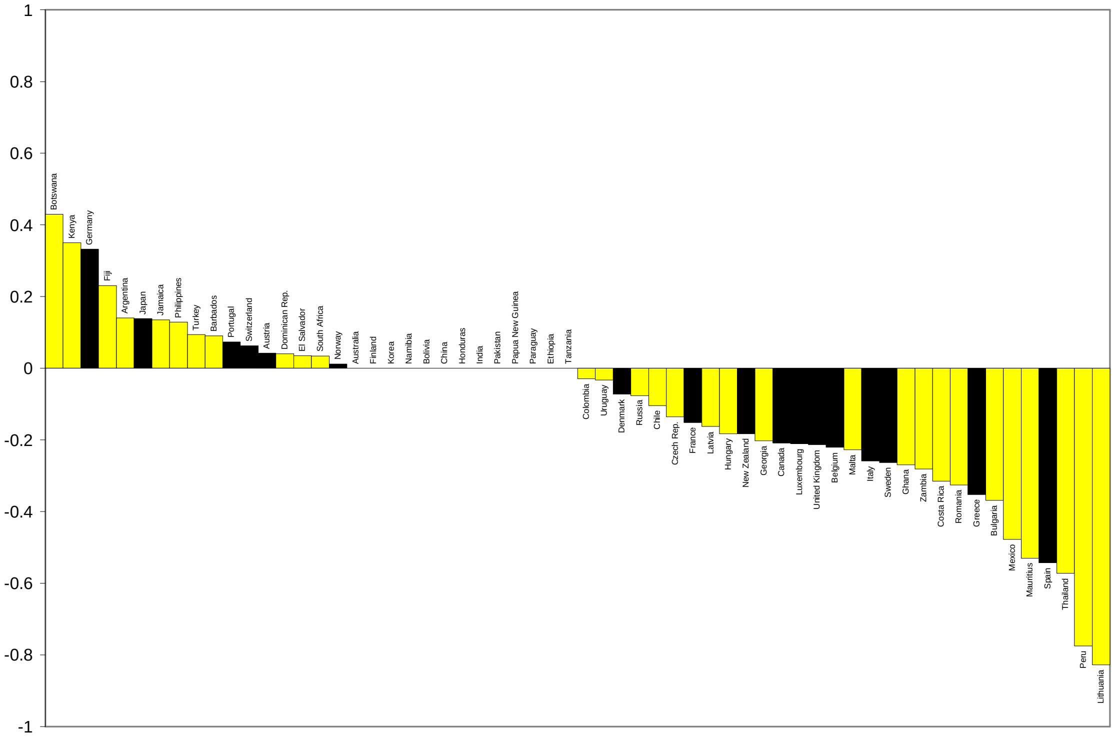
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 62 countries.

Figure 10. Country correlations between the cyclical components of the corporate income tax and real GDP. 1960-2009



