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EVIDENCE FROM OECD COUNTRIES

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CONTENTS

Abstract

This paper investigates empirically the effect of personal income tax progressivity on output volatility in a sample of OECD countries over the period 1982-2009. Our measure of tax progressivity is based on the difference between the marginal and the average income tax rate for the average production worker. We find supportive empirical evidence for the hypothesis that higher personal income tax progressivity leads to lower output volatility. All other factors constant, countries with more progressive personal income tax systems seem to benefit from stronger automatic stabilisers.

Keywords: Progressivity, personal income taxes, output volatility, automatic stabilisers.

JEL classification: E63, E32, H10.

Non-technical summary

The recent financial and economic crisis has revived the discussion on the role that governments may have in smoothing out business cycle fluctuations. The role of automatic stabilisers, and their advantages in terms of being timely, targeted, and temporary, has been widely discussed on this occasion. In particular, since under a progressive tax scheme tax liabilities decrease more than one by one when taxable income falls, progressive income tax systems are seen to reduce output volatility by freeing up resources in times of economic slowdown (and vice versa in upturns) and being well targeted to liquidity-constrained households.

The size of automatic stabilisers depends on both the size of government and the sensitivity of expenditure or revenue items to the business cycle. Several empirical studies test either the hypothesis that large governments are better able to withhold output fluctuations or they assess the sensitivity of government expenditures or revenues to the business cycle. However, a largely absent piece in the literature is the direct relationship between tax progressivity and output volatility. We try to fill this gap by using a measure of personal income tax progressivity, based on the difference between the marginal and the average income tax rates for the average production worker, to assess the effect of tax progressivity on output volatility (measured as the standard deviation of log changes of real GDP) for a panel of OECD countries over the period 1982-2009.

We find that higher personal income tax progressivity leads to reduced output volatility. Based on our benchmark model, keeping all the other factors constant, an increase in the progressivity index by one standard deviation leads to a decrease in output volatility by 0.33 units on average. For Switzerland, for example, which is the median country in 2000, an increase in the index by one standard deviation could be the result of an increase in the marginal tax rate from 22.2% to 30.3%. This would imply a reduction in Switzerland's output volatility from 1.7 to 1.4, i.e. by 18%. The empirical results of our paper allow us to conclude that, ceteris paribus, countries with more progressive income tax systems seem to have stronger automatic stabilisers, which can be used as a first line of defence in times of economic downturn.

1 Introduction

The recent financial and economic crisis has revived the discussion of the role of automatic stabilisers, and their advantages in terms of being timely, targeted, and temporary (see Taylor, 2009; van Riet (Ed.), 2010). In particular, since under a progressive tax scheme tax liabilities decrease more than one by one when taxable income falls, progressive income tax systems are seen to reduce output volatility by freeing up resources in times of economic slowdown (and vice versa in upturns) and being well targeted to liquidity-constrained households. This paper presents empirical support for the hypothesis that higher personal income tax progressivity reduces output volatility based on panel data from OECD countries over the period 1982-2009.

The size of automatic stabilisers depends on, among other factors, the size of government and the sensitivity of government expenditures and/ or tax revenues to the business cycle. A long strand of empirical literature assesses the relationship between government size, measured either by the ratio of government expenditures to GDP or by the ratio of tax revenues to GDP (or to tax base), and output fluctuations (see, for example, Galí, 1994, Silgoner et al., 2011, Carmignani et al., 2011, forthcoming, Posch, 2011, forthcoming). Other empirical studies assess the sensitivity of public expenditures or revenues to the business cycle (see, for example, Girouard and André, 2005; Darby and Melitz, 2008). However, a largely absent piece in the literature is the direct relationship between tax progressivity and output volatility. Fatás and Mihov (2001) investigate this relationship, though only indirectly. For a sample of US states, they show that higher ratios of state income tax revenues to state GDP are associated with lower state output volatility. Given the same federal income tax schedule across states, the authors attribute this negative relationship to the progressivity of the federal income tax schedule as states with higher per capita income tend to have higher revenue ratios.

Our contribution to the literature is threefold: first, following Arnold (2008), we use a direct measure of personal income tax (PIT) progressivity. More precisely, this measure captures variation in progressivity due to both variation in the tax schedule and variation in income, whereas the measure used by Fatás and Mihov (2001) is only driven by variation in income (or its distribution). Second, we present cross-country evidence on the relationship between tax progressivity and output volatility. Finally, while much of the empirical literature has focused on the impact of government size (on output volatility) and correcting its endogenous nature, endogeneity seems to be less of a concern in the case of tax progressivity. The degree of progressivity of the personal income tax system largely reflects societal preferences on equity and redistribution. It is rather determined by philosophical and political views on the role of the state, or by efficiency considerations, but it is typically unrelated to stabilisation goals. This allows us to use a measure which can be considered exogenous.

We focus on personal income taxes for several reasons (besides data availability): first, they are more progressive than corporate or consumption taxes (see Girouard and André, 2005; Baunsgaard and Symansky, 2009). Second, they play a crucial role for income and spending decisions of liquidity-constrained households. Third, other taxes, in particular corporate taxes, are not found to act as significant automatic stabilisers (see Devereux and Fuest, 2009; Buettner and Fuest, 2010). Fourth, income taxes payable by individuals are more important in terms of budgetary revenues than income taxes payable by corporations. Moreover, in many developed EU countries in particular, the relative importance of the former has grown significantly during the past one and a half decade. Last, but not least, we are interested in exploring a specific aspect of the topic of personal income tax progressivity per se, namely its effect on output fluctuations.

The structure of the paper is as follows. Section 2 reviews the related literature and discusses potential determinants of output volatility, Section 3 presents the data and some basic statistics. Section 4 contains the empirical analysis. We first present OLS estimates and then we investigate the potential endogeneity of tax progressivity using instrumental variables estimation. Section 5 shows that our results are insensitive to various other robustness checks, including alternative measures of the dependent variable, alternative estimation strategies, and several subsample estimates. The last section concludes.

2 Literature review

We first review the literature on automatic stabilisers and then we turn to the literature on the measurement of tax progressivity.

2.1 Automatic stabilisers

In a seminal paper Galí (1994) shows that a standard RBC model fails to account for the negative correlation between output volatility and government size, measured either as the ratio of government expenditures or tax revenues to GDP, for a sample of OECD countries. In the model, higher income taxes, by increasing the elasticity of labour supply, amplify the response of output to technology shocks. In contrast, Andrés and Doménech (2006) show that in a model with significant rigidities, distortionary taxes tend to reduce output volatility relative to lump-sum taxes. Here, distortionary taxes increase the volatility of hours worked as well but since they are negatively correlated with output, volatility of the latter is reduced. Andrés et al. (2008) show that the introduction of rule-of-thumb consumers into a New Keynesian model generates a negative relationship, in addition to that with output volatility, between government size and consumption volatility since higher labour taxes moderate fluctuations in disposable income of those households. Finally, in a neoclassical growth model with monopolistic competition, Moldovan (2010) shows that more progressive income taxes, by affecting the after-tax wage rate and thereby hours worked and consumption via the wealth and substitution effect, lead to lower volatility of consumption, investment, and output, while the effect on the volatility of hours worked is ambiguous.

