Average tax rate cyclicality in OECD countries: A test of three fiscal policy theories

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Average tax rate cyclicality in OECD countries: A test of three fiscal policy theories*

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Abstract

This paper investigates the cyclical properties of the average effective tax rate in 26 OECD countries over 1965-2003 in order to test the validity of three theories of fiscal policy: (i) the standard Keynesian theory which recommends that tax policy should be counter-cyclical, (ii) the Tax Smoothing hypothesis, which implies that changes in GDP should be uncorrelated with tax rates, and (iii) the positive theory of Battaglini and Coate (2008) which predicts that the average tax rate should be negatively correlated with GDP. Our main finding is that the correlations of tax rates with cyclical GDP are generally quite small and statistically indistinguishable from zero. This finding is quite robust and is more consistent with the implications of the Tax Smoothing hypothesis than either the recommendations of the standard Keynesian model or the predictions of Battaglini and Coate's theory.

Keywords: Fiscal Policy, Tax Rates, Business Cycle.
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1. Introduction

Is fiscal policy pro-cyclical? Should it be? The standard Keynesian model implies that fiscal policy should be counter-cyclical, i.e. government spending should increase in economic contractions and fall in expansions, while taxes should follow the opposite pattern. At the same time, Tax Smoothing models inspired by Barro (1979) suggest that the government should smooth the tax rate, by borrowing in recessions and repaying in booms. In other words, changes in GDP will be positively correlated with tax revenue, but should be uncorrelated with tax rates and tax revenue as a percentage of GDP.[1]

The empirical literature has tried to test the main recommendations of both of these normative theories.[2] Focusing on the cyclicality of government expenditure, the basic finding has been that government spending tends to be slightly pro-cyclical in developed countries and strongly pro-cyclical in developing countries.[3]

[1] Versions of the theory also predict that changes in GDP should be uncorrelated with government spending but negatively correlated with government spending as a proportion of GDP, and that debt will be increasing in booms and decreasing in the recessions, i.e. debt is positively correlated with changes in GDP. For an example of the "traditional" Keynesian theory, see Romer (2006, chapter 5). For an exposition of the Tax Smoothing hypothesis in terms of the average effective tax rate, see Romer (2006, chapter 11).

[2] See, for example, Gavin and Perotti (1997), Sorensen et al. (2001), Lane (2003), Alesina et al. (2008), Talvi and Vegh (2005), and Ilzetzki and Vegh (2008).

[3] A possible explanation can be found in the literature of credit supply. In fact, as argued by Catao and Sutton (2002) and Kaminsky, Reinhart and Vegh (2004), developing countries become credit constrained during economic downturns, or can borrow only at very high interest rates. This precludes governments from effectively smoothing economic fluctuations. As a result, government expenditure increases during good times and decreases during bad times, i.e. fiscal policies become procyclical. Another explanation to account for different behavior of fiscal policy is political factors. Persson (2001), Persson and Tabellini (2001), Alesina et al. (2008), find that political and institutional variables matter also for fiscal responsiveness. In particular, Alesina et al. (2008) show that most of the procyclicality of fiscal policy in developing countries can be explained by high levels of corruption in those countries. The authors build a model where a high degree of corruption means that surpluses accumulated in good times when fiscal policy is countercyclical are not optimal because the electorate knows that corrupt political representation would misappropriate them. It is then rational for the electorate to demand higher spending during expansions, i.e. pro-cyclical fiscal policy.

These findings have been interpreted as suggesting that fiscal policy behavior is not consistent with Keynesian recommendations, and only partly consistent (for some developed countries) with the Tax Smoothing hypothesis.

In contrast, both findings appear to be consistent with the political economy theory of fiscal policy recently proposed by Battaglini and Coate (2008). The economic model underlying this theory is a dynamic stochastic general equilibrium model in which a single good is produced using labour, whose productivity depends on the business cycle. The political economy component of the model assumes that policy choices in each period are made by a legislature comprised of representatives elected by single-member, geographically-defined districts.[4]

The main prediction of this theory is that fiscal policy is pro-cyclical. In particular, the model demonstrates that government spending increases in booms and decreases during recessions, while tax rates decrease during booms and increase in recessions. In other words, the theory predicts that government spending as share of GDP should be neutral over the cycle and that tax revenue as percentage of GDP should be negatively correlated with changes of GDP. As we have already said, these predictions appear to be broadly consistent with the empirical evidence on government spending, but are they also with the evidence on tax revenue?

The aim of the present paper is to contribute to the literature by investigating the relation between tax rates and GDP changes. In particular, we will try to assess whether tax revenues as a share of GDP are positively or negatively correlated with the cyclical

[4] The model assumes that the government can raise revenues in two ways (via a proportional tax on labour income and by issuing one period risk-free bonds) and that public revenues are used to finance the provision of public goods. The level of public debt and the persistent level of productivity are the state variables, creating a dynamic linkage across policy-making periods.

component of real GDP. This will test the predictions of Battaglini and Coate's (2008) positive theory and compare them with the normative frameworks of the standard Keynesian model and tax smoothing.

To this purpose we compute the correlations between average effective tax rates and cyclical output using a set of 26 OECD countries for which we have data from 1965 to 2003. The results show that the correlations for the great majority of countries are not statistically significantly different from zero. Moreover, in order to differentiate between different phases of the business cycle, we compute these correlations over expansions (defined as periods with positive cyclical components) and downturns (defined as periods with negative cyclical components). Again, the results uncover almost no statistically significant correlations.

All our findings are robust to the different types of taxes we tried, which include the following: i) total taxes; ii) taxes on income, profits, and capital gains; iii) social security contributions; iv) taxes on payroll and workforce; v) taxes on property; vi) taxes on goods and services; vii) other taxes. Moreover, the results are also robust to using a panel framework in assessing the relationship between tax rates and changes in the cyclical component of GDP.