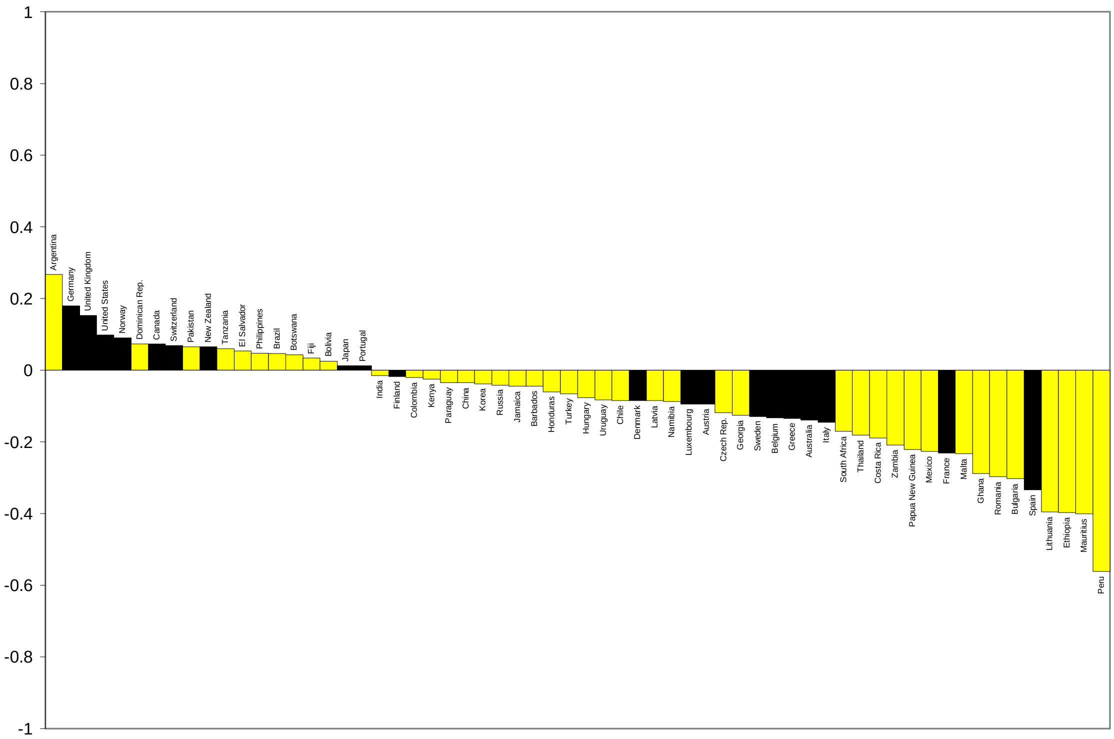
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 62 countries.

Figure 11. Country correlations between the cyclical components of the value-added tax and real GDP. 1960-2009



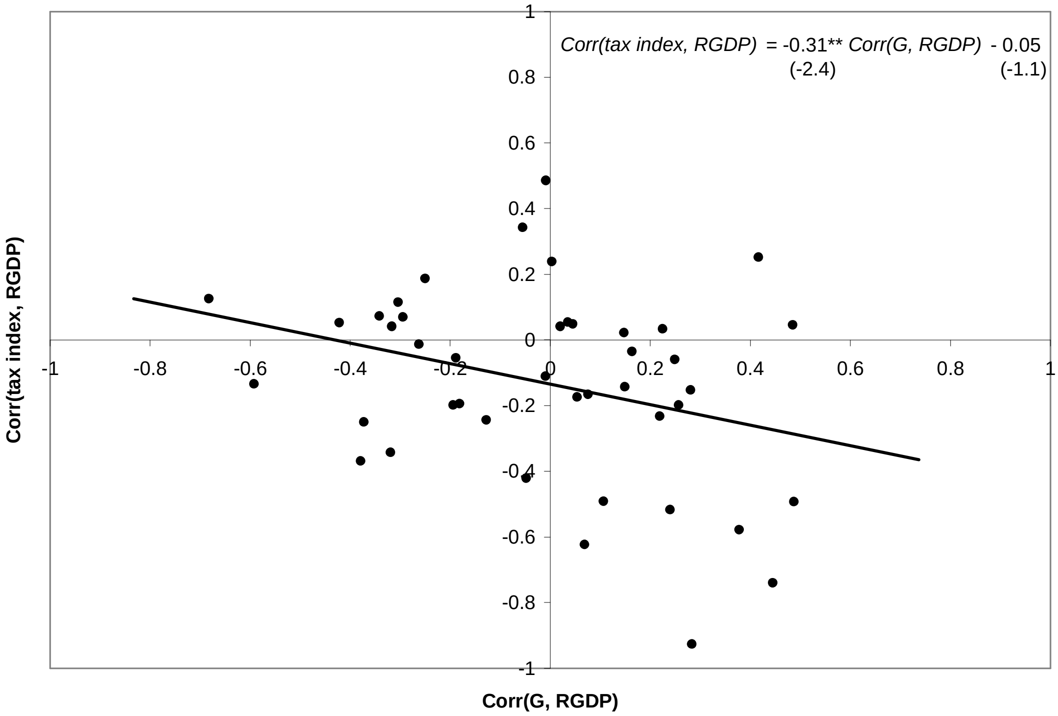
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 60 countries.