Rodrik (1998) points out the potential endogeneity of government size. He argues that residents of more open economies, which are more exposed to external risks, might *choose* to have larger governments to shield themselves against output fluctuations. In an influential study Fatás and Mihov (2001) address this point. For a sample of OECD countries, they show that when using instrumental variables (IV) estimation to correct for the endogeneity of government size, its effect on output volatility indeed becomes stronger. In a second sample of US states, the authors show that higher state income tax revenue ratios lead to lower state output volatility. The authors attribute the negative relationship to the progressivity of income taxes arguing that, given the same federal income tax schedule across states, higher income per capita (or differences in its distribution) leads to higher state income tax revenue ratios. Considering also the time-series dimension of the data, Debrun et al. (2008) show that the negative relationship between government size and output volatility remains important throughout the 1990s when monetary policy and financial development (the latter allowing for better self insurance of the private sector) are controlled for. In contrast, Carmignani et al. (2011, forthcoming), when estimating a system of simultaneous equations to account for the endogeneity of government size to output volatility, find that larger governments lead to higher output volatility (and vice versa). Finally, Silgoner et al. (2011) provide evidence for nonlinear effects of government size on output volatility.

While most of these studies use expenditure and revenue ratios interchangeably as measures of government size, Cottarelli and Fedelino (2010) provide a theoretical argument for using revenue ratios. Intuitively, their argument rests on the observation that expenditures react less to the cycle than taxes.[1] Martinez-Mongay and Sekkat (2005) assess how the structure of the tax system affects output volatility. The authors find that for high ratios of total taxes to GDP further increases in average labour tax rates can be destabilising. Using the revenue elasticities approach, Baunsgaard and Symansky (2009) find that increasing the elasticity of PIT revenues leads only to modest increases in automatic stabilisers.[2] Finally, explicitly modeling the unobserved variance process, Posch (2011, forthcoming) finds that higher average effective taxes on labour

[1] However, Darby and Melitz (2008) show that age and health related social expenditures, as well as incapacity and sick benefits, all react to the cycle in a stabilising manner.

[2] Differences to our results may stem from the different methodology used and from their assumption of no behavioural reaction to changes in the elasticity of PIT revenues.

and corporate income tend to reduce output volatility, while higher average effective capital taxes have the opposite effect and average consumption taxes are unrelated to output volatility.[3]

In sum, the literature has identified three main channels through which automatic stabilisers can affect output volatility: (i) a composition effect via a larger (stable) government sector in output, (ii) a labour supply elasticity effect via distortionary taxation, and (iii) cyclically sensitive expenditure or revenue items. Hence, in principle it is possible that, for a given size of government, automatic stabilisers are stronger in countries with higher PIT progressivity and hence higher responsiveness of PIT revenues. Even more, Li and Sarte (2004) point out that income tax progressivity and revenue ratios might move in opposite directions. The authors show that while the US Tax Reform Act of 1986 led to a decrease in income tax progressivity, it is associated with an increase of the tax share of income. In light of their result, we would interpret previous findings based on revenue ratios rather as supportive evidence for channels (i) and/ or (ii) than for channel (iii) which is the focus of this paper. In particular, our aim is to assess the direct effect of PIT progressivity on output fluctuations, while controlling for government size.

2.2 Measures of tax progressivity

In a seminal study Musgrave and Thin (1948) propose four related measures of local tax progressivity, each looking at progressivity at specific points in the personal income scale, and one measure of global tax progressivity. The latter takes into account the full distribution of personal income before and after taxes. Following their work, a tax schedule is considered to be progressive if the average tax rate rises with income, i.e. the marginal tax rate exceeds the average tax rate. Then, the degree of progressivity tends to decline when moving up the income scale.[4]

The subsequent literature on tax progressivity can be broadly divided into studies focusing either on local or on global measures of progressivity. Earlier studies tend to focus on two out of the four originally proposed measures of local progressivity (see Slitor, 1948; Cohen, 1959), known as liability and residual progressivity. The former is measured as the elasticity of tax liability with respect to income before tax, whereas the latter is measured as the elasticity of income after tax with respect to income before tax

[3]Another strand of literature uses microsimulation models at the country level to assesses the stabilising effects of the tax and expenditure systems on private income (see, for example, Auerbach and Feenberg, 2000; Dolls et al., 2010).

[4]Note that this definition of progressivity is difficult to reconcile with the interpretation of Fatás and Mihov (2001) of their finding of a negative relationship between state ouput volatiliy and state income tax ratios in the US as a result of progressivity. Given the same federal income tax schedule across states, states with higher average income tend to have lower progressivity, according to this definition.

(both at a given point of the income scale). The original measure of global progressivity, initially proposed by Musgrave and Thin (1948), was subsequently refined. Two well known refinements are the index of residual progressivity of Reynolds and Smolensky (1977) and the index of liability progressivity of Kakwani (1977). However, since both measures require detailed microdata as they are based on Lorenz and concentration curves, restricting the empirical applications to one or very few countries and years (see Kakwani, 1977; Piketty and Saez, 2006), they cannot be used for the purposes of this paper. Although there have been attempts to establish a clear relationship between measures of local and global progressivity (see Jakobsson, 1976), no general ranking or dominance relation between these two concepts has been established so far (see Formby et al., 1986).

3 Data and basic statistics

In this section we first describe our measure of PIT progressivity, and then we present some basic statistics on the main data used in the empirical analysis.

3.1 Data

The data consist of an unbalanced panel of annual observations for all 30 OECD member countries over the period 1982-2009 (see Appendix for a list of the data and their sources). Following Arnold (2008), the index of PIT progressivity (*Prog*) is based on the concept of residual progressivity and it is defined as follows:[5]

$$\text{Index of Progressivity} = 1 - \frac{100 - \text{Marginal Tax Rate}}{100 - \text{Average Tax Rate}},$$

where the marginal and average tax rates (MTR and ATR, respectively) are evaluated at the average production worker (APW) wage, full-time employee, not married, and without children.[6] For a progressive tax system, the index is bounded between 0 and 1. For $MTR \rightarrow 100$ (and $ATR \neq 100$) $\Rightarrow$ $Prog \rightarrow 1$ and for $ATR = MTR$, i.e. for purely flat tax systems (without personal allowances or exemptions), $Prog = 0$. Thus, higher values of the index imply higher progressivity.

Arnold (2008) uses the same index for the period 1982-2004 to assess the effect of progressivity on growth. In 2005 the OECD broadened the definition of the APW leading to an upward shift of the level of the MTR, hence of the index, for the years 2005-2009.[7] Therefore, compared to Arnold (2008), we extend the index as follows: We

[5] We are thankful to Jens Arnold and Chris Heady for sharing the data with us.
[6] See OECD (2003a) for a discussion of the concept of the APW.
[7] For details on the broadening of the definition of the APW, see OECD (2003b).

derive the growth rates of the index based on the new APW definition for the years 2005-2009 and apply them to the index based on the old APW definition in the year 2004 in order to generate updated values of the index until 2009.

