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Personal income tax progressivity and output volatility: Evidence from OECD countries

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Abstract. This paper investigates empirically the effect of personal income tax progressivity on output volatility using macro data from a sample of OECD countries over the period 1982–2009. Our measure of progressivity is based on the difference between the marginal and the average personal 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. This effect comes in addition to the stabilizing impact of government size and it is equally important in economic terms. All other factors constant, countries with more progressive personal income tax systems seem to benefit from stronger automatic stabilizers.

Résumé. *Progressivité de l'impôt sur le revenu personnel et volatilité de la production: résultats pour les pays de l'OCDE.* Ce texte étudie empiriquement l'effet de la progressivité de l'impôt sur le revenu personnel sur la volatilité de la production à l'aide de macro-données pour un échantillon de pays de l'OCDE au cours de la période 1982–2009. La mesure de progressivité adoptée est fondée sur la différence entre le taux marginal et le taux moyen d'imposition pour un travailleur moyen dans la production. Il y a un support empirique pour l'hypothèse qu'un taux d'imposition plus élevé entraîne une volatilité moindre de la production. Cet effet s'ajoute à l'effet de stabilisation de la taille du gouvernement et est tout aussi important en termes économiques. Toutes choses étant égales par ailleurs, les pays à forte progressivité de leur régime d'imposition des revenus personnels semblent bénéficier de stabilisateurs plus robustes.

JEL classification: E63, E32, H10

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1. Introduction

The recent economic crisis has revived the discussion on the role of automatic stabilizers and their advantages in terms of being timely, targeted and temporary (see Taylor 2009 and van Riet, ed.). In the traditional Keynesian view, the size of automatic stabilizers depends on two main factors: the size of the government and the sensitivity of government budget items to the business cycle. The first factor works through a composition effect: a larger (stable) government sector stabilizes aggregate demand. Starting with the seminal contributions of Galí (1994) and Fatás and Mihov (2001), a long strand of literature uses cross-country macro data to empirically assess this channel, that is, the relationship between government size and output fluctuations (see Debrun et al. 2008, Debrun and Kapoor 2010, Silgoner et al. 2011 and Carmignani et al. 2011).

The second factor, which comes as a separate, additional element to the size of automatic stabilizers, works through the procyclicality of taxes payable and the countercyclicality or acyclicality of transfers receivable by the private sector: this smooths private disposable income.¹ The main feature underlying the idea of procyclical tax revenues is the progressivity of the tax system. Under a progressive scheme tax liabilities decrease more than proportionally when taxable income falls (and vice versa in upturns). However, while some empirical studies using macro data focus on the sensitivity of revenues or expenditures to the business cycle (see Girouard and André 2005 and Darby and Mélitz 2008), the direct relationship between tax progressivity and output volatility is a largely absent piece in the literature using macro data.² This gap results mainly from a lack of a coherent and comparable measure of progressivity for a sufficiently large number of countries and years to facilitate the use of regression analysis. In this paper, we employ an index of personal income tax progressivity, which is available for 30 OECD countries over the period 1982–2009, to address this relationship empirically. We present support for the hypothesis that higher personal income tax progressivity reduces output volatility, for a given size of government. Both channels of automatic stabilizers seem equally important in terms of smoothing output fluctuations.

We focus on personal income taxes (PIT) for several reasons (besides data availability). First, they are more progressive than most other tax items (see van den Noord 2000, Girouard and André 2005 and Baunsgaard and Symansky 2009). In this respect, they also play a crucial role for income and spending decisions of liquidity-constrained households, which are less able to smooth consumption over time. Second, income taxes payable by individuals are generally more important in terms of budgetary revenues than income taxes payable by corporations.

1 For only the special case of a proportional response of total revenues and no response of expenditures to the business cycle, the only relevant factor for the size of automatic stabilizers is government size.

2 Another strand of literature uses microdata and microsimulation models for individual countries to investigate the size of automatic stabilizers (see, among others, Auerbach and Feenberg 2000, Brunila et al. 2003 and Dolls et al. 2012).

Third, corporate taxes are generally not found to act as significant automatic stabilizers (see Devereux and Fuest 2009 and Buettner and Fuest 2010).³ Finally, given the ongoing debate over the merits of flat versus progressive PIT systems, which is mainly phrased in distributional terms, we analyze a less explored aspect of PIT progressivity, namely, its effect on output fluctuations. Our results indicate that, in addition to their intended goal of redistribution, progressive tax systems also contribute to the public goal of macroeconomic stabilization.

Our contribution to the literature is to present empirical evidence based on macro data for a negative effect of PIT progressivity on output volatility. It rests on three pillars. First, unlike most of the existing empirical studies using macro data, we employ a direct measure of PIT progressivity. It is based on the difference between the marginal and the average personal income tax rate for the average production worker. The measure captures variation in progressivity due to variation in both the tax schedule and income. Usually in previous cross-country empirical studies, only indirectly and remotely related measures to progressivity, such as tax ratios, are used (see Fatás and Mihov 2001). Moreover, those ratios are mostly included to measure the effect of government size. Second, we are able to assess both channels of automatic stabilizers jointly in a unified cross-country empirical framework. Finally, while much of the empirical literature focuses on correcting the endogenous nature of government size, endogeneity of progressivity seems less of a concern. The degree of progressivity of personal income tax systems 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 stabilization goals. This allows us to employ a measure that can be considered exogenous.

The structure of the paper is as follows. Section 2 lays out the conceptual framework, reviews the related literature and discusses potential determinants of output volatility. Section 3 presents the data and basic statistics. Section 4 contains the empirical analysis. We first present OLS estimates. Here, we pay particular attention to the risk of omitted variable bias. In particular, we account for heterogeneity in the composition of public revenues and expenditures, following Darby and Mélitz (2008). Then we investigate potential problems of endogeneity using instrumental variables (IV) techniques. Section 5 shows that our results are insensitive to several robustness checks. Section 6 concludes.

