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Abstract

By how much will faster economic growth boost government revenue? This paper estimates short- and long-run tax buoyancy in OECD countries between 1965 and 2012. We find that, for aggregate tax revenues, short-run tax buoyancy does not significantly differ from one in the majority of countries; yet, it has increased since the late 1980s so that tax systems have generally become better automatic stabilizers. Long-run buoyancy exceeds one in about half of the OECD countries, implying that GDP growth has helped improve structural fiscal deficit ratios. Corporate taxes are by far the most buoyant, while excises and property taxes are the least buoyant. For personal income taxes and social contributions, short- and long-run buoyancies have declined since the late 1980s and have, on average, become lower than one.

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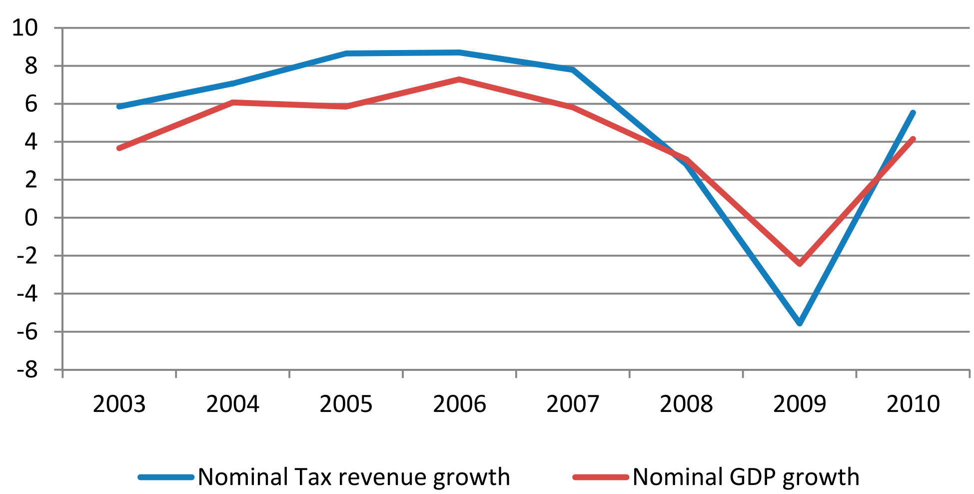
I. Introduction

Many OECD countries face significant fiscal challenges. In the aftermath of the crisis, fiscal deficits have skyrocketed. In some countries, this urges fierce and immediate action to avoid loss of market confidence, restore debt sustainability and rebuild fiscal buffers. In the longer term, the ageing of populations will put further pressure on public finances and risk an unsustainable debt trajectory. This raises the question to what extent higher economic growth can help bring down fiscal deficits. From the revenue side of the budget, the answer depends on so-called tax buoyancy: the measure for how tax revenues vary with changes in GDP. A buoyancy of one would imply that an extra percent of GDP would increase tax revenue also by 1 percent, thus leaving the tax-to-GDP ratio unchanged. A tax buoyancy exceeding one, however, would increase tax revenue by more than GDP and potentially lead to reductions in the deficit ratio.

Figure 1 shows the growth rates of nominal GDP and nominal tax revenue in the OECD between 2003 and 2010. In the period before the crisis, tax revenue growth was larger than GDP growth in every single year. During the crisis years 2008-2009, revenue declined by more than GDP. These observations suggest that tax buoyancy has been larger than one during these years. The question this paper aims to address is whether this hold over longer time periods, for all countries, and for all taxes.

Figure 1. Growth Rates of Nominal GDP and Tax Revenue in the OECD (in percent)



Tax buoyancy may differ between the short-run and the long-run. Short-run buoyancy is closely related to the stabilization function of fiscal policy. Indeed, if tax revenue increases by more than GDP (short-term buoyancy exceeding one), the tax system is a good automatic stabilizer. If short-term buoyancy is smaller than one, tax revenue is more stable than GDP and functions less as an automatic stabilizer. Long-run buoyancy is important for the impact of economic growth on long-term fiscal sustainability. Long-run buoyancy exceeding one would *ceteris paribus* imply that higher growth will improve the fiscal balance through the revenue side of the budget, while with a long-run buoyancy smaller than one growth will do the opposite.

