The effect of loss offset provisions on the asymmetric behaviour of corporate tax revenues in the business cycle

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Abstract: This paper estimates the response of corporate tax revenues to the business cycle and calculates a heterogeneous asymmetry in the tax revenue responses between booms and recessions using a new index of loss offset generosity provisions. I find strong short-run contemporaneous impact of business cycle on corporate tax revenues and a persistent asymmetric response of corporate tax revenues to booms and recession. Loss offset generosity provisions enhance this asymmetry. Countries with more generous loss offset provisions experience much more volatile response of corporate tax revenues to business cycle during recessions, magnifying the asymmetry of cyclicality. As a result the automatic stabilizer impact of corporation tax will differ between booms and recessions, being stronger and more effective in the latter, especially in countries that offer more generous loss-offset provisions.

Key Words: business cycle, corporate tax revenues, asymmetric fiscal policy, loss-offset provisions

JEL: E32, E6, H25, H32

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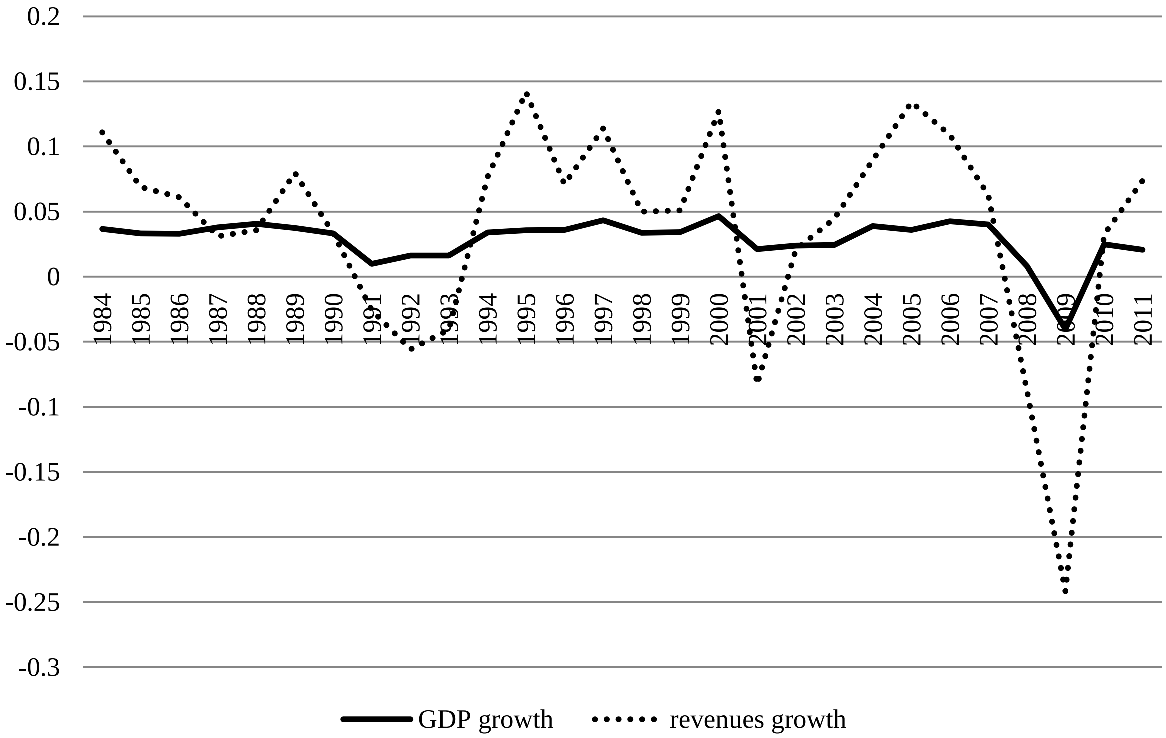
1 Introduction

Corporate tax revenues fluctuate with the business cycle (see Figure 1). In booms employment increases and companies tend to make more profits, so they have more taxable income than in normal times. As a result, they will pay more tax and the total corporate tax revenue in the economy will increase. In contrast, in recessions employment declines, corporate profits decline and some companies may even experience losses. As a result companies pay less tax, which implies that corporate tax revenues collected by the government decline. This paper examines this response of corporate tax revenues to the business cycle, calling this relationship the ‘cyclicality of corporate tax revenues’.

The analysis of the cyclicality of corporate tax revenues feeds into the debate about the automatic stabilizing property of corporation tax. This is extremely relevant, especially after the severe consequence that the latest financial crisis had on growth in many countries. Due to the reduction in corporate tax revenues in response to business cycle fluctuations, government budget deficits increase. This keeps national income higher by maintaining aggregate demand. This happens automatically and reduces the size of recession. If the impact of fluctuations is asymmetric between booms and recessions, then the automatic stabilizer impact of corporation tax will differ between the episodes as well.

Figure 1. Unweighted OECD average GDP growth vs corporate tax revenue growth over the years.

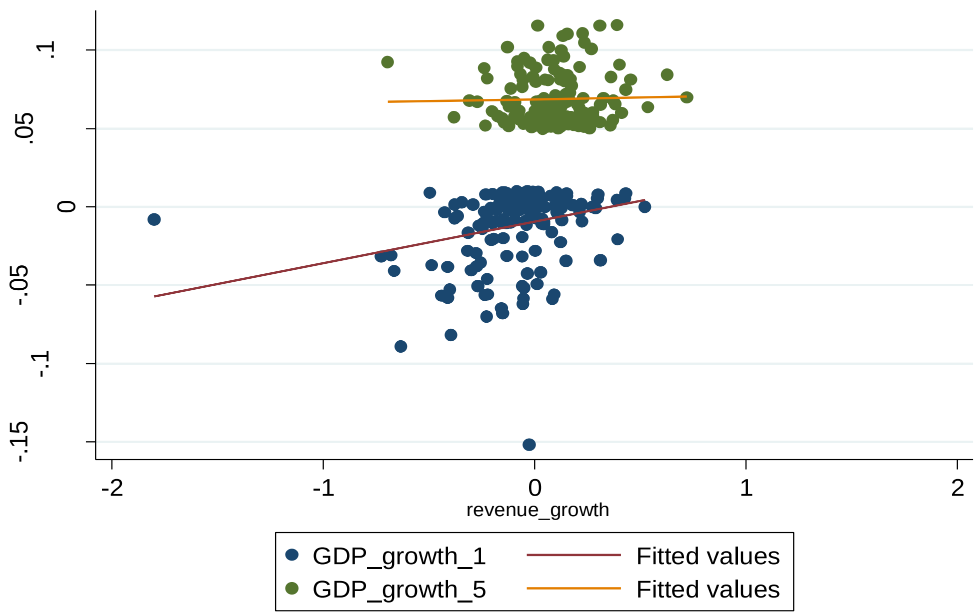


This paper contributes to the literature on the cyclicality of tax revenues by considering the cyclicality of a particular component of tax revenues - corporation tax revenues. I find that the short run contemporaneous impact of business cycle on corporate tax revenues is quite strong in normal times, but it is also much lower in booms. Importantly, I provide novel evidence on how this cyclicality is related to the loss offset generosity provisions that various countries offer. I show that the loss offset generosity provisions enhance the asymmetry in the cyclicality of corporate tax revenues. Countries that are more generous in terms of the loss offset provisions, experience much more volatile response of corporate tax revenues to business cycle during recessions, magnifying the asymmetry of cyclicality.