2. Theoretical considerations and related literature

In traditional Keynesian models automatic stabilizers reduce output fluctuations through two main channels: (i) a composition effect of a large and stable government sector on final demand and (ii) the automatic responses of revenues and government expenditures to the business cycle which smooth private disposable

³ In contrast, Posch (2011) finds that the average effective tax rate on corporate income does reduce output volatility.

income. One main factor that determines the size of the second channel is the degree of progressivity of the tax system. In a purely flat tax system, tax revenues move proportionally to changes in income. If one defines the neutral budget as one, where the GDP ratios of taxes and expenditures are constant over the cycle, then under such a tax system automatic stabilization mainly arises from the expenditure side. Only the expenditure ratio varies over the cycle, due to inertia in public spending, whereas the revenue ratio remains constant.⁴ On the contrary, under a progressive tax system, tax revenues react more than proportionally to output changes such that also the revenue side contributes to automatic stabilization. Hence, tax progressivity augments automatic stabilizers and is thereby expected to reduce output fluctuations.

Given the inherent difficulties in constructing coherent and comparable measures of progressivity for a sufficiently large number of countries and years, a long strand of research that employs macro data focuses on the first channel of automatic stabilizers (see below). More closely related to channel (ii), but using microsimulation models for individual countries, another strand of literature investigates the effectiveness of the tax and transfers system to shield households against income fluctuations (see Auerbach and Feenberg 2000, Brunila et al. 2003, Follette and Lutz 2010 and Dolls et al. 2012). In this paper, we address the second channel using macro data. We employ a measure of PIT progressivity that is available for 30 OECD countries from 1982 onwards. Our claim and the main motivation of this paper is that automatic stabilizers are stronger in countries with higher PIT progressivity, for a given size of the government.⁵ In the following, we first review the literature on automatic stabilizers before we turn to the literature on the measurement of tax progressivity.

In a seminal paper, Galí (1994) documents a negative correlation between output volatility and government size for a sample of OECD countries. He shows that a standard RBC model fails to account for this stylized fact. Subsequent theoretical contributions have tried to overcome this discrepancy by introducing Keynesian features. Andrés and Doménech (2006) show that in a model with rigidities distortionary taxes tend to reduce output volatility relative to lump-sum taxes. Andrés et al. (2008) show that introducing rule-of-thumb consumers into a New Keynesian model generates a negative relationship 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 progressive income

4 Alternatively, the neutral budget can be defined as one where the absolute levels of revenues and expenditures are constant over the business cycle such that changes in the level of tax revenues are viewed as automatically stabilizing (Veld et al. 2013).

5 Since PIT revenues represent only about one third of total government tax revenues, our progressivity index provides a partial view of the overall progressivity of the tax system. However, broader progressivity measures are, to our best knowledge, not available for a sufficiently large sample to use standard regression techniques. Moreover, in the econometric analysis we control for the share of PIT revenues in total revenues.

taxes lead to lower volatility of consumption, investment and output, while the effect on the volatility of hours worked is ambiguous.

Turning to the empirical literature, Rodrik (1998) points to the potential endogeneity of government size since residents of more open economies, which are more exposed to external risks, might choose to have larger governments to shield themselves against output fluctuations. Also focusing on the relationship between trade openness and output volatility, Haddad et al. (2013) find that the sign of this relation depends on the degree of export diversification of the economy. Addressing the endogeneity problem by using IV estimation, Fatás and Mihov (2001) show that the effect of government size on output volatility becomes stronger. On the other hand, Debrun et al. (2008) and Mohanty and Zampolli (2009) find that the stabilizing effect of government size has weakened since the 1980s but that it remains important when monetary policy and financial development (the latter allowing for self-insurance of the private sector) are controlled for. Debrun and Kapoor (2010) take into account the destabilizing role of larger governments, due to implementation failures of fiscal policy, which removes a bias towards zero in the estimates of the effects of government size. In contrast, Carmignani et al. (2011), using a system of simultaneous equations to address the endogeneity of government size, find that larger governments increase output fluctuations. Silgoner et al. (2011) provide evidence for nonlinear effects of government size on output volatility.⁶ Specifically looking at the composition of revenues and expenditures, Darby and Mélitz (2008) show that in particular social spending stabilizes the economy.

Regarding the measurement of tax progressivity, in a seminal study, Thin (1948) proposes four consistent measures of local tax progressivity, each quantifying progressivity at specific points in the personal income scale, and one measure of global tax progressivity, which takes into account the full distribution of personal income before and after taxes.⁷ As global measures require detailed microdata, which restricts their applications to one or very few countries and years (see Kakwani 1977 and Piketty and Saez 2007), they can not be used for our empirical strategy. With regard to local measures, the concept of residual progressivity is one standard, well defined and accepted metric to describe the progressivity of a country's tax schedule (see Liu 1986, Cowell 1995 and Seidl et al. 2013). It is defined as the elasticity of income after tax with respect to income before tax:

$$\frac{d[Y - t(Y)]}{dY} \frac{Y}{Y - t(Y)} = \frac{1 - MTR}{1 - ATR}, \quad (1)$$

6 These studies use mostly the ratio of total government expenditures to GDP as a measure of government size. For studies particularly focused on the effect of taxes on output volatility, see, for example, Martinez-Mongay and Sekkat (2005), Baungsaard and Symansky (2009) or Posch (2011).

7 Although there have been attempts, no general relation between local and global measures has been established (see Jakobsson 1976, Liu 1985 and Formby et al. 1986). For a discussion of the merits of local versus global measures, see Paturot et al. (2013).

where $t(Y)$ denotes tax liabilities expressed as a function of income Y and $MTR = t'(Y)$ and $ATR = t(Y)/Y$ are the marginal and average tax rate, respectively.⁸ A locally progressive tax scheme is characterized by a coefficient of less than one.

3. Data and basic statistics

In this section, we first describe the 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 OECD member countries except of Mexico and Turkey for which some basic variables are not available, that is, 28 countries, over the period 1982–2009 (see the appendix for a list of the data and their sources).⁹ Following Arnold (2008) and based on the concept of residual progressivity, the index of PIT progressivity is defined as follows:¹⁰

$$Progressivity = 1 - \frac{1 - MTR}{1 - ATR}, \quad (2)$$

where MTR and ATR are evaluated at the average production worker (APW) wage, full-time employee, not married and without children.¹¹ Compared to equation (1), we re-scale the index such that higher values imply higher progressivity in order to facilitate a straightforward interpretation of the empirical results. For a progressive tax system the index is bounded between zero and one. For $MTR \rightarrow 1$ (and $ATR \neq 1$) $\Rightarrow Progressivity \rightarrow 1$. For $ATR = MTR$ (that is, for purely flat tax systems without personal allowances) $\Rightarrow Progressivity = 0$.