This paper estimates long and short-run tax buoyancy for OECD countries during the period 1965-2012. To that end, it adopts an Error Correction Model (ECM) that simultaneously estimates short-run effects, a long-term relationship and a speed of adjustment. The main contributions are twofold. First, we estimate tax buoyancy for aggregate revenue for each OECD country separately, as well as in a panel of all OECD countries. We also look at buoyancy in the panel during two different episodes. Second, the buoyancy of six different tax revenue components is estimated using panel regressions. These tax components include the personal income taxes (PIT), corporate income taxes (CIT), goods and services taxes (GST), excise taxes, recurrent taxes on immovable properties and social security contributions (SSC). We also present the robustness of our results with respect to some underlying assumptions.

Several other studies have estimated short and long-run tax buoyancy using time series for individual countries (see e.g. Upender (2008) for India, Cotton (2012) for Trinidad Tobago, Sobel and Holcombe (1996) and Bruce et al. (2006) for the US, and Poghosyan (2011) for Lithuania). Girouard and André (2005) is the closest to our study. They explore the relationship between taxes and GDP for a panel of 28 OECD countries between 1980 and 2003 for four revenue components. In particular, they estimate the impact of cyclical budget components to the output gap in two steps: first by estimating effects of each tax component to its base; and second, by estimating effects of the base to the output gap. Our approach uses a larger set of countries and a longer time frame. Moreover, the ECM approach allows us to not only explore short-run buoyancy, but also the long-term relationship and the speed of adjustment.

The rest of this paper is organized as follows. Section II discusses the specification and estimation strategy and data. Section III elaborates on the regression results for, respectively, total revenue and revenue components, and then performs robustness analysis regarding some important assumptions. Finally, Section IV concludes.

II. Methodology

Tax buoyancy is generally measured by regressing the log of tax revenue on the log of GDP, sometimes with controls for other factors influencing revenue performance. Tax buoyancy differs from the so-called macroeconomic *tax elasticity,* which is similar but corrects revenue data for changes in tax policy parameters. In the absence of such information in a systematic way for all countries, we focus only on tax buoyancy.

A. Specification and Estimation

The starting point for our econometric specification is the following panel autoregressive distributed lag model, which allows for a flexible dynamic relationship between tax revenue and GDP:

$$\boldsymbol{ln\,Tax_{i,t} = \sum_{j=1}^{p} \phi_{ij} ln\,Tax_{i,t-j} + \sum_{j=0}^{q} \theta_{ij}\, ln\,GDP_{i,t-j} + \mu_i + \varepsilon_{it}} \quad \textbf{(1)}$$

where $Tax_{i,t}$ denotes tax revenue in country *i* in year *t*, and $GDP_{i,t}$ stands for its level of GDP, μ_i are country fixed effects and ε_{it} is the error term. Both the tax variable and GDP are expressed in logs. Equation (1) suggests that developments in tax revenue can be explained by a distributed lag of order p of the dependent variable, and a distributed lag of order q of GDP. Choosing the appropriate lags *p* and *q* addresses possible problems of autocorrelation and endogeneity. The Bayesian information criterion is used to choose the optimal lag structure, i.e. values for p and q, for each country and for each equation. We find that p=1 and q=1 are optimal and use this in the estimations below. In particular, subtracting the lagged tax variable from both sides of Eq. (1), the above model is transformed into a single Error Correction Model (ECM) of the form:

$$\boldsymbol{\Delta ln\,Tax_{i,t} = \lambda_i \left(ln\,Tax_{i,t-1} - \beta_i\, ln\,GDP_{i,t-1} \right) + \theta_{i,0} \Delta ln\,GDP_{i,t} + \mu_i + \varepsilon_{it}} \quad (2)$$

where the parameters can be written as: $\beta_i = -\frac{\theta_{i,0}+\theta_{i,1}}{\lambda_i}$ and $\lambda_i = -(1 - \phi_{i,1})$. In Equation (2), $\theta_{i,0}$ measures the instantaneous effect of a change in GDP on tax revenue, reflecting the short-term buoyancy of the tax. The first term on the right-hand side of Eq (2) reflects the long-run relationship between taxes and GDP. Here, the parameter β_i denotes the long-run buoyancy. The parameter λ_i measures the speed of adjustment, i.e., how fast buoyancy converges to its long-run equilibrium value. Our interest is in all three parameters: $\theta_{i,0}$, β_i and λ_i.

Equation (2) is estimated for both aggregate tax revenue and revenue by category: PIT, CIT, SSC, GST, Excises and Property taxes. The equation for aggregate revenue is estimated per country, using the mean group (MG) estimator. It assumes that both long and short-term buoyancy (slopes and intercepts) and error variances differ across countries. The simple average of the estimates is taken to obtain an average for the OECD. While this approach does not put restrictions on the estimates, they will not be consistent if data is limited.