First, I find that corporate tax revenues react strongly to business cycle. Preliminary findings suggest that the short-run volatility of corporate tax revenues with respect to business cycle is in the range between 2.7% and 4.6%. What is means is that 1% shock to GDP changes the revenues by 2.7% (using OLS) up to even 4.6% (using instrumental variables approach). Since corporate tax revenues as a percentage of GDP have been stable over the years in most of the countries, we would expect that these fluctuations are only short-lived and the relationship between corporate tax revenues and business cycle reverts to its long-run mean. I confirm that by estimating the long-run elasticity of corporate tax revenues with respect to business cycle to be one.

The cyclicality of fiscal policy has been analyzed extensively in the macroeconomic literature. Authors have mainly concentrated on the cyclical properties of government spending (Lane, 2003; Hercowitz and Strawczynski, 2004) or government spending and government revenues (Sorensen et al 2001; Lee and Sung, 2007; Hallerberg and Strauch, 2002; Sorensen and Yosha, 2001). However, there is not much work on the impact of business cycle on the components of government revenues and government spending, apart from contributions studying differences between cyclicality of direct and indirect taxes (Hallerberg and Strauch, 2002; Furceri and Karras, 2011). They find very weak to none evidence that direct taxes, are responsive to business cycle. However, there is no work focusing on the relationship between corporate tax revenues and business cycle directly.

Figure 2. GDP and corporate tax revenues growth – country-year data points.



My second finding is that the responses of corporate tax revenues to the business cycle are asymmetric. In Figure 2 I plot GDP growth data points against corporate tax revenues growth. Each dot corresponds to country-year observation. There seems to be a clear relationship between GDP and corporate tax revenues growth in the recession periods (blue dots), but not in booms (green dots). The preliminary empirical evidence suggests that this relationship is more sophisticated than just an asymmetry between booms and recessions. I find that the strongest response of corporate tax revenues to business cycle occurs in normal times, rather than in booms or recessions.

Previous literature has documented asymmetries in the response of fiscal variables over the business cycle (Hercowitz and Strawczynski, 2004; Lee and Sung, 2007; Sorensen and Yosha, 2001; Fatas and Mihov, 2013; Sancak et al, 2010). The general consensus is that the response of government spending and tax revenues to the business cycle tends to be quite strong in recessions relative to booms. What is more, government expenditures and revenues, even at the state level, have a strongly counter-cyclical response during recessions, but pro-cyclical response during booms (Lee and Sung, 2007; Sorensen and Yosha, 2001). This suggests that fiscal policy tends to mute economic booms to roughly the same degree it mitigates slowdowns.

The definition of booms and recessions is crucial when one wants to distinguish between the impact of business cycle in recession and booms. Most of the previous literature classifies all growth rate periods as either booms or recessions. In reality, most of the periods are actually normal times, neither a boom nor a recession. In this respect, another contribution of our paper lies in analyzing different thresholds of the definition of recessions and booms and comparing the impact of business cycle in normal times versus these extreme instances. The importance of identifying three-phase business rather than two-phase one (recession and boom) has recently been outlined in Fatas and Mihov (2013).

It has been documented in the literature that corporate tax system is asymmetric with respect to profits and losses. When a company is making losses it does not pay any tax and even when it starts making profits again some countries allow the so-called loss offset provisions. That means that companies can offset part of the losses from past and future periods against profits made in the current period. Therefore, in recessions and in periods following these episodes, the corporate tax revenues would be lower than the behavior of corporate profits in countries with no loss-offset provisions would suggest.

Since this property is linked with loss-offset provisions offered by countries, we would also expect that the cyclicality in recessions and in years following recessions would differ depending on how generous these loss-offset provisions are. To explore this, I construct a novel measure - the ‘loss-offset generosity index’. This is an index variable that measures how generous a given country is in a given year with its loss-offset provisions; it ranges from 0 to 6. It summarizes whether a country allows loss carry forward, loss carry back and whether these are limited or not. It also includes group consolidation of losses and minimum tax. Using this index I investigate how the response of corporate tax revenues varies in recessions depending on how generous the loss-offset is.

I find that the more generous the loss offset provisions, the more responsive the corporate tax revenues are to output shocks. What is more, the effect is only significantly heterogeneous for recessions. According to the evidence presented, if a country faces a recession and does allow generous loss-offset, the decline in corporate tax revenues it faces will be larger. This in turn will enhance the stabilizing property of corporation tax in recession and in periods immediately following the recession. Countries with less generous loss-offset provisions will benefit less from this automatic adjustment and might suffer more from recession as a result.

The rest of the paper is organised as follows. Section 2 gives definition of booms and recession episodes. Section 3 sets up the empirical model and describes the data that is the basis for empirical analysis in section 4. I discuss heterogeneity of the cyclicality parameter in section 5 and conclude in section 6.

2 Booms and recessions

2. 1 Definition of booms and recession

The most crucial aspect of the analysis of asymmetric responses of corporate tax revenue to the business cycle is the definition of booms and recessions. In this section we describe how we construct the appropriate dummies and describe the dataset we use in this paper.

The data we use comes from the OECD Annual Accounts and includes information on Gross Domestic Product (GDP) in national currency, current prices in millions. We convert it to constant prices using GDP deflator; taking logs and first differencing it gives us the growth rate of GDP. We work with this variable to define booms and recessions. In this paper, we experiment with four different definitions of booms and recessions, which we summarize below.

Method 1. This method is based on absolute values of growth rates:

a. Define recession as a year where growth rate is below certain threshold. As a threshold we use the following growth rates: 0/0.5/1/1.5/2 percent.
b. Define boom as a year where growth rate is above certain threshold. As a threshold we use the following growth rates: 4/4.5/5/5.5/6 percent.

Method 2. This method is based on the distribution of growth rates in our sample. We sort growth rates by size and divide them into 20 percentile bins, each one consisting of 5 percent of observations.

c. Define recession as a year where growth rate is below a certain percentile threshold. As a threshold use the following percentiles of growth rate: 10, 15, 20, 25, 30, 35, 40, 45, 50.
d. Define boom as a year where growth rate is above a certain percentile threshold. As a threshold use the following percentiles of growth rate: 50, 55, 60, 65, 70, 75, 80, 85, 90.

Method 3. This method is based on the distribution of growth rates in each year. For each year we sort growth rate by size and divide the sample into percentile bins, each one consisting of 5 % of observations. We define booms and recession as in definition 2.

Method 4. This method is based on the distribution of growth rates in each country. For each country we sort growth rates by size and divide the sample into percentile bins, each one consisting of 5% of observations. We define booms and recession as in definition.

Tables 1 and 2 and Figure 4 summarise the mean growth rates for particular sub-samples obtained using methods 1, 3 and 2 respectively. We can see that the mean size of the episodes in each bin is slightly different depending on the method used. Nevertheless, the episodes identified using these methods are correlated, with average correlation of around 50%. Larger percentile bins display larger correlation between each other.

Each definition has its own benefits and disadvantages. Definitions 1 and 2 are concerned with large episodes of booms and recessions in the whole sample. Therefore they can be slightly skewed towards representing mainly the recent financial crisis. In contrast, definition 3 compares the size of recessions and booms to OECD average. Therefore it could well be that during good times when all OECD countries experience a positive growth rate, this method classifies bottom 10 percent of observations as recessions even though the countries might be actually growing strongly in terms of definitions 1 and 2. Similar applies to recessions. When all OECD countries experience negative growth rate and we classify boom as a top 10^{th} percentile of observations in a given year, it can happen that boom describes actual recession period according to other definitions.