Arnold (2008) uses the index based on OECD-constructed data for the period 1982–2004 to assess the effect of progressivity on growth. In 2005, the OECD broadened the definition of the APW, which shifted the MTR and ATR upwards.¹² Therefore, we extend the index to the years 2005–2009 by using the growth rate of the index based on the new APW definition.

Regarding the measurement of our dependent variable and our main control variables, we follow the existing literature (see Fatás and Mihov 2001, Debrun and Kapoor 2010 and Carmignani et al. 2011). Our main measure of output volatility (*Vola*) is the standard deviation of log changes of real GDP over fixed windows of seven years.¹³ As proxies for government size we use either the GDP ratio of total government expenditures (*Expenditures*) or of total revenues (*Revenues*). To

⁸ To obtain the expression on the RHS note that $\frac{d}{dY}[Y - t(Y)] = 1 - t'(Y)$.

⁹ However, the progressivity index is available for these two countries.

¹⁰ We are thankful to Jens Arnold and Chris Heady from the OECD for sharing the index with us.

¹¹ See OECD (2003a) for a discussion of the concept of the APW.

¹² For details on the broadening of the definition of the APW, see OECD (2003b).

¹³ In section 5, we check the robustness of our results to alternative definitions of the volatility of output and take a closer look at the volatility of its components.

measure the openness of the economy, we use the ratio of exports plus imports to GDP (*Openness*) and (log) total real GDP itself (*GDP*). The latter accounts for the size of internal markets. For financial sector development, we employ the ratio of domestic credit to the private sector to GDP (*Credit*). The quality of monetary policy (*QMP*) is measured as the exponential deviation of inflation from a 2% target, following IMF (2007) and Debrun et al. (2008). To control for the cyclical and discretionary behaviour of fiscal policy (*Cycl. FP* and *Discr. FP*, respectively), we construct two measures following the methodology of Debrun and Kapoor (2010).¹⁴

3.2. Basic statistics

First, we look only at the cross-section. Progressivity is the lowest in the US (0.05) and highest in Belgium (0.30) and Netherlands (0.35).¹⁵ The large European economies Italy, France and Germany rank in the middle with values between 0.13 and 0.17. Most emerging market and transition economies display lower progressivity. This country ranking is broadly in line with previous studies on income tax progressivity based on alternative measures (see Bishop et al. 1998 and Piketty and Saez 2007). We also compare our progressivity index to the elasticity of income taxes with respect to earnings, which is computed by the OECD to derive cyclically adjusted budget balances (see Girouard and André 2005).¹⁶ The correlation with our index is 0.28, which shows that the index accords with this alternative, though only indirect, measure of PIT progressivity. Turning to output volatility, high-income European economies tend to have the smallest business cycle fluctuations. Most emerging market economies are at the upper end of the range.

Next, we consider the time-series dimension. In all countries, the index varies over time. The variation reflects either legislated changes in the tax schedule or changes in income.¹⁷ Figure 1 plots the mean of the progressivity index across countries over the sample period. The index captures well the decline in progressivity which, starting in the early 1980s, took place in many OECD countries. Such decline was associated with a shift of the tax policy paradigm away from the Keynesian welfare state towards efficiency considerations, mainly implemented

14 To construct those indicators, we regress, for each country separately, the cyclically adjusted balance on a constant, its first lag and the output gap (using the HP filter). The estimated coefficient of the output gap is our measure of cyclical fiscal policy while the standard deviation of the residuals is our measure of discretionary fiscal policy.

15 For a full table of summary statistics by country on the index of PIT progressivity and on real GDP growth (volatility), see table 1 of the ECB working paper (no. 1380) version of this article.

16 Several recent papers point to shortcomings in that estimation method and to potentially higher tax elasticities (see Mertens and Ravn 2012).

17 In several countries, nominal tax schedules are not indexed to inflation. As nominal income grows the APW 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.

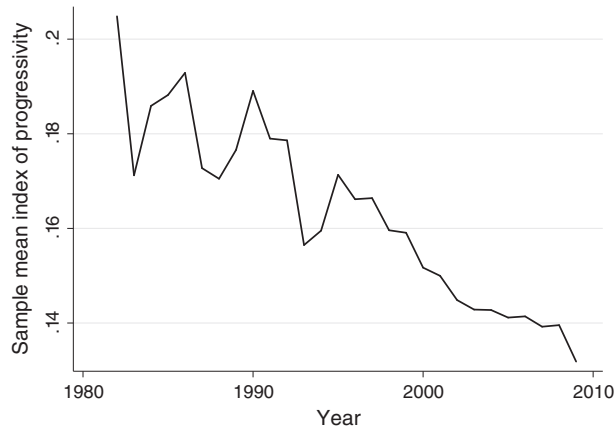


FIGURE 1 Mean progressivity index across countries over sample period 1982–2009

TABLE 1
Table of correlation

	Vola	Prog.	Openn.	Expend.	Reven.	Credit	QMP	Cycl. FP	Discr. FP
Vola	1.00								
Progressivity	−0.22	1.00							
Openness	0.15	0.43	1.00						
Expenditures	−0.10	0.26	0.14	1.00					
Revenues	−0.25	0.42	0.30	0.89	1.00				
Credit	−0.09	−0.19	−0.02	−0.12	0.07	1.00			
QMP	−0.40	0.23	0.19	0.06	0.41	0.51	1.00		
Cycl. FP	−0.13	−0.26	−0.24	0.01	0.05	0.10	0.06	1.00	
Discr. FP	0.20	−0.09	0.10	−0.03	0.00	0.24	−0.17	0.26	1.00

NOTE: Max./min. number of pairwise observations: 111/92.

via cuts in top marginal tax rates and broadening of the tax base (see Swank and Steinmo 2002 and Johansson et al. 2008).¹⁸

To exploit both the cross-sectional and time-series information contained in the data, in most of our empirical analysis, we split the sample into four sub-periods 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. Moreover, this allows generating time intervals of equal length.

Table 1 shows corresponding correlations. The correlations between output volatility and our main explanatory variables all have the expected signs. First and foremost, progressivity is negatively correlated with output volatility at -0.22 .