With regard to the dependent variable, our main measure of output volatility is the standard deviation of log changes of real GDP (*Vola1*), in line with the existing literature (see Fatás and Mihov, 2001, Carmignani et al. 2011, forthcoming). The first set of control variables includes measures related to the openness of the economy. Openness (*Open*) is measured as the ratio of exports plus imports to GDP. To further control for the output volatility associated to open economies we use the standard deviation of log changes in purchasing power parity (*PPP*) and the share of employment in industry as percent of total employment (*Industry*). The second set of control variables includes measures of the size of the general government commonly used in the literature (see, for example, Fatás and Mihov, 2001, Silgoner et al., 2011) such as total government expenditures (*Expend*) and total tax revenues (*RevTot*), both as a ratio to GDP. Following Posch (2011, forthcoming), to measure the development of the financial sector we use the ratio of domestic credit to the private sector relative to GDP (*Credit*). In line with Fatás and Mihov (2001), we control for larger and richer economies using as additional explanatory variables total real GDP adjusted for PPP (*GDP*), real GDP per capita adjusted for PPP (*GDPpc*), and the growth rate of real GDP (*Growth*).

3.2 Basic statistics

Table 1 provides summary statistics on the index of PIT progressivity and on real GDP growth. Progressivity is the lowest in the US, where the index mean equals 0.05, and is the highest in Belgium and the Netherlands, where it equals 0.30 and 0.35, respectively. The large European economies, i.e. Italy, Germany, and France, rank approximately in the middle with a mean comprised between 0.13 and 0.17. Most emerging market and transition economies display lower progressivity (see, for example, Korea, Turkey, or Slovakia). These cross-sectional country rankings are broadly in line with previous studies on income tax progressivity based on alternative measures (see Bishop et al., 1998, and Piketty and Saez, 2006). In all countries the index varies over time, as shown by the respective standard deviations. This variation can either be the result of legislated changes in the tax schedule or of changes in income.[8] Turning to the standard deviations of real GDP growth, the table shows that high income European economies tend to have smaller business cycle fluctuations while all emerging market economies

[8] In several countries nominal tax schedules are not inflation indexed. As nominal income grows, the AWP moves up the income scale into higher tax brackets. This implies that the degree of progressivity, measured at the APW wage, tends to decline as in most countries progressivity declines when moving up the income scale. We do not view this effect as blurring our measure of tax progressivity, but conversely as being a possible driving force of changes in progressivity which we want to be captured by the index.

Table 1: Summary statistics by country, 1982-2009.

	Index of Progressivity					Growth rate real GDP				
	Obs	Mean	Sd	Min	Max	Obs	Mean	Sd	Min	Max
AUS	28	0.155	0.079	0.07	0.31	28	3.115	1.771	-2.33	5.16
AUT	28	0.254	0.011	0.23	0.28	28	2.128	1.544	-3.69	4.04
BEL	28	0.296	0.015	0.25	0.32	28	1.913	1.572	-3.14	4.58
CAN	28	0.182	0.066	0.07	0.39	28	2.453	2.278	-2.90	5.65
CHE	25	0.129	0.009	0.12	0.15	28	1.592	1.658	-1.47	4.45
CZE	17	0.102	0.015	0.06	0.12	19	1.659	4.422	-12.35	6.58
DEU	28	0.173	0.028	0.13	0.22	28	2.001	2.852	-5.11	13.04
DNK	28	0.224	0.036	0.14	0.29	28	1.873	2.077	-5.01	5.38
ESP	25	0.142	0.031	0.11	0.25	28	2.761	1.927	-3.70	5.40
FIN	28	0.215	0.013	0.20	0.25	28	2.299	3.324	-8.11	6.01
FRA	28	0.160	0.077	0.05	0.29	28	1.904	1.400	-2.28	4.49
GBR	28	0.080	0.009	0.07	0.10	28	2.370	1.985	-5.04	4.90
GRC	15	0.167	0.061	0.12	0.29	28	2.156	2.218	-2.28	5.75
HUN	16	0.165	0.043	0.09	0.23	18	2.279	3.014	-6.53	5.07
IRL	28	0.251	0.095	0.10	0.35	28	4.561	3.920	-7.35	10.84
ISL	20	0.213	0.046	0.15	0.27	28	2.626	3.434	-6.72	8.20
ITA	28	0.131	0.035	0.09	0.20	28	1.432	1.831	-5.17	4.11
JPN	27	0.083	0.014	0.06	0.11	28	2.045	2.566	-5.34	6.90
KOR	14	0.085	0.046	0.04	0.15	28	6.111	3.685	-7.10	10.53
LUX	28	0.224	0.019	0.19	0.27	28	4.449	3.026	-3.45	9.84
MEX	18	0.142	0.024	0.11	0.18	28	1.972	3.536	-6.71	6.55
NLD	28	0.346	0.096	0.22	0.47	28	2.358	1.849	-4.06	4.58
NOR	27	0.129	0.083	0.03	0.27	28	2.710	1.749	-1.54	5.73
NZL	27	0.085	0.065	0.00	0.18	28	2.329	2.166	-1.59	6.24
POL	16	0.102	0.046	0.03	0.14	19	3.762	3.194	-7.29	6.84
PRT	26	0.078	0.027	0.00	0.10	28	2.426	2.476	-2.69	7.64
SVK	12	0.108	0.031	0.06	0.15	17	4.628	3.351	-4.67	10.19
SWE	25	0.126	0.093	0.03	0.31	28	1.993	2.230	-4.98	4.49
TUR	26	0.089	0.046	0.02	0.22	28	3.985	4.434	-5.87	9.06
USA	28	0.050	0.023	0.03	0.11	28	2.771	2.006	-2.47	6.95
Total	728	0.160	0.089	0.00	0.47	801	2.667	2.831	-12.35	13.04

Source: Author's own calculations, based on OECD and AMECO.

are at the upper end of the range. The pure cross-sectional correlation between the progressivity index and the standard deviation of output growth is –0.19.

Figure 1 plots the mean of the progressivity index across countries over the sample period. As shown in the figure, our index captures well the decline in progressivity which, starting in the early 1980s, took place in many OECD countries. Such decline was associated to a shift of the tax policy paradigm away from the Keynesian welfare state towards efficiency considerations, which were mainly implemented via a cut in the top marginal tax rate and a broadening of the tax base (see Swank and Steinmo, 2002, or Johansson et al., 2008).[9]

[9]The large fluctuations in the index mean until the mid 1990s mirror the changing composition of

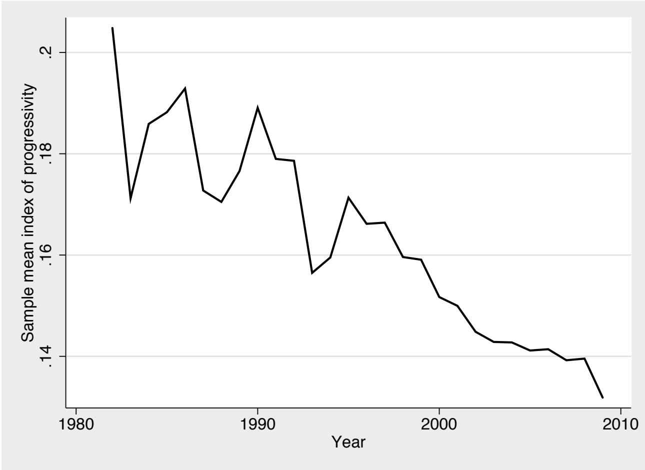

Figure 1: Mean of progressivity index across countries over sample period 1982-2009.