Figure 12. Country correlations between the cyclical components of the tax index and real GDP. 1960-2009



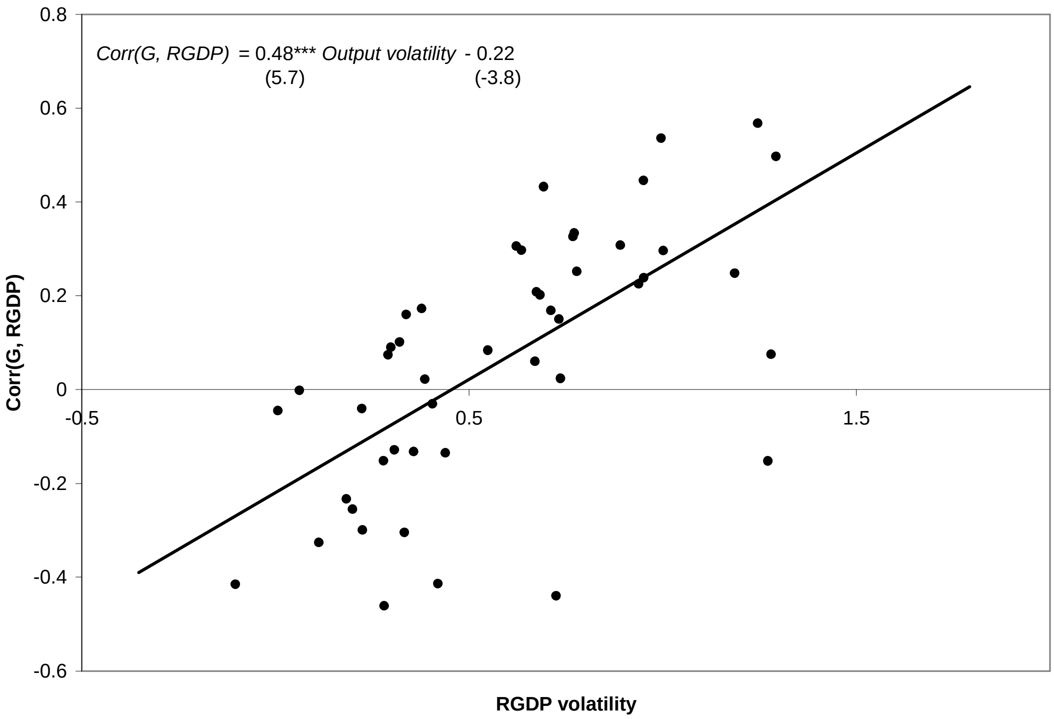
Notes: Dark bars are industrial countries and light ones are developing countries. The cyclical components have been estimated using the Hodrick-Prescott Filter. A negative (positive) correlation indicates procyclical (countercyclical) fiscal policy. Sample includes 62 countries.

Figure 13. Country relationship between the cyclicality of taxation and cyclicality of government spending