18 The large fluctuations in the index mean until the mid 1990s mirror the changing composition of the unbalanced panel. After 1996, where data on all countries are available, the series is much smoother.

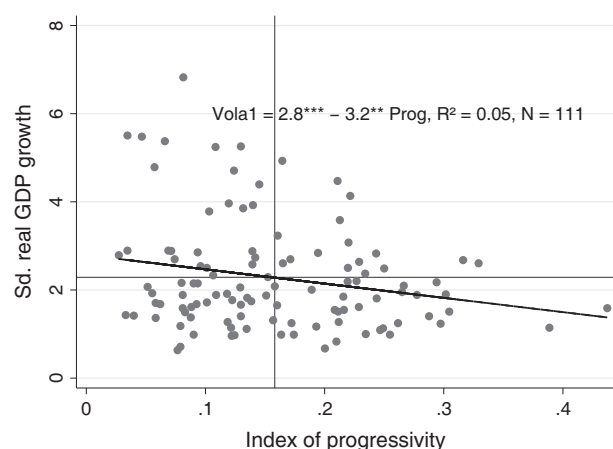


FIGURE 2 Output volatility and personal income tax progressivity (1982–2009)

Moreover, this correlation is stronger than the one of many of the variables usually thought as having an impact on output volatility such as expenditures (−0.10), credit (−0.09) as well as cyclical and discretionary fiscal policy (−0.13 and 0.20, respectively) and openness (0.15). Finally, the progressivity index is positively correlated to both measures of government size, but it is far from identical, thus potentially providing additional information on the size of automatic stabilizers.

Figure 2 provides a graphical illustration of the relationship between progressivity and output volatility. It contains a scatter plot and the predicted values from a pooled OLS regression of output volatility on a constant and the progressivity index. It 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.

4. Progressivity and output volatility: Empirical analysis

In this section, we estimate empirically the effect of PIT progressivity on output volatility, exploiting both the cross-section and time variation in the data. Methodologically, we follow Fatás and Mihov (2001), Debrun et al. (2008) and Debrun and Kapoor (2010), and we derive our main results from (pooled) OLS and IV estimation. 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:

$$Vola_{i,t} = \beta_0 + \sum_{t=2}^4 \beta_t P_t + \sum_{j=5}^J \beta_j X_{i,t,j} + \delta_1 Gov.size_{i,t} + \delta_2 Progressivity_{i,t} + \varepsilon_{i,t},$$

where $i = 1, \dots, 28$ (countries), $t = 2, \dots, 4$ (windows) and $j = 5, \dots, J$ (control variables). $Vola_{i,t}$ is a measure of the volatility of output or its components, *Progressivity* is the index of PIT progressivity, *Gov.size* measures the size of the government, P_t denotes period fixed effects, X_j 's are control variables and $\varepsilon_{i,t}$ is the error term. Throughout the empirical implementation, we adjust the standard errors for heteroskedasticity.¹⁹

4.1. Personal income tax progressivity and output volatility

The first step in our analysis is to assess the effect of PIT progressivity by carefully controlling for other potential determinants of output volatility that have been used in the literature. For this, we follow the main specification of Fatás and Mihov (2001), as extended by Debrun et al. (2008) and Debrun and Kapoor (2010). The results of table 2 are based on pooled OLS (columns (1) to (7)) and fixed effects estimation (columns (8) and (9)).

Column (1) contains our benchmark model. Here, output volatility depends on the progressivity of the PIT schedule, the openness of the economy, the size of the government—as proxied by the expenditure ratio, the quality of monetary policy-making, the depth of the financial system, two proxies used to capture the cyclical and discretionary aspects of fiscal policy and, finally, total GDP. The progressivity index is statistically significant and has the hypothesized negative sign. Concerning the other variables, both fiscal policy measures are statistically significant and have the expected signs. A systematic, cyclical response of fiscal policy to the business cycle over and above that of automatic stabilizers reduces output fluctuations while an unsystematic response has the opposite effect.²⁰ Finally, more open economies seem to be more volatile, while larger internal markets shield against the turbulences from world markets.

In columns (2) to (5), we augment the benchmark model by additional control variables, as in Fatás and Mihov (2001) or Debrun and Kapoor (2010). In columns (2) and (3), we introduce (log) GDP per capita (*GDPpc*), adjusted for PPP, and the growth rate of real GDP (*Growth*), respectively. These variables are potentially correlated with government size 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. Regarding economic growth, it is often associated with higher volatility while larger governments tend to reduce the growth performance of a country.

¹⁹ 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. Indeed, the Breusch–Pagan test specified for a linear form of heteroscedasticity rejects the null hypothesis of homoscedasticity in most of the following models. Moreover, use of the Newey estimator, robust to both heteroskedasticity and time series autocorrelation (one lag), does not significantly change the results. Finally, period fixed effects are not reported in the tables. They are mostly jointly statistically significant.

²⁰ However, the impact of discretionary fiscal policy is not robust. The variable loses statistical significance in most of the other specifications.

TABLE 2
Personal income tax progressivity and output volatility: Pooled OLS and fixed effects estimation for 1982–2009