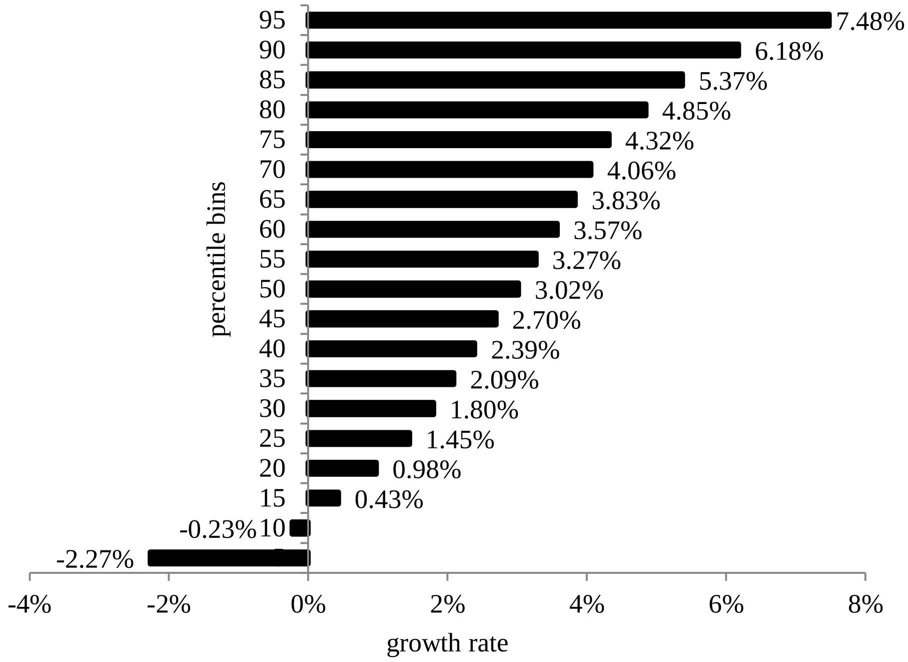
Table 1. Mean growth rates by threshold – method 1.

thresholds	mean growth	no of observations
<0	-0.0277854	105
<0.005	-0.0200726	141
<0.01	-0.0136506	183
<0.015	-0.0082481	230
<0.02	-0.0018216	306
>0.04	0.0581743	284
>0.045	0.0641778	207
>0.05	0.0687191	162
>0.055	0.073125	128
>0.06	0.0768142	104

Table 2. Mean growth rates by threshold – method 3.

threshold	mean growth	no of observations
<10th	-0.01132	104
<15th	-0.00461	157
<20th	-0.00236	188
<25th	0.000768	235
<30th	0.003869	290
<35th	0.005247	320
<40th	0.0075	372
<45th	0.009444	422
<50th	0.010522	452
>50th	0.044897	478
>55th	0.046184	448
>60th	0.04856	395
>65th	0.051107	345
>70th	0.054086	293
>75th	0.056161	263
>80th	0.060025	213
>85th	0.06493	161
>90th	0.068836	130

Figure 4. Mean growth rates by threshold - method 2.



When it comes to definition 4 the problem could be that a given country might be persistently under or over performing relative to other countries. Therefore even if for this country 0.5% growth rate is a boom according to this definition, it is certainly not for the others.

Definition number 3 would be most appropriate to identify the effects of asymmetries along the business cycle for country specific business cycle shocks. This is due to the fact that it identifies the episodes by effectively comparing them to the average OECD growth in a given year. In contrast, definition number 4 would be more appropriate for identification of asymmetries along the business cycle for aggregate effects of business cycle, together with definitions 1 and 2.

3 Data and Estimated Model

In this section we describe the theoretical basis for our estimation and discuss the simple model estimated. Each company determines their taxable profits and pays the corporate tax on this basis, using the statutory tax rate and various deductions available. As a result, the corporate tax revenues in each country are just the sum of all the corporate tax paid by each company. Here, we work with the aggregate corporate tax revenues, so we can write corporate tax revenue in country *i* at time *t* as a product of corporate taxable profits and corporation tax rate:

$$R_{it} = \tau_{it} \times \Pi_{it} \quad (1)$$

Here Π_{it} is just a sum of all the taxable profits made by each company, whereas τ_{it} is the top statutory tax rates. We realise that this is large approximation, since some of the corporate tax systems are progressive and multiple corporate tax rates apply depending on the amount of profits made (for example small companies in UK pay lower corporate tax rate). However, as evidence from UK shows almost 90% of all tax paid is paid by the top 10% companies. Therefore one could argue that most of the profits are subject to the top statutory tax rate and these would make most of the corporate tax revenues in each country.

This paper is concerned with estimating the effects of business cycle on corporate tax revenues. One of the main ways in which the business cycle affects corporate tax revenues is through the cyclical nature of corporate profits. Since we do not have an adequate measure of corporate profits on country level we will instead specify a reduced form equation where we use fluctuations in GDP as an approximation for business cycle and corporate profits fluctuations. However, the non-stationary nature of the GDP and corporate tax revenue series means that estimation in levels would yield biased standard errors. To correct for the problem we use first-differencing. This means that we will be estimating an equation of the form:

$$\Delta \ln(R_{it}) = \alpha + \beta_1 \Delta \ln(\tau_{it}) + \beta_2 \Delta \ln(GDP_{it}) + \varepsilon_{it} \qquad (2)$$

Our dependent variable in the above regression is the annual growth rate of corporate tax revenues measured in millions of national currency. We use data provided by the OECD Revenue Statistics; we normalise it using GDP deflator to express it in constant prices.

Independent variables of consideration are GDP and corporate tax rates. For gross domestic product (GDP) we use data as discussed in section 2. Corporate tax rates come from the CBT database. They include only main federal rate of corporate tax and exclude local taxes and surcharges.[1]

The impact of business cycle here will be measured by the coefficient β_2 in equation (2). The interpretation of the coefficient is analogous to what Lane (2003) proposed on government spending- it measures the elasticity of corporate tax revenues with respect to output growth; i.e. that 1% increase in GDP would increase corporate tax revenues by β_2 percent. Also, positive β_2 implies procyclical behaviour, while a value above unity means more than proportionate response to output fluctuations.

To obtain the asymmetric effect of business cycle on corporate tax revenues, we re-estimate equation (2) separating the effects of business cycle in recessions and booms. We use different definitions of recession and boom as described in section 2. As a result we specify the following equation, where recession and boom are dummies as defined above:

$$\begin{aligned} \Delta \ln(R_{it}) &= \alpha + \beta_1 \Delta \ln(\tau_{it}) + \beta_2 \Delta \ln(GDP_{it}) \\ &+ \gamma_{1R} \Delta \ln(GDP_{it}) \times recession + \gamma_{1B} \Delta \ln(GDP_{it}) \times boom + \varepsilon_{it} \end{aligned} \qquad (3)$$

Here, we concentrate on coefficients γ_{1R} and γ_{1B} that will tell us how different the response of corporate tax revenues to business cycles is in booms and recessions in contrast to normal times - β_2.

[1] The cyclicality coefficients do not change if we include local taxes and surcharges.

4 Empirical Evidence

4.1 Baseline model

In the baseline specification in Table 3 we present results from equation (2) and we consider two types of models: with (column 1) and without (column 2) time fixed effects. The inclusion of time fixed effects implies that we take out the OECD wide business cycle shocks. As a result we interpret the coefficients on GDP as a response of corporate tax revenue growth to changes in country–specific GDP growth. Of course that means that when we exclude time FE we will be able to interpret the coefficients on GDP growth as a response of revenues growth to OECD wide shocks in GDP.

Table 3. Cyclicality of corporate tax revenues – OECD wide vs country-specific shocks.