The equation by period and by tax category is estimated using panel regressions, thereby including country fixed effects (FE). With ordinary FE estimation, time-series data for each group are pooled and only the intercept can differ across countries. If the slope coefficients are in fact not identical, the FE approach produces inconsistent and potentially misleading results. Therefore, we use the pooled mean group (PMG) estimator following Pesaran, Shin and Smith (1999). It combines pooling and averaging and allows the intercept, short-run coefficients, and error variances to differ across groups (as would the MG estimator). However, it constrains the long-run coefficients to be equal across groups (as would the FE estimator). The PMG estimator thus assumes that countries converge in the long run to the same buoyancy, but they might differ in the short run.

B. Theoretical Expectations

As a benchmark, we expect the coefficient for long-run buoyancy to be one. Yet, long-run buoyancy may differ across countries and between tax categories.[2] First, long-run buoyancy is expected to be larger for more progressive taxes, such as the PIT, and smaller for regressive taxes such as the SSC and GST. Second, if luxury goods (for which the income elasticity exceeds one) are mostly subject to standard VAT rates, while necessities (for which the income elasticity is smaller than one) are subject to reduced VAT rates, then long-run buoyancy of the VAT can exceed one. Third, if GDP growth comes along with a decline in the labor-income share (as experienced in many countries during the past decades, see Stockhammer (2013)), this can reduce tax buoyancy of the SSC and increase it for the CIT. At the same token, if growth is more export-driven or driven by growth in certain sectors, this will impact buoyancy of certain taxes. Fourth, in many countries, excise rates on gasoline, tobacco and alcohol are not automatically indexed to GDP growth. Tax buoyancy is then smaller than one if annual discretionary adjustments in rates are smaller than GDP growth.

Also short-run buoyancy will vary between tax categories and countries. For instance, taxes that are known to be good automatic stabilizers, such as the CIT, are expected to feature a relatively high short-run buoyancy coefficient. As local governments generally aim to stabilize revenue from property taxes by adjusting rates counter-cyclically (Norregaard, 2013), property taxes may feature particularly small short-run buoyancy. In countries with rigid wages and tight employment protection, revenue from PIT and SSC are relatively stable and, therefore, the short-run buoyancy coefficient might be below one. As regards the GST, people may smooth consumption in response to fluctuations in the business cycle, so that short-run buoyancy can be smaller than one. Short-term buoyancy can also depend on tax compliance. For instance, if a recession exacerbates credit constraints of taxpayers, compliance may fall and revenue decline by more than income.

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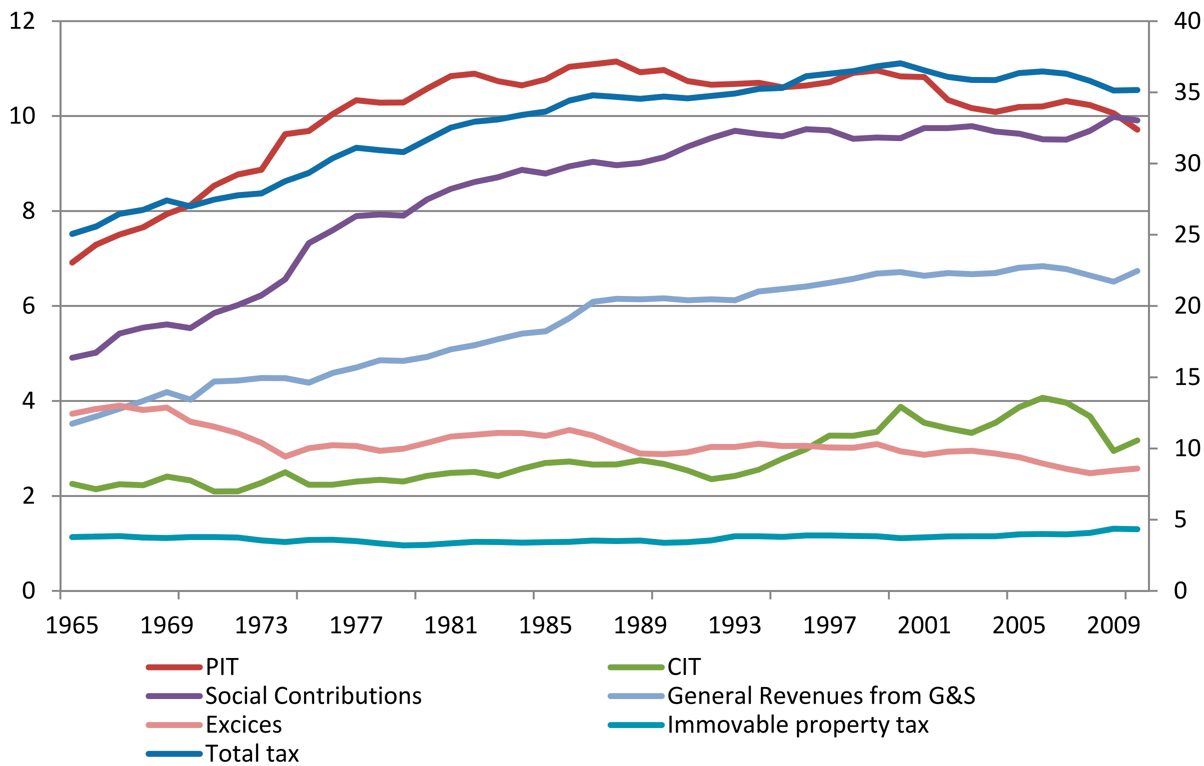
[2] A full account of the underlying determinants of tax buoyancies goes beyond the scope of this paper.