To exploit both the cross-sectional and time-series information contained in the data, in most of the empirical analysis we split the sample into four fixed-window subperiods of seven years and compute means and standard deviations over these. We choose this time span so as to strike an appropriate balance between the need to have a sufficient number of observations to increase efficiency of the coefficient estimates and the need to eliminate purely cyclical effects. Finally, this also allows generating time intervals of equal length. Table 2 shows the correlation between key variables used in the empirical analysis over the subperiods under consideration. Several facts

Table 2: Table of correlation.

	Vola1	Prog	Expend	RevTot	Open	PPP	Credit
Vola1	1.00						
Prog	-0.22	1.00					
Expend	-0.17	0.29	1.00				
RevTot	-0.13	0.27	0.48	1.00			
Open	0.16	0.43	0.13	0.12	1.00		
PPP	0.19	-0.13	-0.27	-0.20	-0.02	1.00	
Credit	-0.08	-0.19	-0.14	-0.04	-0.05	0.00	1.00

Max./Min. number of pairwise observations: 111/92.

stand out. First, progressivity is negatively correlated with output volatility at –0.22. Second, this correlation is stronger than the correlation with those variables usually

the unbalanced panel. After 1996, where data on 29 countries are available, the series is much smoother.

thought as having an impact on output volatility such as the GDP ratios of government expenditures (–0.17), total tax revenues (–0.13), credit (–0.08), and openness (0.16). Third, the index is positively correlated to measures of government size, but far from being identical to those.

To provide a graphical illustration of the relationship between progressivity and output volatility, Figure 2 reports a scatter plot and the predicted values from a pooled OLS regression of output volatility on a constant and the index, based on the fixed-windows of seven years. The figure shows a negative relationship between PIT progressivity and output volatility. The coefficient on progressivity is –3.2 and it is statistically significant at the 5% level.

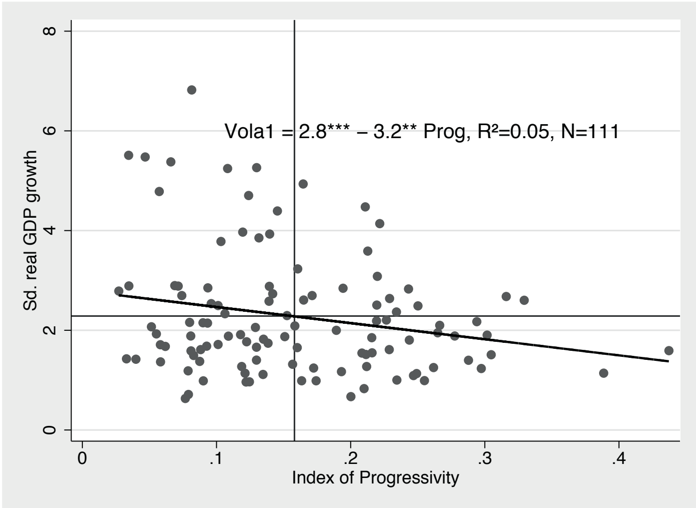

Figure 2: Output volatility and personal income tax progressivity (1982-2009).

4 Empirical analysis

In this section, we empirically estimate the effect of PIT progressivity on output volatility based on our four 7-year fixed-window subperiods. Methodologically, we follow Fatás and Mihov (2001) and derive our main results from OLS and IV estimation. In order to take into account time-varying factors that may affect the business cycle across all countries, and which are not fully captured by our set of control variables, we introduce period fixed-effects. Our baseline empirical model is specified as follows:

$$Volatility_{i,t} = \beta_0 + \delta\, Progressivity_{i,t} + \sum_{t=2}^{4} \beta_t P_t + \sum_{j=5}^{J} \beta_j X_{i,t,j} + \varepsilon_{i,t},$$

where $i = 1, \ldots, 30$ (countries), and $t = 2, \ldots, 4$ (7-year fixed-windows). $Volatility$ is a measure of the volatility of output or its components, *Progressivity* is the index of PIT progressivity, P_t denote period fixed-effects, X_j's are control variables (see below), and $\varepsilon_{i,t}$ is the error term. Our main measure of output volatility is the standard deviation of log changes of real GDP over each period t.[10]

4.1 OLS estimates

The first step in our empirical analysis is to assess the effect of tax progressivity on output volatility by carefully controlling for other potential determinants of output volatility. All equations in Table 3 are estimated with ordinary least squares and the standard errors are adjusted for the presence of heteroskedasticity.[11] Indeed, according to macroeconomic theory, when the dependent variable is some measure of volatility, it is likely to be affected by the size of shocks hitting the economy.

We begin with our baseline model in column (1), including only period fixed-effects, the progressivity index, and two variables which control for the openness of the economy, namely: openness and the standard deviation of log changes of PPP so as to account for the hypothesis that more open economies tend to be more volatile (see Rodrik, 1998). The coefficient on *Prog* is significant at the 1% level and it has the expected negative sign. The coefficient on *Open* and *PPP* are both statistically significant at the 1% and 5% level, respectively, and have the expected positive sign. Column (1) confirms the negative and significant effect of progressivity on output volatility shown in Figure 2.

In column (2) we add the share of employment in industry as an additional measure of the output volatility associated to open economies. Unlike the services sector, the demand for products of the industrial sector is more likely to be affected by conditions in the world markets. However, the coefficient on *Industry* is insignificant. The coefficient on *Prog* remains basically unaffected.

In column (3) we include a measure of government size. Following Cottarelli and Fedelino (2010), we use the revenue-to-GDP ratio to control for the stabilising *level* effect of larger governments. While having the expected negative sign, the coefficient on *RevTot* is insignificant. When we drop *Prog* from model (3), the coefficient on *RevTot* remains insignificant. The coefficient on *Prog* drops in absolute value to –3.2 but remains significant at the 5% level. Since many studies use expenditure and revenue ratios interchangeably as measures of government size, we alternatively include the total expenditures-to-GDP ratio in column (4). The coefficient on progressivity drops further

[10] In Section 5, we check the robustness of our results to other measures of output volatility and take a closer look at the volatility of consumption, investment, and hours worked.

[11] All regressions includ period fixed-effects, not reported in the table, which are jointly statistically significant most models.