VARIABLES	(1)	(2)
$\Delta\ln(\tau_{it})$	0.322***	0.337***
	(0.124)	(0.129)
$\Delta\ln(GDP_{it})$	1.412***	2.702***
	(0.380)	(0.330)
Constant	0.0703*	-0.0249
	(0.0395)	(0.0261)
Year FE	Yes	No
Observations	833	833
R-squared	0.234	0.168

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

From the estimated coefficients of the regressions without time-fixed effects we learn that the corporate tax revenues are strongly and significantly pro-cyclical with respect to aggregate business cycles. The effect from column 2 means that 1% increase in GDP would increase corporate tax revenues by 2.7%. This is quite large effect.

The results with time-fixed effects are smaller and suggest that countries respond differently to country-specific and aggregate output shocks. The effect of country specific business cycle shocks is much smaller and equal to 1.4% change in corporate tax revenues in response to 1% GDP change. These results are directly comparable with Sorensen et al (2001), where the coefficient without the year FE on overall revenues is almost twice the size of the one with FE.

Additionally, if we treat equation (1) as an identity, then one would expect the coefficient on corporation tax rate to be 1. As we can see in Table 3 it is much smaller than that - 0.3 - and of magnitude that does not change whether or not we include year fixed effects. There could be multiple reasons for that, one of them being the previously mentioned progressivity of the corporation tax system.

Furthermore, we would expect the long run relationship between corporate tax revenues and GDP shocks to be equal to 1. We can test that by estimating the single equation

Error Correction Model.[2] We estimate the long run coefficient on GDP that is equal to 1. The short run response to the business cycle is similar to what we discover in the OLS model and is 2.4%. The ECM also allows us to estimate the speed of return to equilibrium after a deviation. Here, the coefficient is negative and significant suggesting that deviations from equilibrium are corrected at about 10% per year.

4.2 Asymmetric cyclicality estimations

In this section we explore the possibility of asymmetric effects of the business cycle on corporate tax revenues. We present results using different definitions of booms and recessions as outlined in section 2. All of the estimations of asymmetric behaviour are based on equation (3) from section 3.

Tables 4 and 5 present evidence for business cycle asymmetry using definitions 1 and 2 of booms and recessions respectively. These are the results for regressions without year fixed effects. Columns 1 to 9 give results for different thresholds for recessions and boom; the first number in the top row describes the recession threshold and the second describes boom threshold. Both methods give very similar results.

We can observe very strong response of corporate tax revenues to business cycle shocks in normal times – the magnitude is somewhere between 3 - 4% response of corporate tax revenue to 1% GDP shock. In booms, the response is significantly smaller than in normal times, while in recessions the response is not statistically significantly different from normal times. Interestingly, the difference between normal times and booms as well as normal times and recessions is statistically significant. However, the coefficients in booms and recessions are not statistically significantly different from each other in any of the regressions in Tables 4 and 5. In column 9 of Table 5 we do a similar exercise to what the previous literature has done and divide episodes into either boom or recession - above and below median growth rate ones. The results indicate towards the larger effect of GDP on corporate tax revenues in recessions. However, the effect is not statistically significantly different between the two types of episodes. What is more, regression from column 9 in Table 5 has the worst fit of all the regressions with R-squared of 16.9%. In contrast, regression from column 5 in that table has the best fit. In this regression the difference between normal times and recession coefficient is actually significant and the impact of GDP shock on corporate tax revenues in recession is smaller than in boom.

These results indicate that the approach taken by the previous literature, such as Sung and Lee (2007) as well as Sorensen et al (2001), in identifying the asymmetric response of tax revenues or government spending to GDP shocks is flawed. The asymmetric response of corporate tax revenues to GDP shocks is much more intricate than just the difference between booms and recessions. The difference exists not between booms and recessions, but between normal times and booms and recessions.

To show the magnitudes of the asymmetric cyclicality parameters, in Figure 5 we compute the average marginal effects of corporate tax revenues response to business cycle in booms, recessions and normal times using the thresholds corresponding to columns in Table

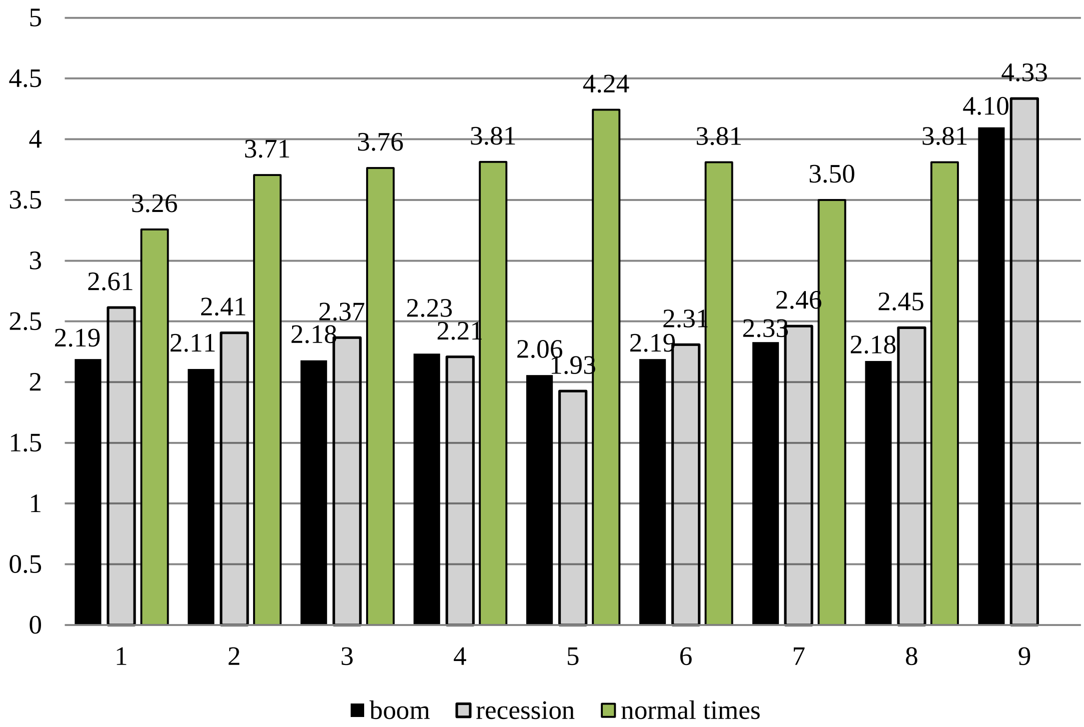
[2] Results are not presented here.

5.[3] This means that for the first set of bars the results correspond to marginal effects from column 1 in Table 5; the average marginal effect of business cycle in recession is 2.61%, in boom is 2.19% and in normal times is 3.26%.

Figure 5 visualizes the results from Table 5 and confirms that the asymmetry between corporate tax revenues response in normal times versus in booms and recessions is prevalent; it holds irrespective of the episodes threshold we use. The effect of business cycle on corporate tax revenues in normal times is the smallest when we define booms and recession as in column 1, while largest when we define these episodes as in column 5. At the same time the response of corporate tax revenues to business cycle in booms and recessions is strongest in column 1, while weakest in column 5. This would suggest that the general response of corporate tax revenues to business cycles is quite strong during very large recessions and during very large booms, but much smaller during mild booms and recessions. This is why the inclusion of these smaller recessions and booms in the recessions and booms episodes as we move along columns in Figure 5 results in increasing coefficients for normal times episodes and decreasing ones for both booms and recessions.