The dependent variable is the standard deviation of log changes of real GDP									
	OLS						FE		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Progressivity	−4.08** (−2.53)	−4.15** (−2.61)	−3.80** (−2.47)	−3.74** (−2.40)	−3.19** (−2.28)	−4.51*** (−2.82)	−4.35*** (−2.64)	−5.75** (−2.15)	−6.10* (−1.94)
Openness	0.38* (1.81)	0.40* (1.85)	0.46* (1.87)	0.48* (1.99)	0.34 (1.22)	0.43** (2.08)	0.48** (2.12)	1.15 (1.08)	2.25** (2.02)
Expenditures	−3.07 (−1.54)	−3.19 (−1.55)	−3.29 (−1.57)	−3.30 (−1.57)	−3.56* (−1.78)	−17.72*** (−4.60)	−9.15** (−2.27)	−2.43 (−0.68)	−5.76* (−1.68)
QMP	1.92* (1.84)	1.96* (1.82)	2.13* (1.86)	2.15* (1.87)	1.75 (1.63)	−4.28* (−1.71)	1.93** (2.09)		1.70 (1.49)
Credit	−0.78 (−0.28)	−1.02 (−0.38)	0.21 (0.07)	0.40 (0.13)	−0.90 (−0.26)	−0.70 (−0.25)	−27.42* (−1.96)		6.76 (1.22)
Cycl. FP	−0.61*** (−2.72)	−0.62 (−2.78)	−0.55** (−2.44)	−0.48* (−1.77)	−0.51* (−1.77)	−0.61*** (−2.67)	−0.57*** (−2.55)		
Discr. FP	20.91* (1.68)	21.77* (1.67)	21.64 (1.64)	22.16* (1.68)	14.67 (1.01)	20.50 (1.63)	18.43 (1.64)		14.48 (0.89)
GDP	−0.18** (−2.59)	−0.18** (−2.49)	−0.18** (−2.46)	−0.17** (−2.28)	−0.18** (−2.37)	−0.18** (−2.61)	−0.16** (−2.18)		−1.97 (−1.29)
Growth		−0.02 (−0.21)	−0.02 (−0.24)	−0.02 (−0.21)	0.01 (0.12)				
GDPpc			−0.26 (−0.62)	−0.28 (−0.66)	−0.13 (−0.30)				
Oil				−0.16 (−0.57)	0.01 (0.05)				
Crisis					0.54 (1.37)				
Expend*QMP						15.90*** (2.95)			
Expend*Credit							67.37** (2.11)		
Obs.	88	88	88	88	88	88	88	96	88
R ²	0.43	0.43	0.44	0.44	0.47	0.45	0.46	0.40	0.54

NOTES: Robust t-statistics in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. All models include period fixed effects, not reported in the table.

In column (4), we introduce a dummy for oil producing countries (*Oil*).²¹ In column (5), we include a dummy variable for crisis episodes (*Crisis*), as identified by Laeven and Valencia (2010).²² Since in times of crisis, output volatility tends to be overproportionately high relative to normal times, we seek to exclude the possibility that our results are driven by crisis outliers. However, the additional controls in columns (2) to (5) are insignificant and affect the results only marginally. Therefore, we drop them in the following specifications to save degrees of freedom.

In column (6), we interact the expenditure ratio with the quality of monetary policy to analyze the possibility of nonlinear effects, as in Debrun et al. (2008). By including the interaction term, we check for the presence of substitution effects between alternative fiscal monetary policy-related means of output stabilization. In column (7), we alternatively include an interaction term of the expenditure ratio with the credit ratio. In this way, we account for the possibility of self insuring of the private sector against output fluctuations and possible substitution effects with automatic stabilizers. Both interaction terms are statistically significant with the hypothesized sign. For higher quality of monetary policy (credit), the stabilizing effect of expenditures is smaller, supporting to the idea of substitution effects between automatic stabilizers and monetary policy (self-insurance). In these specifications, the statistical significance of our progressivity index also strengthens. Moreover, now the expenditure ratio is significantly negatively related to output volatility. Finally, not reported in the table, we alternatively include an interaction term of discretionary fiscal policy with the quality of monetary policy to account for potential coordination failures between fiscal and monetary policy, that is, whether ill-designed fiscal policy weakens the effect of monetary policy. However, the interaction term is insignificant and leaves the other estimates basically unchanged.

As further robustness checks, not reported in the table, we add three alternative controls to our benchmark model one at a time: (i) a dummy variable for euro-area countries, which is equal to one for the last sub-period and zero before; (ii) the government budget balance as percent of GDP (or alternatively an interaction term of *Progressivity* with the latter) and (iii) an interaction term of *Progressivity* with a dummy variable equal to one if the ratio of total tax revenues to GDP is above its sample mean, and zero 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 could destabilize 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 stabilizers may be smaller, as shown by Martinez-Mongay and Sekkat (2005). However, neither of the additional control variables appears

21 We classify Canada, Great Britain and Norway as oil producers.

22 The dummy equals one if in a given sub-period a country is experiencing an economic crisis, and zero otherwise. We identify 28 crisis episodes in our sample.

to be significant and the results regarding the progressivity index are virtually unaffected.

Finally, in columns (8) and (9), we use the fixed effects estimator to control for unobserved, time-constant institutional factors of a country that we do not capture by our explanatory variables. To save degrees of freedom, column (8) presents a parsimonious specification, while in column (9), we include all our benchmark controls except cyclical fiscal policy, which is calculated as time invariant. In both columns, the progressivity index increases in absolute size and it remains significant.²³ Based on table 2, we conclude that PIT progressivity is significantly negatively related to output volatility.

4.2. *Composition of government expenditures and revenues*

In this section, we analyze the role of the composition of public expenditures and revenues for output volatility. By controlling for composition effects, we aim at reducing the risk that our measure of progressivity captures more general societal preferences for equity and redistribution. These goals could also be achieved by other public policies which themselves could dampen output fluctuations. Specifically, Darby and Mélitz (2008) show that in particular social outlays by governments, such as health and pension related spending, act as automatic stabilizers. In section 4.2.1, we therefore explicitly account for the composition of expenditures. On the revenue side, governments often use reduced or zero value added tax (VAT) rates on certain goods of basic needs to implement redistributive policies. In section 4.2.2, we hence include measures of VAT progressivity as additional control variables. Moreover, we correct for revenue composition to address the fact that personal income taxes form only part of overall revenues and that other categories may be more or less progressive.

4.2.1. Expenditure composition, government size and progressivity

The first column of table 3 repeats the benchmark model for convenience. In the next columns, we include successively the shares of several expenditure categories in total expenditures as additional control variables, following the categorization of the OECD and as used by Darby and Mélitz (2008). By including both the level of total expenditures and the shares of subcategories, we aim at estimating the effect of government size and expenditure composition jointly.

In column (2), we add the share of health spending. It accounts for 14% of total expenditures on average. The point estimate is significant and has the expected negative sign. Interestingly, now the effect of total expenditures turns significant

23 The relatively short time dimension of our sample—though necessary to fully capture the variability of our data and increase the degrees of freedom—does not make this estimator fully appropriate. Moreover, the fixed effects estimator would account only for those omitted variables, which are constant over time. Finally, the Hausman test (based on column (8)) yields a p-value of 0.64, which indicates that random effects—whose results are similar with our pooled OLS—would be preferable to fixed effects. Wooldridge's test for autocorrelation based on column (8), which gives a p-value of 0.54, fails to reject the null hypothesis of no first-order autocorrelation.