Table 3: Progressivity and output volatility: OLS, 1982-2009, fixed-windows of 7 years. *Dependent variable: Sd. log changes real GDP.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Prog	-4.43***	-4.45***	-3.20**	-2.84*	-3.51**	-3.52**	-3.48**	-3.63**	-3.48*
	(-2.88)	(-3.02)	(-2.34)	(-1.98)	(-2.01)	(-2.03)	(-2.00)	(-2.07)	(-1.92)
Open	0.79***	0.79***	0.81***	0.80***	0.81***	1.02***	0.69**	0.78*	0.71
	(3.47)	(3.97)	(3.84)	(4.02)	(3.63)	(3.21)	(2.00)	(1.93)	(1.65)
PPP	0.05**	0.05**	0.05**	0.06***	0.05**	0.05*	0.05*	0.05*	0.05
	(2.02)	(2.02)	(2.15)	(2.89)	(2.15)	(1.94)	(1.78)	(1.76)	(1.62)
Industry		-0.00	0.02	0.03	0.02	0.00	0.01	0.00	0.01
		(-0.07)	(0.63)	(1.46)	(0.58)	(0.04)	(0.20)	(0.09)	(0.23)
RevTot			-0.10		-0.05	-0.02	-0.35	-0.45	-0.41
			(-0.22)		(-0.11)	(-0.04)	(-0.79)	(-0.94)	(-0.89)
Expend				-0.93					
				(-1.45)					
Credit					-0.64	1.79	2.06	1.80	1.23
					(-0.23)	(0.50)	(0.59)	(0.50)	(0.35)
GDPpc						-0.23	-0.15	-0.17	-0.13
						(-1.16)	(-0.80)	(-0.81)	(-0.66)
GDP							-0.15	-0.15	-0.15
							(-1.49)	(-1.44)	(-1.47)
Growth								-0.08	-0.06
								(-0.60)	(-0.41)
Crisis									0.29
									(0.95)
Obs.	111	110	100	95	97	97	97	97	97
R^2	0.30	0.29	0.35	0.42	0.35	0.36	0.38	0.38	0.39

(1) Robust t-statistics in parentheses.
(2) ***,**,* indicate sigificance at the 1%, 5%, and 10% level, respectively.
(3) All models include period fixed-effects, not reported in the table.

in significance and (absolute) size but remains significant at the 10% level. Again, while having the expected negative sign, the coefficient on *Expend* is insignificant.

In column (5) we introduce the credit-to-GDP ratio as a measure of financial development, following Posch (2011, forthcoming). Enhanced access to the credit market allows the private sector to better smooth income fluctuations and might weaken the link between automatic stabilisers and output volatility. Therefore, omitting this factor could bias the coefficient on *Prog* towards zero. In line with this argument, the coefficient on *Prog* increases (in absolute value) to –3.5, although the coefficient on *Credit* itself is insignificant.

In columns (6)-(8), following Fatás and Mihov (2001), we introduce three general control variables, namely: GDP per capita, total GDP (both adjusted for PPP), and the growth rate of real GDP.[12] However, in these specifications neither of the three variables significantly explains output volatility. In all three cases, the coefficient on tax progressivity remains statistically significant at the 5% level and basically unchanged in size.

In column (9) we include a dummy variable controlling for crisis episodes, as identified by Laeven and Valencia (2010).[13] Since in times of crisis, output volatility tends to be overproportionally high relative to normal times, we seek to exclude the possibility that our results are driven by crisis outliers. For example, Korea, Turkey, and Mexico were all hit by severe crises during our sample period and are characterised by having PIT systems with relatively low degree of progressivity. However, while the coefficient on *Crisis* has the expected positive sign, it is insignificant. The coefficient on *Prog* drops in absolute size, but it remains significant at the 10% level.

Finally, we include three additional controls to the specification reported in column (8) one at a time, namely:[14] a dummy variable for euro area countries which is equal to 1 for the last subperiod and 0 before; the government budget balance as percent of GDP (or alternatively an interaction term of *Prog* with the latter); and an interaction term of *Prog* with a dummy variable which is equal to 1 if *RevTot* is above its sample mean and 0 otherwise. The reason for the inclusion of these controls is as follows. First, euro area countries tend to have more progressive PIT systems but are less exposed to exchange rate shocks, given their common currency. Second, a high budget deficit combined with high tax progressivity could destabilise the economy in a recession by raising concerns about the sustainability of public finances. Third, in the presence of nonlinearities, for countries with higher tax burdens the effectiveness of automatic stabilisers may be smaller, as shown by Martinez-Mongay and Sekkat (2005). However, neither of the additional control variables appears to be significant and our results are virtually unchanged.

Based on the results of Table 3, we conclude that higher PIT progressivity leads to reduced output volatility. Based on column (8) and keeping all other factors constant, an increase in the progressivity index by one standard deviation of 0.09 leads to a decrease in output volatility by 0.33 on average. This effect is statistically and economically significant. Consider for example the case of Switzerland which is the median country

[12] These variables are potentially correlated with government size (and/ or tax progressivity) and output volatility. According to Wagner's Law richer economies tend to have larger governments as the demand for public services increases with income. Moreover, richer economies might have more developed private and public institutions (not captured by our other control variables) which allow the private sector to smooth income fluctuations. In case of total GDP, larger internal markets tend to shield against the turbulences from world markets. Finally, higher economic growth is often associated with higher volatility while larger governments tend to reduce the growth performance of a country.

[13] The dummy equals 1 if in a given subperiod a country is experiencing an economic crisis, and 0 otherwise. We identify 28 crisis episodes in our sample.

[14] The results, not reported in the table, are available from the authors upon request.

in 2000 with an index value of $1 - \frac{100-MTR}{100-ATR} = 1 - \frac{100-22.2}{100-10.6} = 0.13$. An increase in the index by 0.09 could either be the result of an increase in the MTR from 22.2% to 30.3% or, rather unlikely, the result of a drop in the ATR from 10.6% to 0.5%. Such an increase in PIT progressivity would imply a reduction in Switzerland's mean output volatility from 1.7 to 1.4, i.e. by 18%.

4.2 IV estimates

In this subsection we address potential endogeneity problems. As pointed out by Rodrik (1998), if more open economies face higher output volatility their residents might choose to have larger governments, creating a potential problem of endogeneity of government size to output volatility. Then, the coefficient estimates of models (1)-(9) in Table 3 would be biased. In addition to government size, this argument potentially applies to all right hand side variables which can be influenced at a national level.

Using IV estimation, previous studies focused on correcting the endogeneity of government size and of the credit-to-GDP ratio. The evidence on the endogeneity of these two variables is mixed. While Fatás and Mihov (2001) point out the importance of correcting the endogeneity of government size, Martinez-Mongay and Sekkat (2005) and Debrun et al. (2008) do not find notable differences between OLS and IV estimates. In case of financial development, Debrun and Kapoor (2010) cannot reject the exogeneity of the credit-to-GDP ratio.