The inclusion of year fixed effects (results not shown here) does not change the main conclusion of the baseline asymmetric model. The response of corporate tax revenues to the business cycle is the strongest in normal times while much smaller in both booms and recessions. What changes is that the average marginal effect of GDP shocks on corporate tax revenues in recessions is now not statistically significant and not statistically significantly different than zero.

Fig. 5. Boom, recession and normal times average marginal effects of corporate tax revenues to the business cycle.



[3] Here marginal effect is computed for each case and these are averaged over the sample. This will yield different values than the coefficients in the regression results table.

Table 4. Business cycle asymmetries using absolute definition of booms and recessions.

VARIABLES	(1) GDP_0/6	(2) GDP_0/4	(3) GDP_05/55	(4) GDP_05/4	(5) GDP_1/5	(6) GDP_1/4	(7) GDP_1/6	(8) GDP_15/45	(9) GDP_2/4
$\Delta \ln(\tau_{it})$	0.326**	0.330**	0.332**	0.330**	0.327**	0.331**	0.326**	0.330**	0.330**
	(0.129)	(0.129)	(0.129)	(0.129)	(0.129)	(0.129)	(0.129)	(0.130)	(0.129)
$\Delta \ln(GDP_{it})$	3.481***	4.262***	3.703***	4.204***	3.794***	4.149***	3.456***	3.743***	4.058***
	(0.542)	(0.778)	(0.549)	(0.744)	(0.529)	(0.671)	(0.479)	(0.522)	(0.541)
$\Delta \ln(GDP_{it}) \times boom$	-1.262***	-1.590***	-1.503***	-1.558***	-1.465***	-1.532***	-1.250***	-1.238***	-1.541***
	(0.461)	(0.541)	(0.446)	(0.527)	(0.436)	(0.498)	(0.441)	(0.435)	(0.459)
$\Delta \ln(GDP_{it}) \times recession$	-0.841	-1.782	-1.082	-1.677	-1.186	-1.589	-0.804	-1.186	-1.382*
	(1.318)	(1.511)	(1.285)	(1.446)	(1.175)	(1.277)	(1.146)	(1.016)	(0.837)
Constant	-0.0511*	-0.0581*	-0.0582*	-0.0563*	-0.0584*	-0.0548*	-0.0501*	-0.0520*	-0.0500*
	(0.0303)	(0.0312)	(0.0304)	(0.0305)	(0.0299)	(0.0293)	(0.0290)	(0.0286)	(0.0277)
Year FE	No	No	No	No	No	No	No	No	No
Observations	833	833	833	833	833	833	833	833	833
R-squared	0.177	0.178	0.180	0.178	0.179	0.178	0.177	0.176	0.179

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note: An example on how to interpret the column headers: GDP_05/55 means that in this column the recession episodes are defined as years when GDP growth rate is below 0.5%, while boom episodes occur when GDP growth rate is above 5.5%.

Table 5. Business cycle asymmetries using percentiles from overall distribution of GDP growth rates.

VARIABLES	(1) GDP_10/90	(2) GDP_15/85	(3) GDP_20/80	(4) GDP_25/75	(5) GDP_30/70	(6) GDP_35/65	(7) GDP_40/60	(8) GDP_45/55	(9) GDP_50/50
$\Delta \ln(\tau_{it})$	0.326**	0.333**	0.327**	0.332**	0.333***	0.329**	0.336***	0.333**	0.334**
	(0.129)	(0.129)	(0.129)	(0.129)	(0.128)	(0.128)	(0.130)	(0.130)	(0.130)
$\Delta \ln(GDP_{it})$	3.257***	3.706***	3.763***	3.812***	4.242***	3.810***	3.500***	3.811***	
	(0.517)	(0.570)	(0.551)	(0.543)	(0.550)	(0.515)	(0.561)	(0.668)	
$\Delta \ln(GDP_{it}) \times boom$	-1.013**	-1.438***	-1.362***	-1.258***	-1.629***	-1.241***	-0.891*	-1.269**	2.544***
	(0.464)	(0.448)	(0.440)	(0.438)	(0.453)	(0.444)	(0.491)	(0.597)	(0.309)
$\Delta \ln(GDP_{it}) \times recession$	-0.555	-1.101	-1.143	-1.304	-1.849**	-1.085	-0.692	-0.805	3.077***
	(1.308)	(1.316)	(1.201)	(1.041)	(0.923)	(0.813)	(0.757)	(0.796)	(0.596)
Constant	-0.0436	-0.0554*	-0.0551*	-0.0499*	-0.0581**	-0.0359	-0.0274	-0.0257	-0.0223
	(0.0297)	(0.0306)	(0.0300)	(0.0280)	(0.0276)	(0.0259)	(0.0256)	(0.0257)	(0.0260)
Year FE	No	No	No	No	No	No	No	No	No
Observations	833	833	833	833	833	833	833	833	833
R-squared	0.174	0.179	0.178	0.176	0.181	0.174	0.170	0.171	0.169

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note: An example on how to interpret the column headers: GDP_10/90 means that in this column the recession episodes are defined as years when GDP growth rate is below 10th percentile of the GDP growth distributions in the sample, while boom episodes occur when GDP growth rate is above 90th percentile of GDP growth distributions in the sample.

VARIABLES	(1) 0	(2) 0.5	(3) 1	(4) 1.5	(5) 2	(6) 2.5	(7) 3
$\Delta \ln(\tau_{it})$	0.375***	0.374***	0.374***	0.374***	0.373***	0.372***	0.373***
	(0.135)	(0.135)	(0.135)	(0.136)	(0.137)	(0.136)	(0.136)
$\Delta \ln(GDP_{it})$		2.651***	3.097***	3.108***	3.128***	3.308***	2.962***
		(0.532)	(0.447)	(0.375)	(0.368)	(0.369)	(0.352)
$\Delta \ln(GDP_{it}) \times recession$	3.306***	0.681	0.205	0.128	0.0203	-0.449	0.536
	(0.434)	(0.567)	(0.552)	(0.565)	(0.641)	(0.706)	(0.848)
$\Delta \ln(GDP_{it}) \times boom$	2.371***	-0.265	-0.827**	-0.923**	-0.960**	-1.185***	-1.062**
	(0.343)	(0.482)	(0.404)	(0.362)	(0.375)	(0.401)	(0.433)
Constant	-0.0277	-0.0280	-0.0349	-0.0371	-0.0386	-0.0443	-0.0354
	(0.0284)	(0.0274)	(0.0277)	(0.0277)	(0.0274)	(0.0273)	(0.0273)
Observations	751	751	751	751	751	751	751
R-squared	0.190	0.190	0.191	0.191	0.190	0.191	0.192

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note: Each column corresponds to deviations from zero in terms of defining booms and recessions. In Column 1, for example, recession is when output gap is below zero while boom when it is above zero. In column 7 recession is defined as episodes when output gap is below -3% while boom when it is above 3%.

An alternative way to distinguish between booms and recessions is to look at output gap measure. We can define boom to be en episode with positive output gap and recession and episode with negative output gap. What is more, following previous logic of defining normal times as well, we can look at absolute values of output gap that are below -0.5% and above 0.5% or differ by 1 and 1.5% from zero. Then we define normal times as episodes close to zero, while severe booms and recessions as episodes far away from zero.

4.3 Instrumental variables estimation

One of the concerns with the estimation of the effect of GDP on corporate tax revenues is the reverse causality problem. This issue is obviously larger when you think about overall tax revenues, since they are large in proportion to GDP. Corporate tax revenues are on average about the size of 3% of GDP. However, we still proceed with the IV estimation to show that our results hold.