Thus, the empirical evidence of our paper is largely consistent with the Tax Smoothing hypothesis, while it seems to be inconsistent with both the standard Keynesian recommendations and the predictions of the theory proposed by Battaglini and Coate (2008). Taken together with the literature's findings on the cyclical behavior of government spending, our results call for a new theory of fiscal policy that is consistent with the empirical evidence on the behavior of *both* government spending and revenue (as well as debt) over the cycle.

The rest of the paper is organized as follows. Section 2 describes the empirical methodology and the data we use to assess the pattern of tax revenue over the cycle. Section 3 presents and discusses the empirical results, and section 4 concludes.

2. Data and Empirical Methodology

All tax data are from the *Revenue Statistics of OECD Member Countries* database, and measure various taxes as a percentage of GDP. In particular, we consider the following average effective tax rates: i) total taxes; ii) taxes on income, profits, and capital gains; iii) social security contributions; iv) taxes on payroll and workforce; v) taxes on property; vi) taxes on goods and services; vii) other taxes.

Table 1 provides a list of these 26 OECD economies together with country averages over 1965-2003 for the seven tax series.[5] The average total tax rate has varied from 17.2% in Mexico to 46.7% in Sweden. Though these OECD countries have relied very differently on the various forms of taxes, income taxation has been the largest revenue generator for most of them.[6] Taxes on income, profits, and capital gains have ranged from 4.6% of GDP in Mexico to 25.1% of GDP in Denmark. In nine of the countries, most of the revenues were raised by taxes on goods and services.[7] Only in

[5] Country selection is dictated by data availability only.

[6] To be specific, for 14 countries out of the 26: Australia, Belgium, Canada, Denmark, Finland, Japan, Luxembourg, the Netherlands, Norway, New Zealand, Sweden, Switzerland, the UK, and the US.

[7] The nine are Austria, Greece, Iceland, Ireland, Korea, Mexico, Portugal, Spain, and Turkey.

three countries has the largest share been generated by social security taxes,[8] and in none of the countries by property taxes, which are generally the smallest.

As shown in Figure 1, total tax rates in these OECD countries have generally increased over time, but with important differences among countries, in terms of starting and ending values.

Real GDP data are obtained from the OECD's *Economic Outlook* database. We consider the same set of 26 countries for most of which we have data on taxes from 1965 to 2003.[9]

We have tried several methods of obtaining the cyclical components of GDP. First, we use three different filtering techniques to detrend the (log) output series of each country and estimate its cyclical component: i) the Hodrick-Prescott (HP) filter with a smoothness parameter equal to 100; ii) the HP filter with a smoothness parameter equal to 6.25; and iii) a Band-Pass filter. These are among the most commonly used detrending methods in the business-cycle literature. As an additional measure of cyclical GDP we also considered data of the output *GAP* from the OECD *Economic Outlook* n.86 (2009)[10]. As our main findings proved quite robust to these different cyclical measures, we will only report results based on the HP-6.25 filter in the next section to preserve space. [11]

[8] These three are France, Germany, and Italy.

[9] The exceptions are Iceland (1980-2003), Korea (1972-2003), and Mexico (1980-2003).

[10] See Beffy et al. (2006) for details.

[11] We provide a more detailed discussion of these filtering methods and their properties in the Appendix. We have also preferred the HP-6.25 filter to simple differencing because the HP produces a cyclical component that has a long-run average value of zero. This is a desirable property for a cyclical component, but it is strongly violated by output growth rates.

In Figure 2 we plot the business cycle component of real GDP obtained using the HP filter with a smoothness parameter equal to 6.25, our benchmark method. Casual inspection of Figure 2 reveals that countries differ substantially in terms of cyclical behavior. This variability together with that of the tax rates should facilitate the empirical identification of the relationship between the tax rates and the business cycle.

In order to assess the behavior of a tax rate over the cycle we then compute the correlation between the tax rate and the cyclical component of the corresponding country's GDP:

$$corr\left(tax_{i,t}^{j}, gdp_{i,t}^{c}\right) \qquad (1)$$

where $gdp_{i,t}^{c}$ is the cyclical component of (log) output for country *i* at time *t*, and $tax_{i,t}^{j}$ is the tax rate *j* for country *i* at time *t*.

Moreover, in order to differentiate between different phases of the cycle, we compute these correlations over expansions (defined as times of positive cyclical components) and downturns (defined as times of negative cyclical components).

As a final test we try to assess how the tax rates respond to cyclical changes in GDP when all countries are considered together. To this purpose we estimate a simple bivariate relationship between tax rates (tax revenue as percentage of GDP) and cyclical (log) GDP:

$$\left(\frac{Tax}{GDP}\right)_{i,t} = \alpha + \beta \cdot gdp_{i,t}^{c} + \varepsilon_{i,t} \qquad (2)$$

In particular we estimate equation (2) using OLS, country fixed effects (FE), country and time FE, and Instrumental Variables (we instrument cyclical GDP with lagged values of our dependent and independent variables).