With regard to tax progressivity, in our view, endogeneity is less of a concern than in case of government size and of the credit ratio. The degree of progressivity of the PIT system largely reflects societal preferences on equity and redistribution. It is rather determined by philosophical and political views on the role of the state, or by efficiency considerations, but it is typically unrelated to stabilisation goals.[15] Nevertheless, since endogeneity in case of government size or of the credit ratio can also bias estimates of the coefficient on progressivity and since we cannot completely exclude, based on purely theoretical arguments, the possibility of endogeneity of progressivity itself, we resort to IV estimation.

We select instruments capturing institutional and structural characteristics of a country likely to be correlated with the explanatory variables but orthogonal to output volatility itself. We pay special attention in our choice of instruments to the issue of weak identification. Therefore, we choose a parsimonious combination of instruments that yields a F-statistic for the instruments in the first stage regression larger than (or close to) 10 across all considered specifications. Our approach is to instrument the potentially endogenous variables, i.e. the progressivity index, the revenue or alternatively

[15] We are not aware of any public debate, now or in the past, which links PIT progressivity to stabilisation goals.

the expenditure ratio, and financial development, one at a time. Instrumenting more than one variable at a time did not yield meaningful results. In line with the literature (see, among others, Fatás and Mihov, 2001; Martinez-Mongay and Sekkat, 2005; Debrun and Kapoor, 2010), we use the following four instruments for tax progressivity and the revenue and expenditure ratios: a dummy indicating the type of political system (presidential vs. parliamentary), an index of checks and balances of the executive authority, the rate of urbanization, and a dummy identifying Anglo-American countries. As instruments for *Credit* we use the share of employment in agriculture and the investment share in GDP.[16] Table 4 presents seven models based on IV estimation. The baseline specification used for the IV estimation is model (1) of Table 3. In columns (1)-(4) we instrument the progressivity index while in column (5)-(7) we instrument the revenue-, the expenditure-, and the credit-to-GDP ratio, respectively.

In column (1) we re-estimate our baseline model. In line with the argument outlined above, the coefficient on progressivity increases (in absolute value) from –4.4 in column (1) of Table 3 to –5.4. Moreover, it remains significant at the 5% level. The bottom of the table reports several statistics assessing the performance of the instrumental variables. To check for the possibility of weak identification, we report the first-stage F-statistic.[17] Since the value of this statistic is 11.1, the estimation does not seem to suffer from a weak instruments problem. The next line reports the p-value from the Wu-Hausman test for weak exogeneity of the instrumented variable. In line with our argument on the unlikely endogeneity of tax progressivity, the large p-value indicates the consistency of the OLS estimator. The last row in the table reports the p-value of Wooldridge's robust score test of overidentification, with a p-value of 0.17, we do not reject the validity of our instruments.

A similar picture emerges in columns (2)-(4) where we introduce as selected additional controls real GDP per capita, total real GDP, and the growth rate of real GDP, respectively. The coefficient on progressivity drops slightly in absolute size and its significance level drops to 10%. The coefficient on *GDPpc* is now significant and has the expected negative sign. The F-statistics from the first-stage regressions and the p-values of the score tests indicate that the estimations do not suffer from a weak instruments problem or from overidentification. Most importantly, the Wu-Hausman test again indicates the consistency of the OLS estimator.

In column (5) we instrument the revenue-to-GDP ratio, using the same set of in-

[16] The correlation of the two variables with *Credit* is –0.49 and 0.20, respectively. While the agricultural sector is less dependent on credit supply by the financial sector than the industrial sector, a higher investment share is usually associated with higher credit needs.

[17] The F-statistic tests the hypothesis that the coefficients on the instruments in the first-stage regression are zero. As a rule of thumb, weak instruments are less of a concern when the F-statistic is larger than 10.

Table 4: Progressivity and output volatility: Instrumental variables estimation, 1982-2009, fixed-windows of 7-years. *Dependent variable: Sd. log changes real GDP.*

	Progressivity instrumented				RevTot/Expend/Credit instr.		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Prog	-5.38**	-4.14*	-4.12*	-4.56*	-2.85*	-3.67**	-5.74***
	(-2.18)	(-1.83)	(-1.83)	(-1.91)	(-1.92)	(-2.17)	(-3.10)
Open	0.87***	1.03***	0.85**	0.93**	0.91***	0.97***	0.46
	(3.34)	(3.82)	(2.54)	(2.27)	(3.41)	(3.89)	(1.06)
PPP	0.05**	0.04	0.04	0.04	0.05*	0.06***	0.05**
	(2.05)	(1.53)	(1.52)	(1.50)	(1.83)	(2.91)	(2.30)
GDPpc		-0.37***	-0.35**	-0.36**	-0.11	-0.20	0.26
		(-2.67)	(-2.41)	(-2.42)	(-0.89)	(-1.54)	(0.79)
GDP			-0.08	-0.08			
			(-0.95)	(-0.95)			
Growth				-0.04			
				(-0.36)			
RevTot					-1.07		
					(-1.33)		
Expend						-0.25	
						(-0.23)	
Credit							-16.13*
							(-1.96)
Obs.	111	111	111	111	101	96	107
R^2	0.30	0.35	0.36	0.36	0.32	0.42	0.20
Weak ident. F-stat.	11.13	10.97	10.34	9.11	10.14	9.72	11.42
Wu-Hausm. p-value	0.724	0.987	0.965	0.930	0.209	0.604	0.027
Overid. p-value	0.173	0.528	0.336	0.325	0.717	0.681	0.073

(1) Robust t-statistics in parentheses.
(2) ***,**,* indicate sigificance at the 1%, 5%, and 10% level, respectively.
(3) All models include period fixed-effects, not reported in the table.

struments, and keep *GDPpc*. The coefficient on the revenue ratio is insignificant. The coefficient on progressivity drops further in absolute size to –2.9 but remains significant. Alternatively, we use the expenditure ratio, which we instrument, to measure government size in column (6). The coefficient on *Prog* regains significance at the 5% level and its absolute size increases.[18] In both cases the Wu-Hausman test does not reject the exogeneity of government size.

Finally, in column (7) we instrument *Credit*. The coefficient on *Credit* is negative

[18] We obtain similar results when using alternative measures of government size such as the ratios of direct and indirect taxes, respectively, to GDP and the share of government consumption in GDP. Except for the case of government consumption, they are never statistically significant. In all cases the Wu-Hausman test does not reject the efficiency of the OLS estimator.

and statistically significant at the 10% level. Moreover, the Wu-Hausman test rejects the exogeneity of *Credit* at the 5% level. The coefficient on progressivity regains significance at the 1% level and is similar in size to column (1).

We conclude that, when using the IV estimator, tax progressivity has a statistically significant negative effect on output volatility. However, as we do not find evidence of endogeneity of tax progressivity we refer to the more efficient OLS estimates in the previous subsection as our preferred estimates of the effect of tax progressivity on output volatility.[19]

5 Other robustness tests

In this section we assess first the effect of tax progressivity on alternative measures of output volatility and on the volatility of its components. Second, we address some methodological aspects of the empirical model. Finally, we present results based on alternative lengths of our fixed-window subperiods, as well as for the subsample 1982-2004, so as to check whether our results are sensitive to the extension of the progressivity index from 2005 to 2009.