There is a large empirical literature offering different methods of measuring the impact of tax changes on output and growth. The methods include VARs as applied by Blanchard and Perotti (2002) or narrative approach as offered by Romer and Romer (2010). Recently, Mertens and Ravn (2012) have combined both approaches to arrive at tax multipliers. Each of these approaches offers unique advantages, but differs greatly in the size of the estimated responses of output to tax change shocks, ranging from huge 3% effects offered by Romer and Romer to smaller than 1% offered by Blanchard and Perotti and Mertens and Ravn. Most of these studies use tax receipts as a measure of tax change. Hence, these multipliers can be interpreted as the impact of tax revenue reduction on GDP. In spite of differing methodologies, what these approaches do not question is the direction and significance of the relationship. A positive tax shock, i.e. tax revenue increase has a negative impact on output growth.

The fact that the impact of tax revenues on GDP is negative means that the OLS coefficient on GDP in our baseline regression may pick up this effect and may be biased downwards. To correct for that problem we need to find instruments that are correlated with GDP growth but are unrelated to corporate tax revenues.

We use trade (imports and exports) weighted GDP of trade partner OECD countries. This type of instrument was proposed in the context of cyclical fiscal policies by Jaimovich and Panizza (2007) and later also used by Lee and Sung (2007) and Ilzetzki and Vegh (2008). The trade weighted GDP of other OECD countries is strongly correlated with the country's own GDP. However, country's own fiscal policy should have negligible impact on GDPs of other countries, especially corporate tax policy.

To be more specific, for example, for Australian GDP growth IV we need to weight GDP growth of all other OECD countries by amount of imports from each of those countries to Australia (or exports from Australia to all these countries). Thus we use GDP growth for each of these countries in each year and then weight each of these by exports (imports) to Australia. The intuition here suggests that a country can import a crisis from abroad. Alternatively, if we use exports to weight the GDP growth, then if growth rate in the country that imports large amount of products from Australia declines, it will demand less exports from Australia and hence growth rate in Australia will suffer.[4]

We start our analysis with the impact of aggregate shocks on corporate tax revenues to see how the results presented here differ from the OLS ones. We test for weak instruments, endogeneity of regressors, excluded instruments etc. They all seem to be in order for the regressions presented below.

In Table 6 we present results from the baseline estimation. In columns 1 and 2 we reproduce the OLS estimates on the smaller sample that is the result of some missing observations when we create instrumental variables. These are directly corresponding to columns 1 and 2 in Table 3. The coefficients on GDP growth as well as on corporate tax rates are slightly larger in this smaller sample, but do not differ a lot qualitatively. Columns 3 – 6 show results from IV estimations. Column 3 uses export weighted GDP growth as an instrument for country's own GDP. Columns 4 and 5 use imports weighted GDP growth, while columns 6 includes both export weighted and imports weighted GDP growth as instruments.[5]

The results from IV estimation are stronger than the OLS ones; they are almost twice as large in all cases. They suggest that the impact of business cycle on corporate tax revenues is between 4.3-4.6 %. This would confirm the hypothesis that the OLS coefficients are downward bias.

Table 6. IV baseline regressions.

VARIABLES	(1) OLS	(2) OLS	(3) IV:exports	(4) IV:imports	(5) IV:imports	(6) IV:exports and imports
$\Delta \ln(\tau_{it})$	0.408***	0.419***	0.410***	0.410***	0.409***	0.410***
	(0.144)	(0.151)	(0.0900)	(0.0902)	(0.0906)	(0.0900)
$\Delta \ln(GDP_{it})$	1.530***	2.926***	4.389***	4.445***	4.594***	4.393***
	(0.442)	(0.375)	(0.419)	(0.423)	(0.411)	(0.419)
Constant	0.0347	-0.0405	-0.0730***	-0.0744***	-0.0783***	-0.0731***
	(0.0530)	(0.0316)	(0.0136)	(0.0137)	(0.0134)	(0.0136)
Year FE	Yes	No	No	No	Yes	No
Observations	675	675	675	675	675	675
R-squared	0.269	0.204	-	-	-	-

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

[4] For robustness purposes, we also use lagged GDP growth as instruments. This estimation strategy has been used in this context by Braun (2001), Galí and Perotti (2003), and Lane (2003). This strategy is only valid in the absence of any serial correlation in the error term. We test for that and find serial correlation in the levels specification, but not in the differences one. Hence this is also a valid instrument strategy albeit not our preferred one.

[5] The instruments in column 6 pass Sargan test for overidentifying restrictions. However, the inclusion of lagged GDP growth as an instrument results in rejection of the Sargan test and casts doubt on its validity as an instrument.

In Table 7, we explore whether the use of 2SLS strategy has any impact on the asymmetry results. We find that the effects from imports and exports weighted regression are very similar, hence we only report results for exports weighted regressions. We also restrict the IV asymmetric results to only a few examples. In Table 7 columns 1-3 show results using method 1 for identifying recessions and booms as described in section 2, while columns 4-6 show results using method 2. We not only instrument GDP growth in normal times, but also use exports weighted GDP growth to instrument for GDP growth in the interaction term leaving boom and recession dummies un-instrumented and exogeneous.[6]

The size of the normal times coefficient on corporate tax revenues response to business cycle is larger than in the OLS regressions corresponding to the IV baseline regression. What is more, again the boom coefficient is significantly smaller than the normal times one, while the recessions coefficient is not statistically significantly different from the normal times one.[7] The results are qualitatively similar to the OLS ones, though much larger in magnitudes. This is starkly visible when we look at the results from column 6, which splits the sample into half at the median growth rate. This clearly suggests that the response of corporate tax revenues to the business cycle in recessions is more than twice as large as in booms.

Table 7. IV asymmetric regressions.

VARIABLES	(1) GDP_0/6	(2) GDP_05/4	(3) GDP_1/6	(4) GDP_25/75	(5) GDP_30/70	(6) GDP_50/50
$\Delta\ln(\tau_{it})$	0.384***	0.393***	0.389***	0.376***	0.363***	0.401***
	(0.0905)	(0.0897)	(0.0904)	(0.0903)	(0.0941)	(0.0905)
$\Delta\ln(GDP_{it})$	4.607***	5.248***	4.138***	4.724**	5.868**	
	(1.051)	(1.161)	(0.731)	(2.309)	(2.489)	
$\Delta\ln(GDP_{it})\times boom$	-1.799***	-2.261***	-1.566***	-2.263	-3.849	2.693***
	(0.691)	(0.778)	(0.585)	(1.831)	(2.545)	(0.689)
$\Delta\ln(GDP_{it})\times recession$	0.277	0.0885	1.247	0.844	-1.045	5.825***
	(2.162)	(2.084)	(1.535)	(6.367)	(5.180)	(0.924)
Constant	-0.0652**	-0.0593**	-0.0517**	-0.0496	-0.0509**	-0.0451***
	(0.0319)	(0.0284)	(0.0220)	(0.0344)	(0.0235)	(0.0147)
Observations	675	675	675	675	675	675

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.

What is more, in IV estimations the coefficients of the impact of GDP shocks on corporate tax revenues are statistically significantly different between booms and recessions. In contrast, in OLS case they were statistically significantly different from normal times coefficient, but not from each other.

[6] We could alternatively instrument the dummies too, using exports weighted boom and recessions dummies of OECD trade partners, but this creates some unnecessary endogeneity.
[7] Interestingly, the interaction coefficient for recession is actually positive, but has huge standard errors.