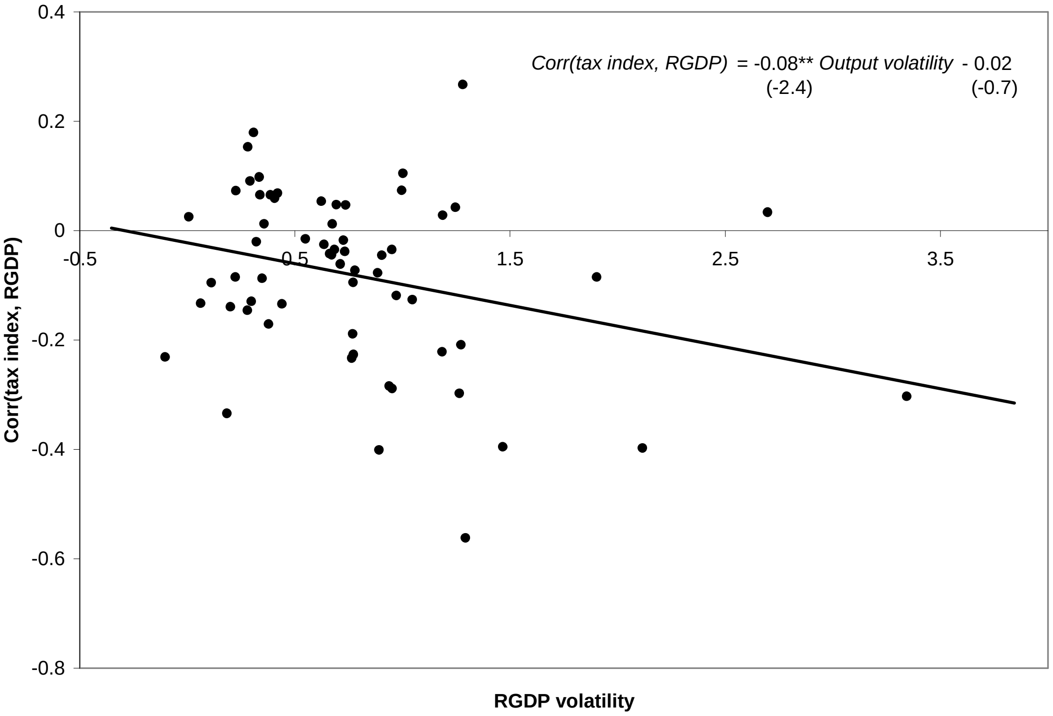
Notes: The cyclical components have been estimated using the Hodrick-Prescott Filter. A positive (negative) Corr(tax index, RGDP) indicates countercyclical (procyclical) fiscal policy. A positive (negative) Corr(G, RGDP) indicates procyclical (countercyclical) fiscal policy. Sample includes 43 countries.

Figure 14. 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 15. 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 $(\pi/(1+\pi))*100$, 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

Direction of tax rates changes

	Personal income tax		Corporate income tax		Value-added tax	
	Industrial	Developing	Industrial	Developing	Industrial	Developing
	(1)	(2)	(3)	(4)	(5)	(6)
Tax rate increases	34	21	52	72	53	53
Tax rate decreases	101	134	114	161	13	27
Total tax rate changes	135	155	166	233	66	80

TABLE 3

Correlation between tax rates changes

	Personal income tax	Corporate income tax	Value-added tax
Personal income tax	1		
Corporate income tax	0.14***	1	
Value-added tax	0.08***	0.05*	1

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

TABLE 4

Frequency and magnitude of tax rate changes

	Industrial	Developing	Difference ≡ (1) - (2)
	(1)	(2)	(3)
PANEL A: Frequency of tax rate changes			
Personal income tax	0.23	0.16	0.07***
Corporate income tax	0.18	0.18	0.00
Value-added tax	0.11	0.11	0.00
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	2.22	-0.65*
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	20.86	-6.45***

Notes: *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively.

TABLE 5

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***
1.2. 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 6

Percentage tax rate changes across different stances of the business cycle

	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)
Good times	-0.29	-1.19	0.74	0.09	-0.64	-0.36	-0.01	-0.21
Normal times	0.16	0.34	-0.08	-0.81	0.23	-0.16	0.12	-0.01
Bad times	-0.11	0.42	-0.55	1.54	0.13	0.77	-0.29	0.24