C. Data

We use annual tax revenue data for 34 OECD countries between 1965–2012 from the OECD revenue statistics. For countries that became OECD member after 1965, data is only available from the year of accession. The first year of data for the whole sample is 1995. The number of years per country varies from 16 for Estonia, to 47 for the oldest members of the OECD. GDP data are taken from IMF data sources. In 2012, the average tax-to-GDP ratio in the OECD is 34 percent.

Figure 2. Composition of Tax Revenues as Share of GDP /1



/1 Right axis is the share of total tax revenue in GDP; left axis is the share of each tax category in GDP.
The figure shows the average of each variable for a balanced panel over years since 1965. The panel excludes Chile, Czech Republic, Estonia, Hungary, Iceland, Israel, Korea, Mexico, the Netherlands, Poland, Slovakia and Slovenia. For PIT and CIT, Portugal is excluded since data on both variables are available only from 1989; Australia and New-Zealand are excluded for SSC because they do not collect them; for GST, Japan and Turkey are excluded because GST is available only since 1988 and 1985, respectively; for property taxes, Finland, Italy, Portugal, Turkey are also excluded.
Source: OECD revenue statistics.

Apart from aggregate revenue data, we use revenue from six different categories of tax: PIT, CIT, SSC, GST, Excises and Property taxes. Figure 2 shows the development of the six tax categories over time as a share of GDP, on average for the OECD. PIT and SSC are the two main sources of revenues. We observe a steady increase in the share of GST and SSC over time, while PIT revenue increased until the late 1980s and started to fall thereafter. The tax composition of OECD countries also differs between countries. Some countries such as the

U.K., the U.S., Australia, Denmark, Finland, New-Zealand, Sweden, and Switzerland rely heavily on PIT. In contrast, Italy, France, Belgium, Greece and Spain rely mostly on SSC.

III. RESULTS

A. Buoyancy of Total Tax Revenue

We first estimate Equation (2) for each of the 34 OECD countries, using data for total tax revenue. Table 1 shows the estimated coefficients for short-run buoyancy, long-run buoyancy and the speed of adjustment per country.

The results suggest an average long-run buoyancy of 1.03 and a median of 1.05. It is significantly smaller than one in four countries: the Netherlands, Israel, Slovak Republic and Hungary. In 16 countries the coefficient is not significantly different from one. In the remaining 14 countries, it significantly exceeds one. The cross-country variation ranges from 0.75 for Slovak Republic to 1.3 for Japan, with a standard deviation across countries of 0.11. Overall, the data tend to support the view that long-run buoyancy over the past decades has been either close to one, or exceeded one by a small degree. For the latter countries, GDP growth has improved fiscal sustainability.

The average short-run buoyancy is 1.01. In only four countries it is significantly smaller than one (Austria, Switzerland, Hungary and Estonia), while in only five countries it significantly exceeds one (France, Japan, Spain, Australia and Chile). In 25 countries, short-run buoyancy is not significantly different from one. Hence, tax systems are mostly neither good, nor bad automatic stabilizers. Short-run buoyancy shows greater variation between countries than long-run buoyancy, with a standard deviation of almost 0.2. The lowest short-run buoyancy is 0.43 in Hungary, while the largest buoyancies are found in Japan and Chile where they exceed 1.5. There are 18 countries for which short-term buoyancy is larger than long-run buoyancy, while for 16 it is smaller.

The speed of adjustment is reported in the seventh column of Table 1. Estimates are negative for all countries and statistically significantly for most of them, consistent with convergence to a long-term relationship. The speed of adjustment ranges from a low 7.8 percent in Sweden to over 75 percent in the Slovak and Czech Republics.