One of the reasons why the impact of recessions is much stronger here could be that the endogeneity bias created by the reverse causality has been shown to be stronger for recessions. For example, Auerbach and Gorodnichenko (2012) and Almunia et al (2010) find that GDP multipliers of government purchases are larger in recession. If that is the case, then the recession multipliers will bias the GDP OLS estimates for recessions even further downward than the boom estimates.

5 Factors affecting the cyclicality of corporate tax revenues

In this section we discuss factors that might affect the cyclicality parameter heterogeneity. We concentrate out discussion on the impact of loss-offset provisions. We first construct the index of loss generosity that is one of the key contributions of this paper.

5.1 Loss-offset generosity index

We use data on loss carry forward, loss carry back, national loss consolidation and minimum taxes; as sources we use CBT tax database. The data in this database comes from E&Y and IBFD for 2002 – 2012 information. We augment our data before 2002 with information from Dreßler & Overesch (2011). As a result we have data on loss carry over, minimum tax and group consolidation for all OECD countries for the period 1996 – 2012. Below we describe how each component affects the constructed index:

1. Tax loss carry forward and carry back: for discussion of properties and impact on investment see Dreßler & Overesch (2011). The larger the number of years carry-forward and back is allowed the more generous the loss treatment is.
2. Group taxation: the possibility of group loss offset is a sign of a more generous loss offset provisions in that companies are allowed to offset losses in one subsidiary against profits in another and hence benefit from not paying tax in either of the subsidiaries.
3. Minimum tax: It has a detrimental effect on the loss generosity parameter. As noted by Dreßler & Overesch (2011) if an alternative minimum tax is in place a subsidiary is obliged to pay the tax irrespective whether it makes losses or not.

As a result of these rules, the construction of the loss-offset generosity index consists of 6 elements, where 1 is given if the statement is true; 0 otherwise. Hence a maximum value that the index could take is 6, minimum is 1.

1. Loss carry forward is longer than 10 years (different thresholds explored)
2. Loss carry forward is unlimited
3. Loss carry back is allowed
4. Loss carry back is unlimited
5. Minimum tax does not exist
6. Group consolidation of losses is permitted – on national level

Figure 6 shows how the loss-offset generosity index is distributed across countries by calculating average index value over 1996-2012 for each country. We can clearly see that there is a lot of variation in the index across countries; the index ranges from 5 in Chile, UK and Ireland to less than 1 in Slovakia. Non-integer values imply that some loss-offset provisions changed over the years. This is indeed the case as we can see from Figure 7, which shows how unweighted average of the loss-offset generosity index over OECD countries developed over time. The loss-offset generosity has increased over the years, especially from 2001 until 2005. There have been fewer changes in the last 5 years. What is more, most of the changes came from extensions in the number of years losses are allowed to be carried forward.

Figure 6. Loss offset generosity parameter - distribution across countries; average over 1996 - 2012 for each country.

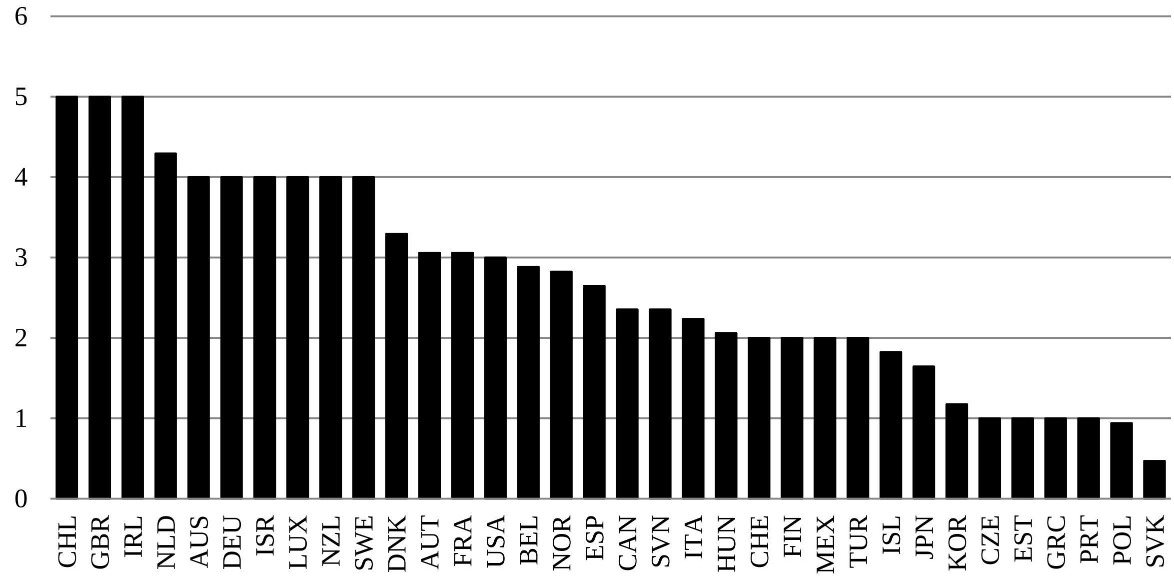
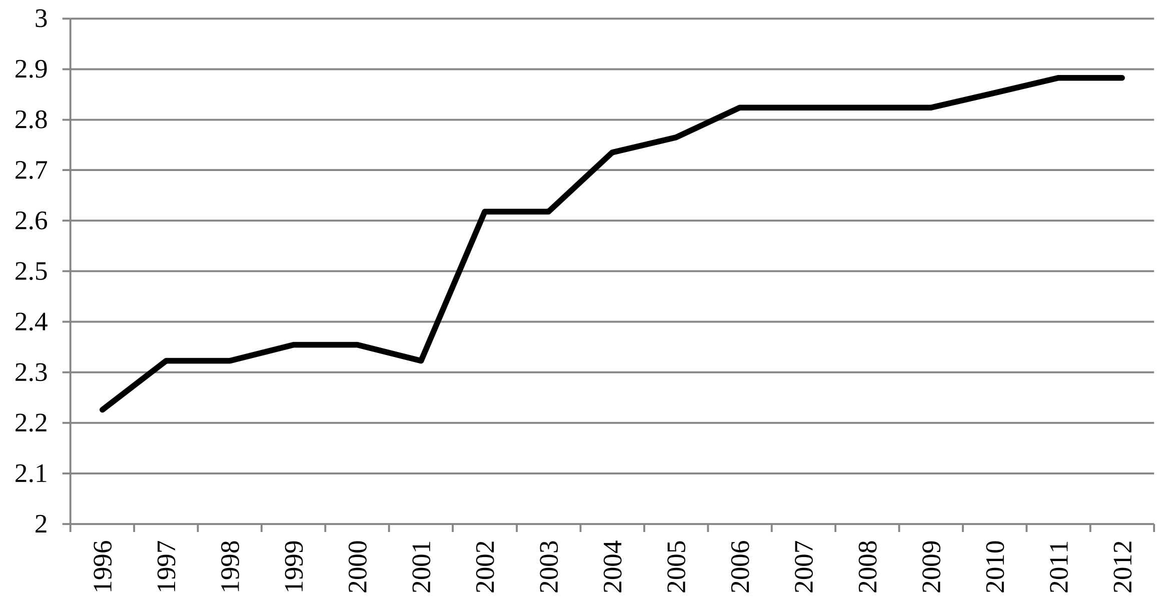


Figure 7. Development of loss - offset generosity index over time; unweighted OECD average.