3. Results

For a preliminary assessment of the behavior of tax revenue over the cycle, we first compute the average total tax rates over the period 1965-2003 in periods of upturns (positive cyclical components of real GDP) and downturns (negative cyclical components of real GDP), and the value of total tax rates at peaks (the highest value of the cyclical component of real GDP) and troughs (the lowest value of the cyclical component of real GDP). The results are reported in Table 2. Looking at the table, it is possible to see that the behavior of the total tax rate over the phases of the cycle differs among countries. In particular, focusing on the first two columns of the table, it emerges that while for 13 of the 26 countries the tax rate is bigger during downturns than during upturns, for the rest half of the sample the tax rate is bigger during upturns. The differences, however, are never sizable. This balanced behavior during cyclical upturns and downturns is confirmed by averaging the tax rate over all countries in the sample: these averages are virtually identical in the two phases of the cycle.[12]

Similarly, focusing on the last two columns of the table, it seems that Battaglini and Coate's (2008) prediction that tax rates decrease during booms and increase in recessions cannot be confirmed. If that prediction were true, we would expect tax rates at peaks to be lower than tax rates at troughs. In fact, for most of the countries (15 out of 26) we find the opposite result, and once again those tax rates averaged over countries are virtually the same at peaks and troughs.

Next, as described in the previous section, we move to a more formal assessment of tax cyclicality by computing the correlations between tax rates and the cyclical

[12] Similar results are obtained for different tax rates. They are available upon request.

components of (log) real GDP for each of the 26 OECD countries, over the period 1965-2003. The results are reported in Table 3. The Table also reports the correlation between tax rates and GDP in cyclical downturns and upturns (columns 2 and 3).

Looking at the first column of Table 3, one can immediately see that, with the exception of the UK (for which there is a sizable and weakly statistically significant negative correlation), the correlation between tax rates and GDP is slight and not statistically significant. The result is broadly confirmed when we look at the correlation during cyclical downturns and upturns. However, for some countries (such as Greece and Italy) the absence of correlation over the all cycle is explained by the fact that tax revenue was negatively correlated to cyclical upturns and positively correlated over downturns.

These results are robust to the different filtering methods (HP-100 and BP) used to retrieve the cyclical components of real GDP, and to the use of the OECD's output *GAP* measure. In fact looking at Table 4, one can see that the absence of a strong and/or statistically significant correlation is confirmed for the great majority of cases. We note that this finding that the tax rate is essentially uncorrelated with cyclical GDP is consistent with the Tax Smoothing hypothesis but inconsistent with both the standard Keynesian recommendation and Battaglini and Coate's (2008) prediction.

So far, our analysis has focused on the total tax rate. We now continue by looking at various different types of taxes and their correlation with cyclical GDP. This is more than a robustness exercise: in fact, many of the relevant theories (including Battaglini and Coate, 2008) are formulated specifically in terms of income taxes. Thus, it is important to differentiate between different tax rates. In Table 5 we report the correlation between cyclical GDP and i) taxes on income, profits, and capital gains; ii) social security contributions; iii) taxes on payroll and workforce; iv) taxes on property; v) taxes on goods and services; and vi) other taxes.

Starting with the results for income taxes (first column of Table 5), it is readily observed that the correlations are not significantly different from zero for all OECD countries in the sample (including the U.K.). This result suggests that income tax rates (i.e. income taxes as a % of GDP) are neutral over the cycle, contradicting Battaglini and Coate's predictions of a negative correlation.[13] Similar implications can be drawn for all the different tax rates, with the exception of the payroll tax rate for Canada, Denmark, and Ireland, and the tax rate on goods and services for Mexico, which are the only cases to show a statistically significant negative correlation with cyclical GDP.[14]

So far, we have been assuming that the correlations between cyclical GDP and tax rates are time-invariant. We now relax this assumption and allow these correlations to vary with time by estimating them for rolling 20-year windows for each country. Figure 3 shows how these time-varying correlations of the total tax rate with cyclical GDP have evolved over time. Two basic results clearly stand out. First, as expected, the results differ substantially among countries, and second, the assumption of time-invariant correlations appears questionable. For some countries (such as Australia, Denmark, Finland, Japan, Norway, Spain and Sweden) the correlation is increasing over time; for other countries (such as Austria, Canada, France, Italy, Korea Turkey and U.S.) it fluctuates around values close to zero (or slightly negative); while for the rest of the

[13] In fact, for the majority of countries, the point estimates of these correlations of cyclical GDP with the income tax rate are positive. It is tempting to observe that this positive sign (though definitely the wrong sign for the Battaglini and Coate's prediction) is consistent with the standard Keynesian recommendation, while the lack of statistical significance is consistent with the tax smoothing hypothesis.

[14] Unlike the results for the income tax, the preponderance of the point estimates of the correlations of cyclical GDP with social security contributions and taxes on goods and services are negative. This sign (though not the lack of statistical significance) is consistent with the Battaglini and Coate (2008) prediction.

sample (Belgium, Iceland, Ireland and Luxembourg) it decreases toward sizeable (and statistically significant) negative values.

Again, however, the results suggest that Battaglini and Coate's prediction of a consistently negative correlation between GDP and the tax rate cannot be confirmed by the empirical evidence in most of the countries analyzed.

As a next test we try to assess how tax rates respond to a cyclical change of GDP when all countries are considered together. For this purpose we estimate a simple bivariate relationship between tax rates (again defined as tax revenue as a percentage of GDP) and cyclical GDP (equation 2). The results are reported in Table 6, where in each column we present the results obtained with a different estimation method.[15] Analyzing the results, one can observe that while the point estimate of the coefficient measuring the degree of cyclicality of the tax rate is negative, it is never statistically significant in any specification.

Next, we allow for a richer lag structure to permit the tax rates respond to cyclical output changes with some delay. To this end, we re-estimate the simple regression of tax rates with one, two, and three lags of cyclical output.[16] The results, reported in Table 7, still point to the absence of a significant relation.

As a final test, we re-estimate tax rates as functions of cyclical GDP and several control variables and interaction terms. In this way, we try to control for possible omission bias and we assess whether the smoothness of tax rates may depend

[15] We consider as instruments two lags of the cyclical GDP. The Anderson statistics, the Cragg-Donald Wald – statistics and the Sargan test of over-identification restrictions suggest that the choice of the instruments is appropriate. For simplicity we report only the Sargan test's p-value in Table 6. Additional results are available from the authors upon request.