TABLE 3
Progressivity, expenditures composition and output volatility: Pooled OLS for 1982–2009

<i>Dependent variable is the standard deviation of log changes of real GDP</i>						
	(1)	(2)	(3)	(4)	(5)	(6)
Progressivity	−4.08** (−2.53)	−3.31** (−2.31)	−2.52* (−1.72)	−2.91** (−2.02)	−3.53** (−2.38)	−3.77** (−2.27)
Openness	0.38* (1.81)	0.42** (2.03)	0.46** (2.31)	0.46** (2.29)	0.42** (2.02)	0.53* (1.89)
Expenditures	−3.07 (−1.54)	−4.51** (−2.04)	−3.93** (−2.14)	−4.06** (−2.16)	−4.57** (−2.07)	−5.29** (−2.11)
QMP	1.92* (1.84)	1.91** (2.19)	1.71* (1.94)	1.57* (1.81)	1.81* (1.97)	2.49** (2.43)
Credit	−0.78 (−0.28)	2.00 (0.70)	0.48 (0.17)	0.69 (0.25)	2.09 (0.72)	2.55 (0.87)
Cycl. FP	−0.61*** (−2.72)	−0.69*** (−2.99)	−0.83*** (−3.51)	−0.81*** (−3.50)	−0.68*** (−2.95)	−0.65*** (−2.84)
Discr. FP	20.91* (1.68)	18.58 (1.52)	16.83 (1.45)	17.09 (1.46)	18.70 (1.52)	20.27 (1.64)
GDP	−0.18** (−2.59)	−0.10 (−1.35)	0.01 (0.13)	0.01 (0.06)	−0.10 (−1.33)	−0.12 (−1.50)
Share health		−13.67* (−1.69)	−13.99** (−2.03)	−14.17** (−2.03)	−13.80* (−1.69)	−15.33* (−1.74)
Share soc. sec.			−4.54** (−2.56)			
Share pens. related				−4.31** (−2.62)		
Share unempl. comp.					2.80 (0.56)	
Share subsidies						−7.00** (−2.10)
Obs.	88	88	88	88	88	75
R ²	0.43	0.48	0.52	0.52	0.48	0.49

NOTES: Robust t-statistics in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. All models include period fixed effects, not reported in the table.

at the 5% level and it increases in absolute value. In column (3), we additionally incorporate the share of total social security spending, which represents 20% of total expenditures on average. The coefficient is significant at the 5% level, but the stabilization effect is less pronounced than in the case of health expenditures. The point estimate of the latter now strengthens in statistical significance. In columns (4) and (5), we replace the share of total social security spending by two of its subcomponents, namely, by the share of pension related spending and unemployment compensation, respectively. The former category is economically more important as it stands for 17% of total expenditures while the latter accounts only for 3%. Finally, in column (6), we include the share of subsidies, which form 4% of total expenditures.²⁴ Pension related spending and subsidies both significantly dampen output fluctuations.

²⁴ We drop the social security subcomponents to save degrees of freedom as the number of observations declines to 75. Further, we also aimed at assessing the effects of sickness pay and incapacity related benefits as Darby and Mélitz (2008) show that they stabilize output. However,

Overall, our findings confirm the results of Darby and Mélitz (2008). Health expenditures, social security spending and subsidies all act as automatic stabilizers. According to the point estimates, the most important expenditure category for output stabilization is health. The effect of PIT progressivity is quantitatively similar to table 2 and remains significant in all models. Moreover, we now, that is, when controlling for expenditure composition, find a significant negative effect of government size—as measured by the expenditure ratio. Indeed, the structure of public outlays has changed considerably over the sample period, even though the overall level expenditures remained roughly constant at 44% of GDP. While the share of health and pension-related spending increased each by four percentage points on average, the share of unemployment compensation and subsidies decreased each by two percentage points. There is also considerable heterogeneity across countries. While, for example, health spending accounts merely for 8% in Korea, it represents 18% in the US.

We now illustrate the economic importance of the different channels of automatic stabilizers using column (2) of table 3. We consider the case of Italy exemplarily as the country ranks close to the median for the progressivity index (0.13, rank 17), the expenditure ratio (0.42, rank 14), as well as for the share of health spending (0.14, rank 15). An increase in the progressivity index by one standard deviation (of 0.083 in the full sample), keeping all other factors constant, would reduce output volatility in Italy by 15% (from 1.83 to 1.55). For government size, an increase by one standard deviation (of 0.077) implies a decline in volatility of 19% *ceteris paribus*. For the share of health expenditures, an increase of one standard deviation (of 0.029) leads to a volatility reduction of 22%.

These numbers suggest that the volatility dampening effect of PIT progressivity is quantitatively similar to that of the overall size of the government or the share of health expenditures. In Italy, an increase by one standard deviation would imply an upward shift of the index from $1 - (1 - 0.29)/(1 - 0.18) = 0.13$ to 0.21. This is approximately the same level as in Finland (rank 7). The increase could, for example, be the result of a rise in the marginal tax rate from 29% to 35%, which would still be below Finland's marginal tax rate of 42%. On the other hand, completely “switching off” the automatic stabilization from PIT progressivity in Italy, that is, implementing a purely flat tax system where $MTR = ATR$, would increase output volatility by 24% (from 1.83 to 2.26). Overall, the economic impact of higher PIT progressivity on output volatility seems plausible given that PIT revenues stand for 38% of total tax revenues in Italy. In the case of the expenditure ratio, an increase by one standard deviation would put Italy at the level of France (rank 3). Finally, increasing the share of health expenditures by one standard deviation would yield the same level in Italy as in Germany (rank 5).

if we include these variables the number of observations drops even further to 25 and 41, respectively. Hence, we do not use them in the estimation.