5.2 Heterogeneity in the cyclicality parameter

Using this index we test whether an increase in loss-offset generosity has an impact on the cyclicality of corporate tax revenues. Loss offset provisions generally apply when companies are making losses or in the following periods. It is important to note that loss carry back and loss carry forward will have different effects on the cyclicality of the corporate tax revenues. For example loss carry forward provisions will influence revenues in the periods following recessions, as firms use these offsets to set against positive profits. As a result more generous loss carry forward will mean weaker relationship between business cycle and corporate tax revenues in the periods after the recession, but not necessarily during the recession. In contrast, in case of group relief and loss carry back provisions past corporate tax payments are recovered, such that revenue does fall by more than it would without carryback provisions (or group relief), at the time when losses are incurred. Hence, group relief as well as loss carry back will strengthen the relationship between business cycle and corporate tax revenues.[8] We expect the effect of the business cycle on corporate tax revenues to vary with the generosity of the loss offset provisions; more generous loss carryback makes the cyclicality of corporate tax revenues with respect to business cycle larger. Companies are able to utilize the more generous loss provisions during recessions and thus their tax payments will be lower when the loss offset is larger – i.e. they will respond more severely to business cycle fluctuations.

Due to the fact that each of these provisions has slightly different impact on the nature of the relationship between the business cycle and corporate tax revenues, we examine each of them separately as well as together as an index.[9] Also, since loss offset provisions will mainly have an effect in recessions, rather than during booms we estimate the heterogeneity of the response only for recession episodes. As a result we estimate using OLS without year fixed effects the following equation:[10]

$$\begin{aligned}
&\Delta \ln(R_{it}) = \alpha + \beta_1 \Delta \ln(\tau_{it}) + \gamma_1 \Delta \ln(GDP_{it}) \\
&+ \gamma_{1R} \Delta \ln(GDP_{it}) \times recession + \gamma_{1RL} \Delta \ln(GDP_{it}) \times recession \times loss_generosity \\
&+ \gamma_{1B} \Delta \ln(GDP_{it}) \times boom + \varepsilon_{it}
\end{aligned}$$

The regression results are reported in Table 8, but let us look at Figure 8 that shows how the average marginal effect of GDP growth on corporate tax revenues in recession actually varies with loss generosity (this is done here for the results from column 5 in Table 8). The marginal effect of business cycle on corporate tax revenues is insignificant and negative at the lower values of loss offset, while the larger the loss generosity of the

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[8] Loss carry back in the OECD data is accounted for in the same year. If a company is claiming tax credit for last year, the amount is used to reduce corporate tax revenue is a given year. The revenue numbers are not retrospectively amended.

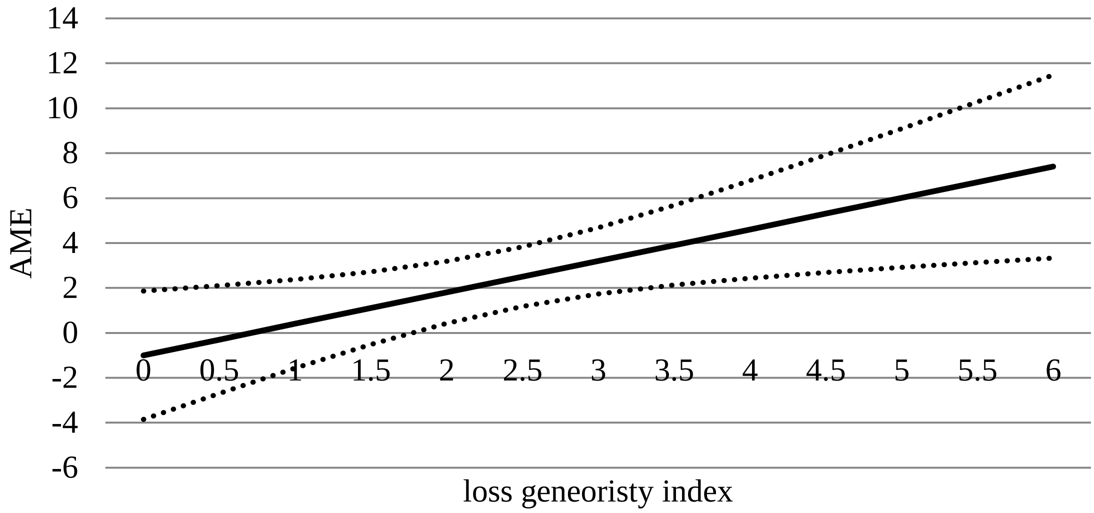
[9] In this version of this paper we only report the results from the index estimations. When we look at the components of the index the most important and significant is loss carryback. It increases the size of the cyclicality parameter. Loss carryforward matters when we look at post recession periods, but is insignificant in recession times.

[10] We do not have enough observations to estimate this equation by IV, even though this would be our preferred strategy.

corporate tax system, the more cyclical the corporate tax revenue is in response to GDP fluctuations. This confirms our prior.

What is more, we tested the heterogeneity of the business cycle response of the corporate tax revenues in normal times and during booms. In both cases the interaction terms are insignificantly different from normal times and booms responses of corporate tax revenues to the business cycle.

Figure 8. Average marginal effect of GDP growth on coprorate tax revenues at different levels of loss generosity index.



6 Conclusion

In this paper we show that corporate tax revenues respond quite strongly to the business cycle. We document the asymmetries in this response between booms and recessions using both OLS and IV estimation strategies. We have also contributed to the debate about loss offset generosity. We construct a loss offset generosity index that we use to explore the heterogeneity of the tax revenue cyclicality. Our findings suggest that when the larger loss offset is allowed the more responsive is corporate tax revenue to the business cycle. According to the evidence presented in this paper, if a country faces a recession and does allow generous loss-offset, the decline in corporate tax revenues it faces will be larger. This in turn will enhance the stabilizing property of corporation tax in recession. Countries with less generous loss-offset provisions will benefit less from this automatic adjustment and might suffer more from recession as a result.

Table. 8. Loss generosity offset and cyclicality of corporate tax revenues.

VARIABLES	(1) GDP	(2) GDP	(3) GDP_10/90	(4) GDP_20/80	(5) GDP_30/70	(6) GDP_40/60	(7) GDP_50/50
$\Delta\ln(\tau_{it})$	0.328**	0.332**	0.309**	0.301**	0.300**	0.314**	0.314**
	(0.135)	(0.133)	(0.134)	(0.136)	(0.133)	(0.135)	(0.137)
$\Delta\ln(GDP_{it})$	2.853***	1.396*	3.241***	3.657***	4.343***	4.445***	
	(0.414)	(0.757)	(0.514)	(0.569)	(0.566)	(0.683)	
$\Delta\ln(GDP_{it})\times loss\_generosity$		0.603**					
		(0.241)					
$loss\_generosity$		-0.0257					
		(0.0168)					
$\Delta\ln(GDP_{it})\times boom$			-0.816	-1.001**	-1.566***	-1.690***	2.776***
			(0.586)	(0.506)	(0.516)	(0.636)	(0.362)
$\Delta\ln(GDP_{it})\times recession\times loss\_generosity$			1.695***	1.648***	1.401**	1.255**	1.109**
			(0.625)	(0.596)	(0.543)	(0.507)	(0.456)
$\Delta\ln(GDP_{it})\times recession$			-4.140**	-4.624***	-4.891***	-4.379***	0.501
			(1.708)	(1.662)	(1.584)	(1.576)	(1.377)
Constant	-0.0477	0.0241	-0.0606	-0.0743*	-0.0834**	-0.0668*	-0.0606
	(0.0411)	(0.0767)	(0.0432)	(0.0441)	(0.0414)	(0.0399)	(0.0410)
Observations	514	514	514	514	514	514	514
R-squared	0.234	0.251	0.262	0.263	0.267	0.262	0.253

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p

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