[16] We are grateful to an anonymous referee for suggesting this extension, as well as the one outlined in the next paragraph.

systematically on structural country characteristics. In particular, the variables included in the analysis are: i) *trade openness* (measured by the sum of total exports and imports as a fraction of GDP); ii) *country size* (measured by the log of total population); iii) the *Gini coefficient* for income inequality; iv) and a political dummy, *left*, that takes the value of 1 for "left-leaning" governments, and zero otherwise.[17] These variables are generally thought to be associated with tax revenue as a share of GDP. For example, smaller and more open economies are generally characterized by a larger government size (Alesina and Wacziarg, 1998). Left-leaning governments may also be associated with a larger tax-to-GDP share, and countries with higher inequality may have an incentive to increase tax rates for redistribution purposes. The results in Table 8 show that indeed these variables are associated with the share of total tax revenue in GDP; however, they do not affect the response of tax rates to cyclical GDP. In particular, the estimated coefficients suggest that smaller and more open economies tend to have higher tax rates, and that income inequality also raises tax rates. In contrast, the effect of a left-leaning government on taxes is not statistically significant. The inclusion of these variables, both as control and as interaction terms, however, does not affect the estimated response of tax rates to cyclical GDP, so that the absence of a correlation between the tax rates and cyclical GDP is still confirmed.

Our results are also robust to using different tax rates in the panel regressions. Table 9 reports the results of estimating regression (2) separately for each of the six types of taxes we considered above. As the results indicate, the overwhelming majority of these estimates are statistically insignificant. In particular, the coefficients for the income

[17] Data for trade openness and populations are taken from the OECD Economic Outlook 85 (2009), data for Gini coefficients are from the OECD Main Economic Indicators (2009), and data for *left* governments are from the DPI Political Database.

tax, as well as taxes on goods and services, payroll, and property taxes are never statistically significantly different from zero. In contrast (at least, when we include country fixed effects) social security contributions appear to be negatively related to cyclical changes, while "other taxes" are positively associated with them. Thus, this method also seems to confirm a generally neutral behavior of tax rates over the cycle.

4. Conclusions

This paper investigated the cyclicality of the average effective tax rate in order to investigate the validity of three theories of fiscal policy. According to the standard Keynesian theory, tax policy should be counter-cyclical, i.e. tax rates should decrease in economic contractions and increase in expansions. The Tax Smoothing hypothesis, instead, implies that changes in GDP should be uncorrelated with tax rates. In contrast to these normative theories, a recent positive theory proposed by Battaglini and Coate (2008) predicts that the tax rate will be negatively correlated with GDP.[18]

This paper relies on these very different theoretical implications in order to test the three theories. We compute the correlations between tax revenue as a fraction of GDP and cyclical output for each of 26 OECD countries for which we have data from 1965-2003. The results show that the correlations are generally quite small and statistically indistinguishable from zero.

This finding is quite robust. It is obtained when we look at the relationship between tax rates and cyclical GDP over upturns and downturns or at business-cycle

[18] It might be helpful to remind the reader that our focus has been on average effective tax rates (tax-to-GDP ratios) rather than marginal tax rates. While the latter is the relevant variable for many important economic issues (such as the effects of taxes on labor supply or long-run economic growth), our focus here has been on the cyclical properties of aggregate tax revenue, for which the former is appropriate.

peaks and troughs. It is also valid when we look at different tax rates, in addition to total taxes, such as income taxes, social security contributions, payroll taxes, property taxes, taxes on goods and services, and "other" taxes. The results are also robust to assessing the relationship between tax rates and cyclical changes of GDP in a panel framework.

Overall, the empirical evidence of our paper seems to be more consistent with the Tax Smoothing hypothesis than either the recommendations of the standard Keynesian model or the predictions of Battaglini and Coate's (2008) theory. This result calls for a new theory of fiscal policy that will be consistent with the empirical evidence on *both* government spending and government revenue (as well as debt) over the cycle.

References

Alesina, A., Campante, F. and Tabellini, G. (2008) "Why is Fiscal Policy Often Procyclcial?", *Journal of the European Economics Association,* 6(5), *forthcoming*

Alesina, A., Wacziarg, R., (1998). "Openness, country size and government" *69(3), Journal of Public Economics,* pp. 305-321.

Barro, R.J.(1979 "On the Determination of the Public Debt," *Journal of Political Economy,* 87, 940-971.

Battaglini, M. and Coate, S. (2008) "Fiscal Policy over the Business Cycle: A Positive Theory" NBER Working Paper 14047.

Beffy, P.O., P. Ollivaud, P. Richardson and F. Sédillot (2006), "New OECD Methods for Supply-Side and Medium-Term Assessments: A Capital Services Approach", *OECD Economics Department Working Papers,* No. 482.

Catao, L., and Sutton, B. (2002). "Sovereign defaults: the role of volatility", International Monetary Fund, Working Paper 02/149.

Gavin M. and Perotti R. (1997). "Fiscal policy in Latin America", NBER Macroeconomics Annual, vol. 12, 11-71.

Hallerberg, M. and Strauch, R. (2002). "On the Cyclicality of Fiscal Policy in Europe". Empirica. 29: 183-207.

Ilzetzki, E. and Végh, C. (2008). "Procyclical Fiscal Policy in Developing Countries: Truth or Fiction?" NBER Working Paper 14191. Cambridge, United States: National Bureau of Economic Research.

Kaminsky, G., Reinhart, C. and Végh, C. (2004). "When It Rains, It Pours: Procyclical Capital Flows and Macroeconomic Policies." NBER Working Paper 10780. Cambridge, United States: National Bureau of Economic Research.