Table 1. Buoyancy of Total Tax Revenue by Country /1

	Long-run buoyancy			Short-run buoyancy			Speed of adjustment	Number of obs.
	<1	1	>1	<1	1	>1		
Canada		0.96***			1.01***		-0.10	47
France			1.12***			1.20***	-0.16*	47
Germany		1.05***			1.08***		-0.33***	47
Italy			1.13***		0.80***		-0.44***	47
Japan			1.29***			1.54***	-0.25***	45
U.K.		1.00***			0.99***		-0.33***	46
U.S.		1.03***			1.34***		-0.27**	46
Austria			1.07***	0.68***			-0.42***	46
Belgium		1.03***			0.89***		-0.16**	47
Denmark		1.06***			0.92***		-0.22**	46
Luxembourg		1.05***			0.70***		-0.14*	47
Netherlands	0.86***				0.77***		-0.31**	32
Norway		1.02***			1.03***		-0.18***	46
Sweden		0.97***			1.12***		-0.08	46
Switzerland			1.12***	0.57***			-0.30***	46
Finland			1.08***		0.92***		-0.25**	46
Greece			1.09***		0.89***		-0.49***	46
Iceland		0.90***			0.82***		-0.11	31
Israel	0.80***				0.72***		-0.48*	17
Ireland		0.98***			1.01***		-0.15**	47
Portugal			1.12***		1.13***		-0.60***	47
Spain			1.21***			1.41***	-0.20**	47
Turkey			1.06***		0.98***		-0.48***	47
Australia			1.09***			1.44***	-0.11	45
New Zealand			1.08***		1.20***		-0.30***	46
Chile			1.12***			1.56***	-0.59***	22
Mexico		1.03***			1.03***		-0.49***	30
Korea			1.16***		1.44***		-0.25*	40
Czech Rep.		1.05***			1.28***		-0.78***	17
Slovak Rep.	0.75***				0.84***		-0.77***	17
Estonia		0.98***		0.75***			-0.32***	16
Hungary	0.87***			0.44***			-0.59***	21
Slovenia		1.01***			1.07***		-0.64***	17
Poland		0.96***			1.08***		-0.54***	21
Mean		1.032			1.019		-0.349	
Median		1.048			1.011		-0.306	
St deviation		0.110			0.275		0.196	

/1 Note: *** p<0.01, ** p<0.05, * p<0.1; Column <1 means statistically smaller than 1 at 5 percent, column = 1 means statistically not different from 1 at 5 percent; column >1 means statistically larger than 1 at 5 percent. New-Zealand and Australia do not collect SSC.

Table 2. Buoyancy of Total Tax Revenue, Panel Estimate /1

	1965-2012	1965-1988	1989-2012
Long-run buoyancy	***1.06****	***1.09****	**1.02*****
	(0.00)	(0.00)	(0.03)
Short-run buoyancy	**1.04*****	**0.93*****	**1.17*****
	(0.05)	(0.06)	(0.10)
Speed of adjustment	-0.17***	-0.33***	-0.39***
	(0.03)	(0.05)	(0.04)

/1 *** p<0.01, ** p<0.05, * p<0.1; bold italic means statistically greater than 1 at 5%, bold means statistically not different from 1 at 5%. Numbers in brackets denote standard errors. The panel is balanced and excludes Chile, Czech Republic, Estonia, Hungary, Iceland, Israel, Korea, Mexico, the Netherlands, Poland, Slovakia and Slovenia. Australia and New-Zealand do not collect SSC, total tax revenue includes SSC.

Table 2 shows panel regressions based on the PMG estimator, using the full panel of OECD countries. It also compares tax buoyancy over two equal periods: 1965−1988 and 1989−2012. The late 1980s mark a significant change in policies of many OECD countries, including through major tax reforms. To eliminate the impact of differences in country coverage in the two periods, we create a balanced panel for the regressions in Table 2.

On average, long-run buoyancy in Table 2 is 1.06 and significantly higher than one. Long-run buoyancy has somewhat declined in the more recent period compared to the 1965-1988 period, and the coefficient is no longer significantly higher than one after 1989. This possibly reflects less progression in tax systems after the reforms in the late 1980s and early 1990s.

Short-run buoyancy over the entire period equals 1.04 and is not statistically different from one. The two periods are markedly different, however. Before the late 1980s, short-run buoyancy was well below one, although due to a large standard error, not significantly so. Since the late 1980s, it has been well above one, but again not significantly different at 5 percent confidence. The difference in short-run buoyancy between the two periods is statistically significant though, implying that the stabilization function of the tax system has strengthened in the more recent period.