5.1 Alternative measures of volatility

In this subsection we analyse the sensitivity of our results to alternative definitions of the dependent variable. Moreover, we assess the effect of tax progressivity on the volatility of consumption, investment, and hours worked. Table 5 presents the OLS estimates of our baseline model (1) presented in Table 3 for different measures of the dependent variable and augmented by GDP per capita and the revenue ratio to control for the level of development and government size, respectively.

To establish the benchmark, the dependent variable in column (1) is our basic measure of output volatility, i.e. the standard deviation of log changes of real GDP. In column (2) the dependent variable is the standard deviation of the output gap measured as deviations of (log) GDP from its linear trend. Given the estimated autocorrelation of (log) GDP of nearly one, column (1) and (2) are virtually identical. A quadratic or cubic trend yields similar results. In column (3) we use the standard deviation of the output gap obtained from the HP-filtered (log) GDP series as the dependent variable. The coefficient on progressivity drops (in absolute value) from –3.5 to –1.9, but it remains significant at the 5% level. The HP-filter removes a larger part of the high

[19] We run a battery of IV regressions (available from the authors upon request) with different instruments and controls. The coefficient on progressivity is always negative, albeit sometime insignificant. However, and more importantly, the Wu-Hausman test never rejects the consistency of the OLS estimates.

Table 5: Alternative measures of volatility: OLS, 1982-2009, fixed-windows of 7-years.

	Dependent variable: Volatility of ...						
	(1) GDP	(2) GDPlin	(3) GDPhp	(4) GDPpc	(5) Cons	(6) Inv	(7) Hours
Prog	-3.51**	-3.54**	-1.86**	-3.45**	-4.35*	-12.32**	0.57
	(-2.32)	(-2.35)	(-2.14)	(-2.44)	(-1.66)	(-2.47)	(0.80)
Open	0.94***	1.01***	0.61***	0.98***	1.30**	2.18*	0.46**
	(3.37)	(3.66)	(3.24)	(3.89)	(2.28)	(1.85)	(2.44)
PPP	0.05**	0.05**	0.03*	0.05*	0.15***	0.10	0.02
	(2.03)	(2.10)	(1.72)	(1.88)	(7.83)	(1.40)	(1.56)
GDPpc	-0.17	-0.20	-0.11	-0.20	-0.39*	-0.13	-0.08
	(-1.28)	(-1.55)	(-1.33)	(-1.62)	(-1.80)	(-0.26)	(-0.81)
RevTot	-0.08	0.00	-0.10	-0.05	0.67	1.90	-0.36*
	(-0.22)	(0.01)	(-0.39)	(-0.13)	(0.96)	(0.85)	(-1.70)
Obs.	101	101	101	101	99	101	96
R^2	0.36	0.40	0.38	0.36	0.28	0.12	0.25

(1) Robust t-statistics in parentheses.
(2) ***,**,* indicate sigificance at the 1%, 5%, and 10% level, respectively.
(3) All models include period fixed-effects, not reported in the table.

frequency movements from the output series, resulting in smaller output gaps and hence smaller variation in the dependent variable that needs to be explained by variation in the explanatory variables. In column (4) we use the standard deviation of log changes of GDP per capita as the dependent variable. Since population growth is modest in most OECD countries, the results are similar to column (1).

In columns (5)-(7) we take a closer look at how tax progressivity affects the volatility of consumption, investment, and hours worked. The correlation of each variable with the progressivity index is –0.15, –0.18, and 0.14, respectively. In column (5) the dependent variable is the standard deviation of log changes of real private consumption. This measure is closely related to traditional metrics of welfare costs of business cycle fluctuations used in theoretical models. The coefficient on progressivity has the hypothesized negative sign, it is larger (in absolute value) than in case of output volatility, and it is significant at the 10% level. However, the R^2 declines relative to the models where output volatility is the dependent variable. In the case of investment volatility in column (6), measured as the standard deviation of log changes of real investment, the coefficient on progressivity has again the expected negative sign (see also Section 2.1), it increases (in absolute value) to –12.3, and it is statistically significant at the 5% level. However, the R^2 drops even further. Finally, in column (7) the dependent variable is the standard deviation of (linearly detrended) hours worked. While the coefficient on progressivity has the expected positive sign (see Section 2.1), it is insignificant.

In sum, Table 5 shows that the output stabilising effects of PIT progressivity is robust to alternative measures of output volatility. In addition, the results indicate a negative impact of tax progressivity on the volatility of consumption and investment. Finally, it is worth noting that, except for the volatility of hours worked, the revenue ratio does not seem to be a significant determinant of volatility in our sample.

5.2 Methodological aspects: fixed- and random-effects

In this subsection we assess the robustness of our results to the use of fixed-effects (FE) estimation. This helps us to control for unobserved, time-constant institutional factors or other 'deeper' characteristics of a country that we do not capture by our explanatory variables. We also report random-effects (RE) estimates.

Again, we resort to our benchmark model (1) of Table 3 augmented by GDP per capita and the revenue ratio, which is replicated in column (1) of Table 6 for convenience. Using the RE estimator, column (2) estimates the same specification while column (3) uses the expenditure instead of the revenue ratio. Comparing columns (1) to columns (2) and (3), respectively, shows that the results from the OLS and RE estimators are virtually identical. The coefficient on progressivity increases (in absolute value) from –3.5 to –3.6 and it remains statistically significant at the 5% level.

Columns (4)-(7) report results using the FE estimator. In column (4), the coefficient on progressivity increases even further (in absolute value) to –5.1 but its significance drops to the 10% level. The coefficient size is similar to the IV estimate of –5.4 reported in column (1) of Table 4. Controlling for unobservable country specific factors attenuates the potential bias from endogeneity of right hand side-variables and thus attributes a larger stabilising role to tax progressivity. However, the Hausman test based on columns (2) and (4) yields a p-value of 0.68, not rejecting the appropriateness of the RE estimator which in that case is more efficient. Nevertheless, we present several sensitivity checks based on the FE estimator in columns (5)-(7) where we include other controls into the specification of column (4). We again use the expenditure instead of the revenue ratio and we include the credit ratio and total real GDP. In all columns the coefficient on progressivity remains significant (at least at the 10% level) and similar in size.

5.3 Alternative fixed-windows and subsample estimates

In this subsection we assess the robustness of our results to splitting the sample into time intervals of different length, to the exclusion of the extended years of progressivity index, and to the exclusion of individual countries or groups of countries. Table 7 reports the results which are all based on OLS.