TABLE 4
Progressivity, revenue composition and output volatility: Pooled OLS for 1982–2009

<i>Dependent variable is the standard deviation of log changes of real GDP</i>								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Progressivity	−3.62** (−2.35)	−4.01** (−2.53)	−4.11** (−2.62)	−4.22** (−2.41)	−4.13** (−2.36)	−4.89** (−2.63)	−4.09** (−2.35)	−3.52** (−2.03)
Openness	0.43* (1.97)	0.64** (2.42)	0.72** (2.62)	0.80** (2.09)	0.81** (2.10)	0.36* (1.73)	0.50** (2.28)	0.46* (1.80)
Revenues	−2.93 (−1.47)	−3.93* (−1.92)	−4.11** (−2.03)	−3.62** (−2.27)	−3.56** (−2.24)			−3.70* (−1.70)
QMP	1.98* (1.69)	2.63** (2.50)	2.44** (2.24)	2.43** (2.26)	2.47** (2.25)	2.27 (1.55)	1.71 (1.49)	1.31 (0.75)
Credit	−0.86 (−0.30)	−1.30 (−0.44)	−2.01 (−0.67)	−1.77 (−0.62)	−0.78 (−0.23)	−3.36 (−1.06)	−1.49 (−0.53)	−1.51 (−0.47)
Cycl. FP	−0.56** (−2.59)	−0.27 (−0.94)	−0.28 (−1.00)	−0.27 (−0.96)	−0.28 (−0.95)	−0.78*** (−3.06)	−0.77*** (−3.13)	−0.43 (−1.59)
Discr. FP	21.89* (1.71)	21.73* (1.69)	23.31* (1.79)	22.66* (1.75)	20.44 (1.49)	30.41** (2.20)	26.10** (2.03)	19.61 (1.34)
GDP	−0.16** (−2.28)	−0.14* (−1.90)	−0.12 (−1.43)	−0.08 (−0.60)	−0.05 (−0.39)	−0.17** (−2.25)	−0.13* (−1.81)	−0.17* (−1.85)
Share corp. taxes		−5.09* (−1.71)	−5.21* (−1.74)	−6.14 (−1.65)	−4.07 (−0.79)			
Share PIT			0.82 (1.08)	−0.30 (−0.10)	1.34 (0.31)			
Share SSC				−1.20 (−0.40)	0.27 (0.06)			
Share ind. taxes					2.45 (0.64)			
VAT progr. 1						−4.89** (−2.11)		
VAT progr. 2							−3.20* (−1.87)	
VAT progr. 3								−0.01* (−1.96)
Obs.	88	87	87	87	87	79	88	69
R ²	0.42	0.44	0.45	0.45	0.46	0.44	0.43	0.45

NOTES: Robust t-statistics in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. All models include period fixed effects, not reported in the table.

4.2.2. Revenue composition, VAT progressivity and PIT progressivity

In this section, we control for revenue composition and explore the role of VAT progressivity as an automatic stabilizer. Column (1) of table 4 is similar to the benchmark model, but we replace the expenditure ratio by the ratio of total revenues to GDP as a measure of government size. The results are similar to the benchmark model. In columns (2) to (5), we add successively the share of corporate taxes, personal income taxes, social security contributions and indirect taxes in total revenues, respectively. They sum up to 92% of total revenues. We thereby account for (time-varying) differences in revenue composition across countries and for the fact that PIT revenues represent only 35% of total revenues and that other revenues may be more or less progressive.

While among the individual categories only corporate taxes seem to stabilize output, now the level of total revenues is significant in columns (2) to (5). As with the expenditure side, the stabilizing impact of government size can be restored once we control for composition effects. The point estimates are similar for both measures of government size. Indeed, there is also considerable heterogeneity in the revenue structure across countries and over time. For example, while the share of corporate taxes in total revenues is only 4% in Austria, it is 17% in Japan. Moreover, on average across countries, it has increased by three percentage points over the sample period. On the other hand, the average share of personal income taxes and indirect taxes has decreased by six and two percentage points, respectively. Finally, compared to model (1), the effect of PIT progressivity strengthens slightly in models (2) to (5).

Next, we assess the effect of VAT progressivity and reduced VAT rates on output volatility and whether omitting these variables affects the estimates for PIT progressivity. In column (6), we introduce a measure of VAT progressivity (*VAT progr. 1*), which we construct along the lines of our PIT progressivity index. Specifically, we use the regular nominal VAT rate to proxy for the marginal rate in equation (2). To measure the average rate, we follow the methodology of Mendoza et al. (1994) and compute average effective VAT rates. They are typically lower than regular nominal VAT rates as they reflect foregone revenues due to reduced or zero VAT rates.

While the VAT index uses the same formula as the PIT index, the interpretation differs. It relies on the fact that VAT progressivity is typically achieved by using zero or reduced rates. These rates usually apply to certain goods and services of basic needs such as foodstuffs, social services or water supplies (see, for example, European Commission 2014). Demand for these goods is relatively inelastic with respect to income, whereas demand for non-exempted goods tends to be more elastic. Hence, the income share of the latter category, where higher rates apply, increases with income, which implies that the average VAT rate increases with income. Higher VAT progressivity is thus expected to reduce output fluctuations. The sample mean of the VAT index is 0.05, which shows that value added taxes are on average progressive. Moreover, the correlation with PIT progressivity is 0.1. Societies with more progressive PIT systems tend to favour progressive VAT schedules as well. In line with this interpretation, the effect of VAT progressivity on output volatility is significantly negative.

In column (7), we use an alternative measure of VAT progressivity (*VAT progr. 2*) to more directly control for the presence of reduced rates. In particular, we use the difference between the regular and the (lowest) reduced nominal VAT rate. It is also significantly negatively related to output volatility. For both VAT indices, the point estimate is roughly similar to that of PIT progressivity.²⁵

25 Moreover, not reported in the table, we explore two further VAT measures: the VAT revenue ratio and an indicator variable, which is equal to one if there is zero rating for a given year and country, and zero otherwise. The VAT revenue ratio “[...] provides an indicator of the effect of exemptions and reduced rates, fraud, evasion and tax planning on government revenues” (see

Note that we exclude the revenue ratio in columns (6) and (7) since it is highly correlated with the VAT indices (at 0.61 and 0.50, respectively).²⁶ Otherwise, both indices and the revenue ratio are insignificant due to problems of multicollinearity. In column (8), we therefore construct yet an alternative measure of VAT progressivity (*VAT progr. 3*) that is less correlated to the revenue ratio, allowing us to re-introduce this variable. Following Kakinaka and Pereira (2006), the measure is based on the ratio of the proportional standard deviation of VAT tax revenues and the VAT tax base, respectively. Here, the idea is that higher VAT progressivity leads to higher fluctuations in VAT revenues relative to the VAT tax base. According to this measure as well, higher VAT progressivity is negatively related to output volatility. This effect comes in addition to the effect of government size—as proxied by the revenue ratio—and PIT progressivity.