Lane, P. (2003). "The cyclical behaviour of fiscal policy: evidence from the OECD", *Journal of Public Economics*, vol.87, 12, 2261-2675 (December).

Persson, T. (2001). "Do Political Institutions Shape Economic Policy?", NBER Working Papers 8214.

Persson, T. and Tabellini, G. (2001). "Political Institutions and Policy Outcomes: What are the Stylized Facts ? ", CEPR Discussion Papers 2872.

Romer, David (2006). *Advanced Macroeconomics*, 3rd edition, McGraw-Hill.

Sorensen, B., Wu, L. and Yosha, O. (2001). "Output fluctuations and fiscal policy: U.S. state and local governments 1978–1994'", European Economic Review, vol. 45, pp. 1271–310.

Talvi E. and Vegh, C. (2005). "Tax base variability and procyclical fiscal policy", Journal of Economic Development, 78 (1), 156-190.

Figure 1. Total Tax Rates (1965-2003)

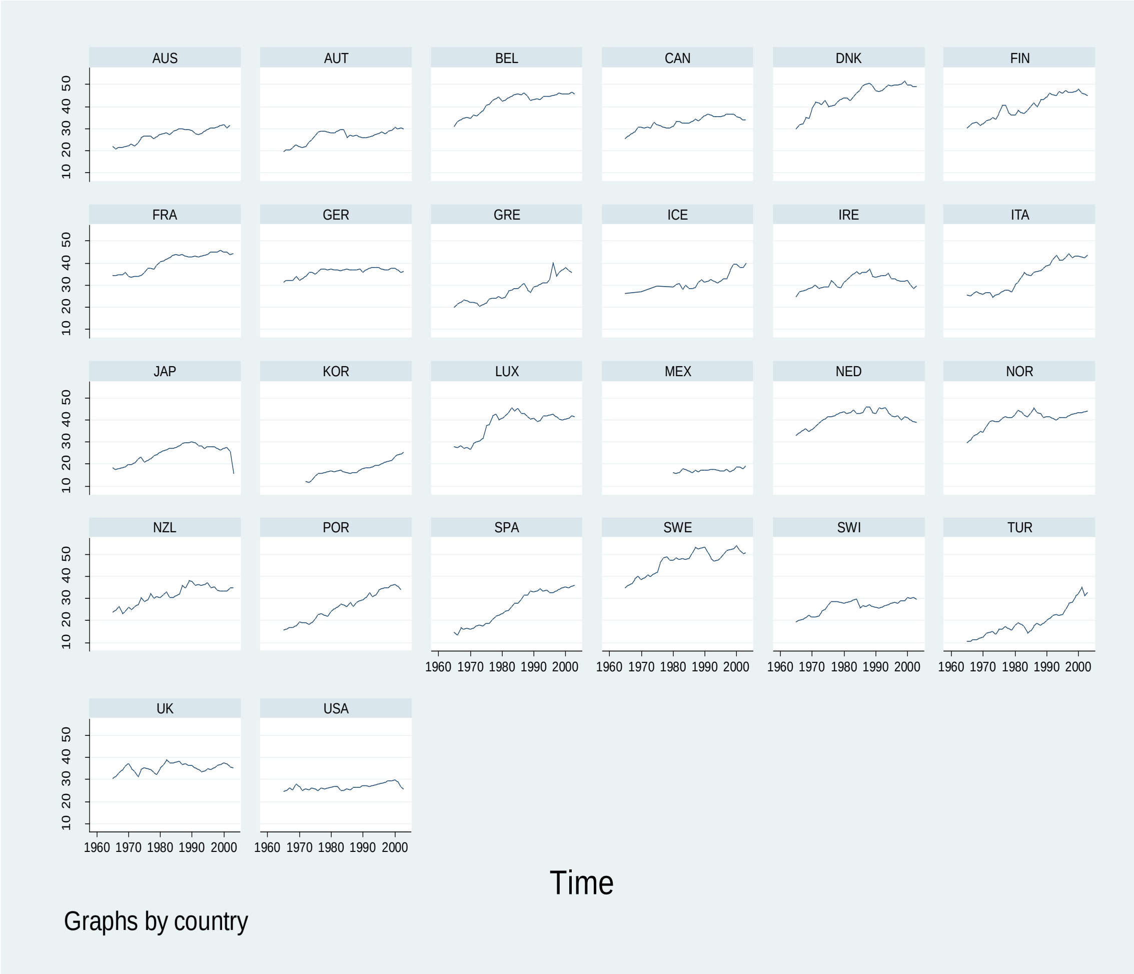
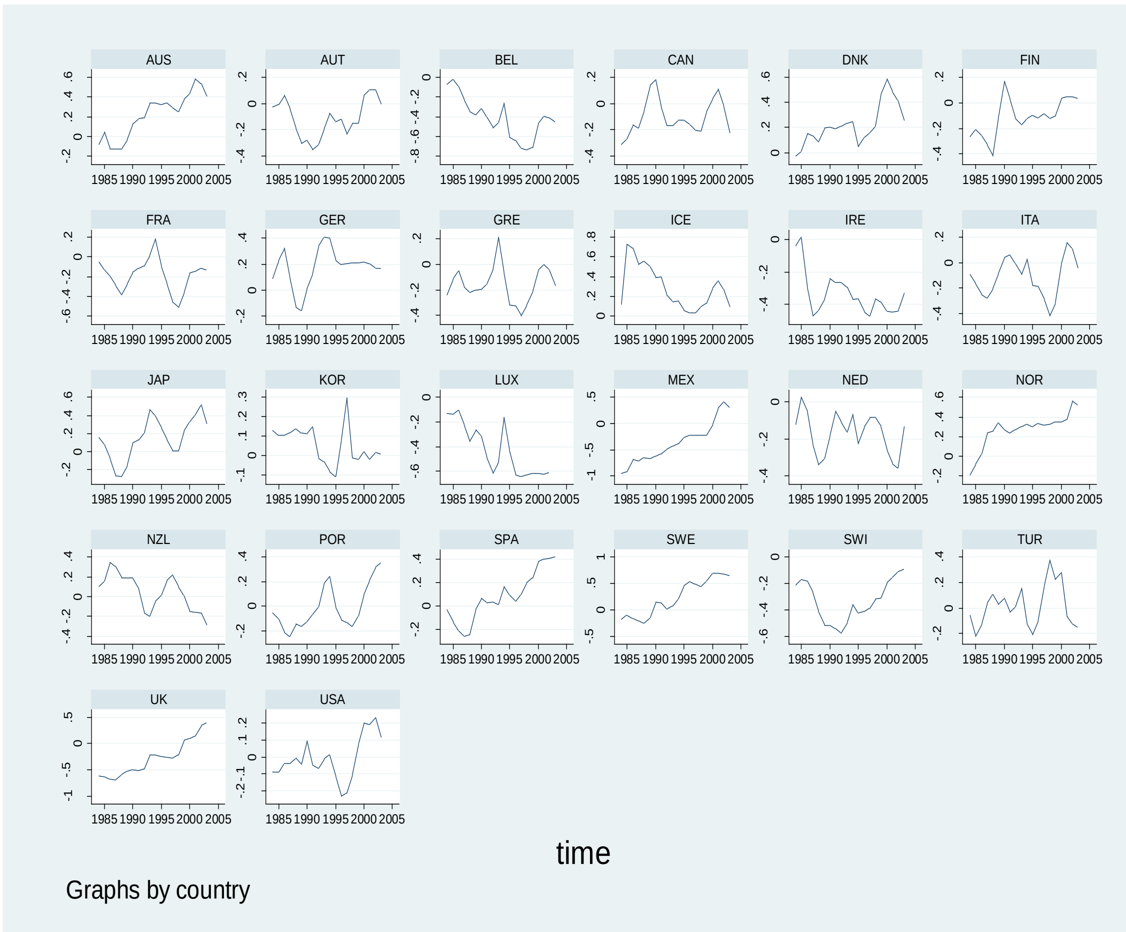