Table 6: Methodological aspects: RE and FE, 1982-2009, fixed-windows of 7-years. *Dependent variable: Sd. log changes real GDP.*

	OLS	RE		FE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Prog	-3.51**	-3.63**	-3.68**	-5.07*	-4.96*	-6.54**	-5.13*
	(-2.53)	(-2.50)	(-2.51)	(-1.85)	(-1.76)	(-2.14)	(-1.85)
Open	0.94***	0.96***	1.02***	1.65	0.65	2.47**	1.66
	(3.53)	(3.36)	(3.51)	(1.46)	(0.55)	(2.14)	(1.46)
PPP	0.05***	0.05***	0.05***	0.10**	-0.09	0.10***	0.10**
	(2.69)	(2.70)	(2.66)	(2.56)	(-1.10)	(2.73)	(2.42)
GDPpc	-0.17	-0.16	-0.20	-0.02	0.29	-0.44	0.12
	(-1.26)	(-1.14)	(-1.48)	(-0.05)	(0.68)	(-0.98)	(0.22)
RevTot	-0.08	-0.10		-0.11		0.20	-0.32
	(-0.18)	(-0.21)		(-0.06)		(0.11)	(-0.17)
Expend			-0.85		-1.14		
			(-1.39)		(-0.71)		
Credit						10.25**	
						(2.01)	
GDP							-0.78
							(-0.42)
Obs.	101	101	96	101	96	98	101
R^2 overall	0.36	0.36	0.42				
R^2 within				0.38	0.42	0.44	0.38

(1) Model (1) uses OLS, (2) and (3) random-effects, (4)-(7) fixed-effects.
(2) ***,**,* indicate sigificance at the 1%, 5%, and 10% level, respectively.
(3) All models include period fixed-effects, not reported in the table.

In columns (1)-(3) the sample is split into two fixed-windows of 14 years each. Column (1) reports results from our benchmark model (1) of Table 3 which we augment with *GDPpc* and *RevTot* in columns (2) and (3), respectively (a time dummy is insignificant). While in columns (1) and (2) the coefficient on *Prog* is statistically significant and similar in size to our benchmark estimates based on fixed-windows of seven years, in column (3) it turns insignificant. With the reduced number of observations it is not possible to distinguish the level effects of higher revenue ratios from higher tax progressivity.[20]

In columns (4)-(6) the sample is split into three fixed-windows of 9, 9, and 10 years, respectively. We estimate the same three models as in columns (1)-(3), augmented by (statistically significant) time dummies. Now, the coefficient on *Prog* is significant at

[20] For the fixed-windows of 14 years, the correlation between *RevTot* and *Prog* is 0.28, similar to the benchmark fixed-windows of seven years where it is 0.27.

Table 7: Alternative fixed-windows and subsample estimates, OLS. *Dependent variable: Sd. log changes real GDP.*

	2 fixed-windows			3 fixed-windows			3 f.-w., no update		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Prog	-4.57**	-4.72**	-3.98	-3.24**	-2.91**	-2.32*	-3.89**	-3.54**	-2.85*
	(-2.07)	(-2.14)	(-1.63)	(-2.33)	(-2.23)	(-1.79)	(-2.36)	(-2.28)	(-1.75)
Open	0.80**	1.18***	1.12**	0.77***	1.08***	1.01***	0.76***	1.09***	0.97***
	(2.49)	(2.82)	(2.62)	(3.33)	(4.14)	(4.15)	(2.70)	(3.18)	(2.74)
PPP	0.03***	0.02**	0.03***	0.03***	0.03***	0.03***	-0.01	-0.01	-0.01
	(3.53)	(2.44)	(2.91)	(5.47)	(3.84)	(4.72)	(-0.47)	(-1.24)	(-0.72)
GDPpc		-0.39**	-0.28		-0.48***	-0.33***		-0.53***	-0.38**
		(-2.14)	(-1.39)		(-3.36)	(-2.75)		(-3.18)	(-2.32)
RevTot			-0.13			0.04			-0.15
			(-0.31)			(0.11)			(-0.38)
Obs.	59	59	57	83	83	77	82	82	74
R^2	0.14	0.23	0.21	0.23	0.35	0.33	0.17	0.29	0.24

(1) Fixed-windows in models (1)-(3): 1982-1995, 1996-2009; Fixed-windows in models (4)-(6): 1982-1990, 1991-1999, 2000-2009; Models (7)-(9) exclude years where progressivity index was updated (2005-2009), fixed-windows: 1982-1990, 1991-1998, 1999-2004.
(2) ***,**,* indicate sigificance at the 1%, 5%, 10% level, respectively.
(3) Models (4)-(9) include period fixed-effects, not reported.
(4) Robust t-statistics in parentheses.

least at the 10% level in all three columns, albeit dropping in (absolute) size. Finally, in columns (7)-(9) we exclude the years 2005-2009 where we updated the progressivity index. The sample is split into fixed-windows of 8, 8, and 7 years, respectively. The results are similar to columns (4)-(6).

Returning to our benchmark fixed-windows of seven years, we next assess whether our results are unduly influenced by an individual country or groups of countries.[21] We use our benchmark model (1) of Table 3 which we augment with *GDPpc* and *RevTot*. First, we exclude one country at a time. The coefficient on *Prog* remains statistically significant (at least at the 10% level) and similar in size for all countries. Then, we exclude, one group at a time, Scandinavian, Anglo-American, oil producing, Euro member, and EU accessing countries.[22] Again, the coefficient on *Prog* remains significant (now at least at the 5% level) and similar in size in all cases.

[21] The results, not reported in the table, are available from the authors upon request.
[22] We classify Canada, Great Britain, and Norway as oil producers. The only two EU accessing countries in our sample are Island and Turkey.

6 Conclusions

The recent financial and economic crisis has revived the discussion on the role that governments may play in smoothing out business cycle fluctuations. While the stabilising role of government size has been widely discussed in the empirical literature, a largely absent piece is the role of tax progressivity. In this paper we investigate the effect of personal income tax progressivity on output volatility using data from a sample of OECD countries over the period 1982-2009. We find supportive evidence for the hypothesis that higher tax progressivity leads to lower output volatility. The empirical results of our paper allow us to conclude that, ceteris paribus, countries with more progressive income tax systems seem to have stronger automatic stabilisers, which can be used as a first line of defence in times of economic downturn.

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7 Appendix: Data and sources

Table 8: Data description and sources.

Variable	Description	Source
Expend	Total expenditure excluding interest	AMECO
Growth	Growth rate of GDP at constant market prices	"
RevTot	Total revenue	"
Cons	Private final cons. expend., constant prices	"
Inv	Gross fixed capital form., tot. econ., const. prices	"
Hours	Average annual hours actually worked per worker	OECD
GDPpc	GDP per capita, adjusted for ppp	Penn World Table (6.3)
GDP	Total GDP, adjusted for ppp	"
PPP	National currency value of GDP divided by the real value of GDP in international dollars	"
Credit	Credit to private sector (% of GDP)	"
Industry	Employment in industry (% of total employment)	"
Agri	Employment in agriculture (% of total employment)	"
Urban	Urban population (% of total)	"
Depen	Age dependency ratio (% of working-age population)	"
System	Presidential vs. parliamentary	PI, World Bank
Checks	Checks and balances	"
Prog	Index of progressivity	own calculations (OECD)
Vola1	Standard deviation of GDP constant market prices	own calculations (AMECO)
Crisis	Dummy for crisis episodes	Laeven and Valencia (2010)