Changes in buoyancy may reflect developments in revenue categories. Indeed, changes in the tax mix from more to less buoyant taxes (or vice versa) can modify buoyancy for aggregate revenue. Moreover, the buoyancy of each of these different tax categories themselves might have changed (see below). Over the last two decades, for instance, many OECD countries have enacted structural tax policy reforms that changed both the tax mix (see Figure 2) and the structure of each of the components.

B. Buoyancy of Tax Revenue Components

Table 3 shows results of panel regressions for each of six tax categories, based on the PMG estimator.[3] Long-run buoyancy is found to exceed one for the CIT. For the SSC and GST, it is not significantly different from one, while it lies below one for the PIT, excises and property taxes. The high buoyancy for the CIT may reflect the gradual decline in the labor-income share over the past decades in advanced countries. This could also explain the low buoyancy of the PIT. For excises, low long-run buoyancy may be due to lack of indexation of excise rates in many countries.

Table 3. Buoyancy of Tax Revenue Components /1

	PIT	SSC	CIT	GST	Excises	Immovable Property
Long-run buoyancy	0.97***	**1.05*****	***1.26******	**0.98*****	0.77***	0.71***
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Short-run buoyancy	**1.10*****	0.75***	***1.96******	**0.92*****	0.51***	0.05
	(0.09)	(0.07)	(0.17)	(0.06)	(0.10)	(0.15)
Speed of adjustment	-0.20***	-0.20***	-0.30***	-0.23***	-0.20***	-0.15***
	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)

/1 *** p<0.01, ** p<0.05, * p<0.1; bold italic means statistically greater than 1 at 5%, bold means statistically not different from 1 at 5%. %; For CIT and PIT, Chile and Mexico are not included in the estimation because of missing data; for SSC, Australia and New-Zealand do not collect SSC. Numbers in brackets denote standard errors.

Short-run buoyancy in Table 3 is not significantly different from one for the PIT and the GST, although the higher point estimate for the PIT suggests that it is a better automatic stabilizer than the GST. The CIT is by far the best automatic stabilizer, with a short-run buoyancy of 1.96. Interestingly, short-run buoyancy of the SSC is significantly smaller than one.[4] One reason for this might be their regressive structure (due to caps on the income subject to SSC). Short-run buoyancy of the property tax is the only that is not significantly different from zero. Municipalities might keep revenue from this source stable, irrespective of what happens to GDP. The speed of adjustment for the property tax is also the lowest of all taxes, i.e., adjustment towards its long-term buoyancy is slow.

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[3] Results on short-run buoyancy per tax category and per country are available upon request. For aggregate revenues and revenue components, results are robust to the inclusion of 1 to 5 lags for GDP. Also these results are available upon request.

[4] Girouard and André (2005) also find the largest short-run effects for the CIT and a short-run effect of the SSC below one.

Table 4 shows buoyancy estimates over the two periods distinguished in Table 2. To eliminate the impact of differences in country coverage in the two periods, we create a balanced panel for this exercise. This explains why results for the entire period differ slightly from those in Table 3.

Table 4. Buoyancy of Tax Components over Two Periods /1

	Period	Long-run buoyancy (s.e.)		Short-run buoyancy (s.e.)	
PIT	1965-2012	0.91***	(0.02)	**1.03*** **	(0.08)
	1965-1988	***1.17**** **	(0.02)	**1.07*** **	(0.12)
	1989-2012	0.82***	(0.01)	**0.94*** **	(0.19)
SSC	1965-2012	***1.08**** **	(0.01)	**0.87*** **	(0.10)
	1965-1988	**1.23*** **	(0.01)	**0.83*** **	(0.13)
	1989-2012	**0.95*** **	(0.01)	0.58***	(0.11)
CIT	1965-2012	***1.25**** **	(0.03)	***1.79**** **	(0.20)
	1965-1988	***1.24**** **	(0.01)	**1.29*** **	(0.31)
	1989-2012	***1.41**** **	(0.05)	***3.58**** **	(0.47)
GST	1965-2012	***1.16**** **	(0.01)	**1.03*** **	(0.09)
	1965-1988	***1.30**** **	(0.02)	**0.93*** **	(0.16)
	1989-2012	***1.13**** **	(0.01)	**1.28*** **	(0.19)
Excises	1965-2012	0.76***	(0.01)	0.56***	(0.14)
	1965-1988	0.79***	(0.01)	0.43	(0.27)
	1989-2012	0.52***	(0.03)	0.36***	(0.12)
Property tax	1965-2012	0.92***	(0.02)	0.13	(0.22)
	1965-1988	0.66***	(0.02)	-0.02	(0.39)
	1989-2012	0.94***	(0.03)	-0.04	(0.15)