Figure 2. Output – Cyclical Components (1965-2003)

Figure 3. Rolling 20-year window correlations (1965-2003)



Note: the time axis shows the 20-year window's terminal year. Thus, "1984" corresponds to the correlations over the period 1965-1984, "1985" to the correlations over 1966-1985, etc…

Table 1. Average tax rates (% of GDP- Averaged over the period 1965-2003)

Country	Total Tax	Income, Profits, Capital gains	Social Security	Payroll	Property	Goods and Services	Others
Australia	27.1	15.0	-	1.5	2.5	8.2	-
Austria	26.4	10.6	12.3	2.7	1.0	12.8	0.4
Belgium	41.9	15.9	13.0	-	1.1	11.8	-
Canada	32.8	14.9	4.0	0.7	3.4	9.8	0.3
Denmark	44.4	25.2	1.4	0.3	2.1	15.6	0.1
Finland	40.0	16.2	8.8	0.9	1.0	13.5	0.1
France	40.4	7.2	16.3	0.9	2.4	12.3	1.3
Germany	36.1	11.8	12.8	0.2	1.3	10.1	-
Greece	27.7	5.1	8.7	0.3	1.8	12.0	-
Iceland	32.2	10.0	1.9	0.9	2.4	17.0	0.7
Ireland	31.6	11.0	4.1	0.5	2.2	14.0	-
Italy	34.2	10.6	11.7	0.2	1.5	10.0	1.9
Japan	24.6	10.6	7.5	-	2.4	4.3	0.1
Korea	17.9	5.1	1.3	0.1	2.0	9.0	0.5
Luxembourg	38.1	15.3	10.5	0.3	2.7	9.3	0.1
Mexico	17.3	4.6	2.5	0.2	0.3	9.5	0.2
Netherlands	41.0	12.5	15.8	-	1.5	11.0	0.1
Norway	40.3	15.4	8.9	-	1.0	15.0	0.2
New Zeeland	31.6	19.7	-	0.4	2.3	9.3	-
Portugal	26.1	6.3	7.3	0.4	0.8	11.1	0.4
Spain	26.3	7.0	10.2	0.2	1.4	7.5	0.2
Sweden	46.7	20.4	11.4	1.6	1.1	12.2	0.1
Switzerland	26.4	11.4	6.9	-	2.2	5.9	-
Turkey	19.5	6.9	2.8	-	1.0	7.3	2.4
United Kingdom	35.3	13.7	6.0	-	4.3	10.8	1.0
United States	26.6	12.6	5.9	-	3.3	4.9	-
Average	32.7	12.2	8.5	0.8	1.9	10.6	0.5