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: Panel regressions

PANEL A: Dependent variable is percentage change in tax rate

	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)
Percentage change in RGDP	-0.06	-0.14*	0.14	-0.10	-0.23*	-0.44***	-0.05	-0.28***
	[-0.3]	[-1.8]	[0.9]	[-1.4]	[-1.9]	[-5.9]	[-0.4]	[-4.5]
Number of observations	576	934	872	1272	594	722	461	559
Number of countries	20	42	20	42	20	42	20	42

PANEL B: Dependent variable is cyclical component of tax rate

	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)
Cycle of RGDP	0.03	-0.39ˣ	0.14	-0.11**	-0.26*	-0.36***	-0.09	-0.28***
	[0.2]	[-1.6]	[0.9]	[-2.2]	[-2.6]	[-5.9]	[-0.9]	[-4.3]
Number of observations	639	1089	900	1323	614	764	509	662
Number of countries	20	42	20	42	20	42	20	42

Notes: 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

Cyclicality of tax policy: Instrumental variable panel country fixed-effects regressions

PANEL A: Dependent variable is percentage change in tax rate

	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)
Percentage change in RGDP	-3.36 [-1.4]	-0.73* [-1.9]	1.06 [0.7]	-0.25 [-0.8]	0.09 [0.2]	-0.57* [-1.9]	-1.24 [-1.2]	-0.39** [-2.1]
STATISTICS								
Over-identification test (p-value)	0.99	0.26	0.70	0.23	0.35	0.35	0.58	0.22
Weak-identification test (F-statistic)	13.07***	16.15***	13.07***	16.15***	13.07***	16.15***	13.07***	16.15***
Number of observattions	358	368	358	368	358	368	358	368
Number of countries	17	26	17	26	17	26	17	26

PANEL B: Dependent variable is cyclical component of tax rate

	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)
Cycle of RGDP	-0.48 [-0.7]	-10.70ˣ [-1.5]	0.09 [0.1]	-1.31 [-1.15]	0.16 [1.1]	-1.17* [-1.8]	-0.03 [-0.1]	-1.61** [-2.0]
STATISTICS								
Over-identification test (p-value)	0.80	0.30	0.26	0.32	0.45	0.79	0.51	0.31
Weak-identification test (F-statistic)	4.95**	3.16**	4.95**	3.16**	4.95**	3.16**	4.95**	3.16**
Number of observattions	397	451	397	451	397	451	397	451
Number of countries	17	26	17	26	17	26	17	26

Notes: The excluded instruments are ShockPX and ShockJP. Errors are allowed to present arbitrary heteroskedasticity and arbitrary intra-country correlation (i.e., clustered by country). t-statistics are in square brackets. Constant term and Global interest rate 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 weak-identification test is the F-statistic of the first stage regression.
ˣ, *, ** and *** indicate statistically significant at the 15%, 10%, 5% and 1% levels, respectively.

TABLE 9

Cyclicality of tax policy: Panel country fixed-effects regressions for average marginal personal income

PANEL A: Dependent variable is percentage change in tax rate

	Basic regressions	IV regressions
	(1)	(2)
Percentage change in RGDP	-0.40 [-1.0]	-3.17 [-0.5]
STATISTICS		
Over-identification test (p-value)		0.20
Weak-identification test (F-statistics)		0.13
Number of observattions	147	130
Number of countries	6	6

PANEL B: Dependent variable is cyclical component of tax rate

	Basic regressions	IV regressions
	(1)	(2)
Cycle of RGDP	-0.51 [-1.1]	-0.92 [-1.0]
STATISTICS		
Over-identification test (p-value)		0.75
Weak-identification test (F-statistics)		19.88***
Number of observattions	141	135
Number of countries	6	6

Notes: The excluded instruments are ShockPX and ShockJP. Errors are allowed to present arbitrary heteroskedasticity and arbitrary intra-country correlation (i.e., clustered by country). t-statistics are in square brackets. Constant term is 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 weak-identification test is the F-statistic of the first stage regression.
ˣ, *, ** and *** indicate statistically significant at the 15%, 10%, 5% and 1% levels, respectively.