/1 *** p<0.01, ** p<0.05, * p<0.1; bold italic means statistically greater than 1 at 5%, bold means statistically not different from 1 at 5%. Numbers in brackets denote standard errors. The panel excludes Chile, Czech Republic, Estonia, Hungary, Iceland, Israel, Korea, Mexico, the Netherlands, Poland, Slovakia and Slovenia. For PIT and CIT, Portugal excluded; Australia and New-Zealand excluded for SSC; for GST Turkey and Japan are excluded; for property taxes, Finland, Italy, Portugal, Turkey excluded.

We see that long-run buoyancy of the PIT was significantly larger before than after the late 1980s, with the point estimate falling from 1.17 to 0.82. This may reflect the reduction in progressivity of PIT systems since the late 1980s. A similar decline in long-run buoyancy is found for the SSC, falling from 1.23 to 0.95. The earmarked spending from SSC for social benefits, however, may imply that developments on the spending side of the budget matter for this change. Long-run buoyancy of the GST and excises has also declined over time. For the GST, it significantly exceeds one in both periods. Hence, growth might well have increased the consumption share of luxuries that are subject to higher tax rates. This result contrasts with Table 3, reflecting a difference in country coverage in Table 4 due to the balanced nature of the panel. Over time, we see that the buoyancy of the GST has declined. For excises, long-run buoyancy is lower than one in both periods. For the CIT and property taxes, long-run buoyancy has increased over time. The buoyancy of property taxes is also larger than in Table 3.

Short-run buoyancy of the PIT and SSC has declined since the late 1980s. In contrast, for the CIT and the GST, we observe a marked increase. The high short-run buoyancy of the GST, well above one, is inconsistent with consumption smoothing. Rather, it seems to reflect precautionary saving by people during busts and buoyant spending on e.g. luxuries during booms. Interestingly, while short-run buoyancy has increased over time, long-run buoyancy has decreased. Note, however, that the estimates are somewhat imprecise and that we cannot reject the null of the coefficient being equal to one.

C. Robustness

Tax buoyancy estimates might be biased if changes in tax revenue and GDP are correlated with changes in tax policy parameters, such as tax rates or exemptions. To explore this possible bias, we run two regressions whereby developments in tax rates are included as a control variable. This is important in light of the reforms enacted since the late 1980s in several countries. The sample period is somewhat reduced in this exercise, due to data limitations. Results for the PIT and the CIT are reported in Table 5. Controlling for the top PIT rate yields significantly higher long-run tax buoyancy for the 1989-2012-period than without controlling for the top PIT rate, although the coefficient is still below one. Hence, adjustments in PIT rates might indeed have been correlated with GDP. The same holds for short-run buoyancy, which is larger when controlled for the rate. However, short-run buoyancy is never significantly different from one. For the CIT, the inclusion of the tax rate does not change the main results.

A second robustness check concerns inflation. In estimating (2), we use nominal changes in tax revenue and nominal GDP, which contain both a price component and a real component. As a robustness check, we run a regression whereby inflation is added as a separate control variable. If the coefficient for inflation turns out insignificant (and the coefficients for buoyancy do not change) we may conclude that tax buoyancy is independent of inflation and that the same relationship would be obtained if real variables were used. However, Table 6 shows that inflation enters with a significant positive coefficient, both in the short-run and in the long-run. Moreover, the coefficients for buoyancy are now smaller than before. Hence, tax buoyancy does not appear neutral with respect to inflation. In fact, tax buoyancy in real terms is smaller than in nominal terms and, in the long-run, significantly so.

Table 5. Buoyancy of PIT and CIT, Controlled for Tax Rates /1

	PIT 1989-2012	
	No control for rate	**Control for tax rate**
Long-run buoyancy	**0.83*****	0.93***
	(0.01)	(0 .02)
Short-run buoyancy	**0.95*****	**1.04*****
	(0.14)	(0.14)
	CIT 1980-2012	
Long-run buoyancy	***1.52******	***1.61******
	(0.03)	(0.04)
Short-run buoyancy	***2.77******	***2.89******
	(0.23)	(0.25)

/1 *** p<0.01, ** p<0.05, * p<0.1; Bold italic means statistically greater than 1 at 5%, bold means statistically not different from 1 at 5%. Chile and Mexico are excluded; numbers in brackets denote standard errors.