Table 2. Total taxes over the cycle (%- Averaged over the period 1965-2003)

country	downturns	upturns	peaks	troughs
Australia	26.4	27.8	29.4	27.2
Austria	27.0	25.7	30.5	27.0
Belgium	42.0	41.8	37.9	40.6
Canada	33.2	32.4	34.8	33.1
Denmark	43.7	45.8	41.1	40.0
Finland	41.4	38.5	43.0	44.9
France	41.7	39.3	43.0	35.9
Germany	36.5	35.7	36.8	32.2
Greece	28.1	27.4	20.3	21.3
Iceland	31.7	32.7	29.7	28.3
Ireland	31.9	31.3	33.5	26.9
Italy	34.5	33.9	25.7	26.1
Japan	23.5	26.0	22.3	18.2
Korea	17.9	17.9	16.6	21.1
Luxembourg	37.9	38.4	31.4	42.4
Mexico	17.4	17.2	15.7	16.7
Netherlands	41.3	40.9	41.2	41.3
Norway	40.0	40.7	42.5	43.5
New Zeeland	31.1	32.0	30.4	23.2
Portugal	25.1	27.0	18.4	20.8
Spain	25.6	27.3	17.5	16.5
Sweden	46.1	47.4	38.5	46.9
Switzerland	26.8	25.9	25.0	28.5
Turkey	20.3	18.7	28.4	35.1
United Kingdom	35.6	34.9	31.4	34.4
United States	26.7	26.6	25.5	27
Average	32.0	32.0	30.4	30.8

Table 3. Correlations between total tax rates and cyclical output (1965-2003)

country	overall	downturns	upturns
Australia	0.10	-0.04	-0.19
Austria	-0.01	0.41	0.30
Belgium	-0.09	0.00	-0.31
Canada	-0.11	-0.19	0.16
Denmark	0.09	0.10	-0.31
Finland	-0.05	0.23	0.27
France	-0.06	0.27	0.32
Germany	0.06	0.66***	0.16
Greece	-0.10	0.45**	-0.57***
Iceland	0.10	0.36	-0.38
Ireland	-0.14	-0.20	0.00
Italy	0.01	0.48**	-0.47**
Japan	0.17	0.10	-0.44**
Korea	0.06	0.03	0.22
Luxembourg	-0.13	-0.02	-0.57***
Mexico	-0.13	0.32	-0.40
Netherlands	-0.08	-0.06	-0.06
Norway	0.02	-0.27	0.10
New Zeeland	0.03	0.30	-0.30
Portugal	0.02	0.01	-0.33
Spain	0.08	0.09	-0.14
Sweden	0.09	0.07	-0.13
Switzerland	-0.16	0.07	-0.19
Turkey	-0.08	-0.39*	0.51**
United Kingdom	-0.27*	0.02	-0.35
United States	0.04	0.37	-0.10
Average	-0.01	0.09	-0.08

Note: *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.

Table 4. Correlations between total tax rates and output business cycle (1965-2003)

country	HP6.25	HP100	BP^	Output GAP
Australia	0.10	0.09	-0.03	-0.04
Austria	-0.01	-0.05	-0.08	-0.31*
Belgium	-0.09	-0.13	-0.25	-0.48***
Canada	-0.11	-0.05	-0.18	-0.20
Denmark	0.09	0.08	-0.06	0.18
Finland	-0.05	-0.06	-0.14	-0.09
France	-0.06	-0.07	-0.26	-0.31
Germany	0.06	0.08	0.06	0.00
Greece	-0.10	-0.09	-0.27	-0.35*
Iceland	0.10	0.26	0.14	0.07
Ireland	-0.14	-0.20	-0.46***	-0.73***
Italy	0.01	-0.05	-0.22	-0.46**
Japan	0.17	0.05	-0.17	0.24
Korea	0.06	-0.05	-0.20	-0.10
Luxembourg	-0.13	-0.16	-0.29	-0.61***
Mexico	-0.13	-0.12	-0.29	0.31
Netherlands	-0.08	-0.05	-0.33*	-0.34**
Norway	0.02	0.09	0.26	0.50
New Zeeland	0.03	0.09	0.16	-0.41**
Portugal	0.02	0.03	-0.10	0.30
Spain	0.08	0.02	-0.20	0.63***
Sweden	0.09	0.08	-0.07	0.05
Switzerland	-0.16	-0.18	-0.44***	-0.26
Turkey	-0.08	-0.01	0.09	-0.16
United Kingdom	-0.27*	-0.25	-0.40**	-0.27
United States	0.04	0.09	0.00	0.06
Average	-0.01	0.09	-0.08	-0.11

Note: *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.
^BP correlation are based on a lower number of observations (6)

Table 5. Correlations between various tax rates and output business cycle (1965-2003)

Country	Income, Profits, Capital gains	Social Security	Payroll	Property	Goods and Services	Other
Australia	0.16	-	0.02	-0.01	-0.02	-
Austria	0.05	-0.05	-0.05	-0.03	-0.10	0.12
Belgium	-0.04	-0.07	-	0.06	-0.30	-
Canada	-0.00	-0.13	-0.64***	-0.26	-0.07	-0.23
Denmark	0.02	0.06	-0.29**	0.09	0.34	-
Finland	0.11	-0.10	-0.18	0.04	-0.6	-
France	0.12	-0.08	-0.26	-0.06	-0.11	-0.10
Germany	0.06	0.00	-0.22	-0.08	0.18	-
Greece	-0.07	-0.11	0.00	-0.03	-0.12	-
Iceland	0.04	-0.10	-0.02	0.00	0.22	0.02
Ireland	-0.02	0.01	-0.45**	-0.11	-0.22	-
Italy	0.03	-0.03	0.07	-0.15	0.04	0.37
Japan	0.31	0.01	-	-0.02	-0.04	-
Korea	0.07	-0.03	-	0.08	0.15	-0.03
Luxembourg	-0.11	-0.24	-0.12	0.13	-0.12	-
Mexico	0.37	0.10	0.29	0.36	-0.40**	-0.20
Netherlands	0.02	-0.18	-	0.16	0.06	0.02
Norway	0.05	-0.03	-	-0.10	0.15	0.27
New Zeeland	0.13	-	-0.27	0.08	-0.07	-
Portugal	0.09	0.01	-0.19	0.14	-0.03	-0.06
Spain	0.11	0.05	-	0.20	0.06	-0.15
Sweden	0.30	0.00	0.03	0.10	-0.09	-0.06
Switzerland	-0.15	-0.15	-	-0.03	-0.09	-
Turkey	-0.03	-0.17	-	-0.16	-0.09	0.33
United Kingdom	-0.17	-0.07	-	0.03	-0.17	-0.22
United States	0.22	-0.12	-	-0.02	-0.13	-
Average	0.06	-0.06	-0.07	0.02	-0.05	0.01

Note: *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.