Table 6. Buoyancy With and Without Controlling for Inflation /1

	Not Controlling for inflation	Controlling for inflation
Long-run buoyancy	**1.06*****	0.79***
	(0.00)	(0.02)
Short-run buoyancy	**1.04*****	**0.89*****
	(0.05)	(0.08)
Long-run price effect		0.37***
		(0.03)
Short-run price effect		0.20**
		(0.08)
Speed of adjustment	-0.17***	-0.18***
	(0.03)	(0.03)

/1 *** p<0.01, ** p<0.05, * p<0.1; bold italic means statistically greater than 1 at 5%, bold means statistically not different from 1 at 5%. Numbers in brackets denote standard errors. The panel excludes Chile, Czech Republic, Estonia, Hungary, Iceland, Israel, Korea, Mexico, the Netherlands, Poland, Slovakia and Slovenia. Australia and New-Zealand do not collect SSC. Regressions use total tax revenue, including SSC.

Finally, an assessment of asymmetries in short-term tax buoyancy can help understand variations in the stabilization role of taxation during periods of growth and contraction. We explore this by defining a dummy variable that takes the value of one for years with positive growth (1632 observations) and zero in years with negative growth (142 observations). We interact the short-run tax buoyancy coefficient with the dummy and its complement to obtain two coefficients: for buoyancy during growth and during contractions. Table 7 shows that tax buoyancy for total tax revenue is larger during contractions than during growth. Hence, tax systems in an average OECD country seem to work better as automatic stabilizer during recessions than during growth. This result is particularly prevalent for excises, property taxes and SSC. Note, however, that results should be interpreted with caution due to the large standard errors for results with negative growth.

Table 7. Asymmetric short-term buoyancy/1

Type of revenue	Short-run buoyancy			
	Growth	(s.e.)	Contraction	(s.e.)
Total revenue	**1.01*****	(0.03)	***1.19******	(0.07)
PIT	**1.03*****	(0.08)	**1.03*****	(0.08)
SSC	**0.83*****	(0.09)	**1.05*****	(0.23)
CIT	***1.79******	(0.20)	**1.31*****	(0.28)
GST	**1.03*****	(0.09)	**1.03*****	(0.09)
Excises	0.55***	(0.14)	0.80***	(0.18)
Property tax	0.14	(0.20)	**1.86****	(0.83)

/1 *** p<0.01, ** p<0.05, * p<0.1; bold italic means statistically greater than 1 at 5%, bold means statistically not different from 1 at 5%. Numbers in brackets denote standard errors. The panel excludes Chile, Czech Republic, Estonia, Hungary, Iceland, Israel, Korea, Mexico, the Netherlands, Poland, Slovakia and Slovenia. For PIT and CIT, Portugal also excluded; Australia and New-Zealand excluded for SSC; for GST, Japan and Turkey are excluded; for property taxes, Finland, Italy, Portugal, Turkey also excluded.

IV. CONCLUSION

Using a single Error Correction Model, this paper examines the tax buoyancy in the long and in the short run in 34 OECD countries for the period 1965–2012. Results suggest that long-run buoyancy is not significantly different from one in about half of the OECD countries. For 14 countries, long-run tax buoyancy exceeds one, implying that GDP growth has helped improve fiscal performance through the revenue side of the budget. Long-run buoyancy has declined since the late 1980s. Short-run buoyancy is close to one for the majority of OECD countries, implying no particularly strong or weak automatic stabilization forces from tax systems. However, short-run buoyancy shows a marked increase since the late 1980s.

The paper also assesses the buoyancy of tax revenue components, using panel regressions. The corporate income tax is the best automatic stabilizer, with the highest short-run buoyancy. Short-run buoyancy is particularly weak for excises and property taxes. Long-run buoyancy is also high for corporate taxes, possibly reflecting the increase in the capital income share during the past decades. Long and short-run buoyancy for the personal income tax seems to have declined since the late 1980s, perhaps due to less progression. Excises and property taxes have the lowest long-run buoyancy.

We see three straightforward directions to expand our analysis. First, one could assess buoyancy for non-OECD countries, even though time series might be shorter. Tax buoyancy can differ because tax ratios are generally lower outside the OECD, especially for personal income taxes. Second, it would be interesting to expand the analysis to tax elasticities, which correct revenue performance for changes in policy parameters. This requires, however, more detailed information about underlying tax reforms and their revenue impacts. Finally, a more thorough analysis of the determinants of tax buoyancy would add to our understanding of why buoyancies differ between countries and across time.

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