Table 6. Response of tax rates to output business cycle (1965-2003)

	OLS	Country FE	Country & Time FE	IV
degree of cyclicality (β)	-4.21	-4.51	-6.32	-26.15
	(-0.23)	(-0.79)	(-1.04)	(-0.42)
Number of Observations	976	976	976	947
R^2	0.00	0.00	0.13	-
Sargan Statisticis p-value				0.84

Note: t-statistics in parenthesis. *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.

Table 7. Response of tax rates to output business cycle (1965-2003)- OLS

	One lag	Two lags	Three lags
degree of cyclicality (β)	5.76	5.61	10.559
	(0.32)	(0.31)	(0.52)

Note: t-statistics in parenthesis. *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.

Table 8. Response of different tax rates to output business cycle (1965-2003)

	I	II	III	IV
degree of cyclicality (β)	-6.16	-6.01	-1.02	-28.07
	(-0.39)	(-0.35)	(-0.05)	(-1.00)
Openness	8.14	-	-	-
	(19.36)***	-	-	-
*Openness*Cyclical Output*	-15.83	-	-	-
	(-0.60)	-	-	-
Population	-	-1.67	-	-
	-	(-9.37)***	-	-
*Population*Cyclical Output*	-	0.22	-	-
	-	(0.02)	-	-
Gini	-	-	31.56	-
	-	-	(5.71)***	-
Gini Cyclical Output*	-	-	-97.29	-
	-	-	(-0.27)	-
Left Government	-	-	-	-0.167
	-	-		(-0.24)
*Left Gov.*Cyclical Output*	-	-	-	86.21
				(1.80)*
Number of Observations	949	975	835	634
R^2	0.28	0.08	0.04	0.01

Note: t-statistics in parenthesis. *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.

Table 9. Response of different tax rates to output business cycle (1965-2003)

	OLS	Country FE	Country & Time FE	IV
Income Tax	5.63	5.22	1.75	0.97
	(0.51)	(1.13)	(0.44)	(0.03)
Social Security	-6.14	-7.09	-6.92	-24.48
	(-0.41)	(-1.66)*	(-2.32)**	(-0.81)
Payroll	-1.40	-1.09	-0.39	2.98
	(-0.58)	(-1.19)	(-0.36)	(0.29)
Property	-0.65	0.10	0.42	-1.05
	(-0.08)	0.09	0.36	(-0.14)
Goods and Services	-3.69	-3.81	-2.79	-1.48
	(-0.55)	(-1.36)	(-0.98)	(-0.06)
Others	0.69	2.30	2.72	1.77
	(0.35)	(2.11)**	(2.23)**	(0.24)

Note: t-statistics in parenthesis. *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.

Appendix- Filtering Methods

The first two methods use the Hodrick-Prescott (HP) filter, proposed by Hodrick and Prescott (1980). The filter decomposes the series into a cyclical $\left(c_{i,t}\right)$ and a trend $\left(g_{i,t}\right)$ component, by minimizing with respect to $g_{i,t}$, for $\lambda > 0$, the following quantity:

$$\sum_{t=1}^{T}\left(y_{i,t} - g_{i,t}\right)^2 + \lambda\sum_{t=2}^{T-1}\left(g_{i,t+1} - g_{i,t-1}\right)^2 \qquad \text{(A1)}$$

The first method uses the value recommended by Hodrick and Prescott for annual data for the smoothness parameter (λ) equal to 100. The second method sets the smoothness parameter (λ) equal to 6.25. In this way, as pointed out by Ravn and Uhlig (2002), the Hodrick-Prescott filter produces cyclical components comparable to those obtained by the Band-Pass filter.

The third method makes use of the Band-Pass (BP) filter proposed by Baxter and King (1995) and evaluated by Stock and Watson (1998) and Christiano and Fitzgerald (1999) who also compare its properties to those of the HP filter. The low pass (LP) filter $\alpha(L)$, which forms the basis for the band pass filter, selects a finite number of moving average weights α_h to minimize:

$$Q = \int_{-\pi}^{\pi}\left|\delta(\omega)\right|^2 d\omega \, ,$$

(A2)

where $\alpha(L) = \sum_{h=-K}^{K}\alpha_h L^h$ and $\alpha_K(\omega) = \sum_{h=-K}^{K}\alpha_h e^{-i\omega h}$. The LP filter uses $\alpha_K(\omega)$ to approximate the infinite MA filter $\beta(\omega)$. Let's define $\delta(\omega) \equiv \beta(\omega) - \alpha(\omega)$. Then, minimizing Q,, we minimize the discrepancy between the ideal LP filter $\beta(\omega)$ and its finite representation $\alpha_K(\omega)$ at frequency ω. The main objective of the BP filter as implemented by Baxter and King (1995) is to remove both the high frequency and low frequency component of a series, leaving the business-cycle frequencies. This is obtained by subtracting the weights of two low pass filters. We define ω_L and ω_H, the lower and upper frequencies of two low pass filters as respectively 8 and 2 for annual data. We therefore remove all fluctuations shorter than two or longer than eight years. The frequency representation of the band pass weights becomes $\alpha_K(\omega_H) - \alpha_K(\omega_L)$, and forms the basis of the Baxter-King filter which provides an alternative estimate of the trend and the cyclical component.