4.3. Instrumental variables estimation

In this section, we address potential problems of endogeneity. As pointed out by Rodrik (1998), if more open economies face higher output volatility their residents might choose to have larger governments. This could create endogeneity of government size to output volatility. Then, the point estimates of the previous sections 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. Previous studies focus on correcting the endogeneity of government size, credit and the quality of monetary policy by using IV estimation (see Fatás and Mihov 2001, Debrun et al. 2008 and Debrun and Kapoor 2010). The evidence on the endogeneity of these variables is mixed.

With regard to tax progressivity, as explained in the introduction, endogeneity is less of a concern in our view.²⁷ Nonetheless, since endogeneity in the case of the other explanatory variables can also bias estimates of the coefficient on progressivity, and as we cannot completely exclude, based on purely narrative arguments, the possibility of the progressivity index being endogenous, we resort to IV estimation.

Our approach is to instrument the potentially endogenous variables one at a time: the progressivity index, the expenditure ratio, cyclical and discretionary fiscal policy, credit and the quality of monetary policy.²⁸ Our choice of instruments is guided by two considerations. First, they should be correlated with the potentially endogenous regressor. Second, they should be unrelated to output volatility itself. We select variables reflecting political institutions of a country and structural features of its economy. Specifically, in line with the above cited

OECD 2012, p. 103). Both measures are insignificant and leave the other results, in particular regarding the effect of PIT progressivity, basically unchanged.

²⁶ We also drop the revenue shares as they are largely insignificant. If we include the revenue ratio in columns (6) and (7), the progressivity index remains significant at the 5% level. The point estimate decreases slightly in absolute value.

²⁷ We are not aware of any public debate, now or in the past, which links grounds of PIT progressivity to stabilization goals.

²⁸ Instrumenting more than one variable at a time did not yield meaningful results.

TABLE 5
Instrumental variables estimation; sample 1982–2009

	<i>Dependent variable is the standard deviation of log changes of real GDP</i>					
	Instrumented variable					
	(1) Prog	(2) Expend	(3) Cycl. FP	(4) Discr. FP	(5) Credit	(6) QMP
Progressivity	−5.01** (−1.97)	−3.84*** (−2.69)	−4.56*** (−3.09)	−4.92** (−2.33)	−4.39*** (−2.80)	−4.69* (−1.70)
Openness	0.39* (1.91)	0.32 (1.36)	0.32 (1.45)	0.40 (1.36)	0.35* (1.72)	0.34* (1.66)
Expenditures	−3.66** (−1.98)	−6.69** (−2.36)	−3.70** (−2.00)	−3.34* (−1.71)	−3.83** (−2.04)	−3.86* (−1.84)
QMP	2.12** (1.97)	2.19** (2.56)	2.05** (2.24)	3.72 (1.60)	2.17** (2.06)	2.66 (0.73)
Credit	1.12 (0.44)	0.79 (0.30)	1.10 (0.45)	−4.84 (−0.65)	−0.93 (−0.22)	0.68 (0.16)
Cycl. FP	−0.65*** (−2.82)	−0.59*** (−2.81)	−0.78*** (−2.90)	−1.00** (−2.00)	−0.64*** (−2.90)	−0.65** (−2.40)
Discr. FP	12.80 (1.13)	10.88 (0.86)	14.68 (1.36)	91.34 (1.19)	16.32 (1.25)	15.08 (0.89)
GDP	−0.24*** (−3.00)	−0.26*** (−3.29)	−0.24*** (−3.28)	−0.09 (−0.59)	−0.22*** (−3.18)	−0.25*** (−2.77)
Obs.	85	85	85	85	85	85
R ²	0.46	0.43	0.46	0.22	0.46	0.46
Weak ident. F-stat.	7.85	7.64	7.05	0.75	10.77	0.66
Wu–Hausm. p-value	0.722	0.154	0.467	0.299	0.546	0.834
Overid. p-value	0.788	0.823	0.794	0.886	0.827	0.801

NOTES: Robust t-statistics in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. All models include period fixed effects, not reported in the table.

literature, we use the following set of instruments, which we keep constant across models: two dummies indicating the type of political system (presidential vs. parliamentary) and the election system (proportional vs. other), an index of checks and balances of the executive authority, its party orientation, log GDP per capita (PPP adjusted), the rate of urbanization, the old dependency ratio and a dummy identifying oil producing countries. In section 5.3, we analyze the sensitivity of the results to an alternative set of instruments.

Table 5 presents six models, all based on our baseline specification, where we instrument the potentially endogenous variables in the above mentioned order. Column (1) shows that the coefficient on progressivity increases in absolute value relative to the OLS estimate when it is instrumented. It remains significant at the 5% level. The bottom of the table contains several statistics assessing the performance of the instrumental variables. We use the first-stage F-statistic to check for the possibility of weak identification.²⁹ The next row reports the

29 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 high and around 10.

p-value of the Wu–Hausman test for weak exogeneity of the instrumented variable. In line with our argument on the unlikely endogeneity of tax progressivity, the p-value indicates the consistency of the OLS estimator. The last row reports the p-value of Wooldridge’s robust score test of over-identification. Given a value of 0.79, we do not reject the validity of our instruments.

A similar picture emerges in columns (2) to (6). The coefficient on progressivity drops slightly in absolute size relative to model (1) but it remains significant. As the set of instruments is kept constant across models, the F-statistic from the first-stage regressions varies considerably. In particular, given its low values, the results in columns (4) and (6) should be interpreted with caution. However, for all models the p-values of the score and Wu–Hausman tests, respectively, indicate the consistency of the OLS estimates and that none of the models suffers from over-identification. We conclude that, when using the IV estimator, PIT progressivity has a significant negative effect on output volatility. However, as we do not find evidence of endogeneity of tax progressivity, we refer to the more efficient, and more conservative, OLS results as our preferred estimates of the effect of progressivity on output volatility.

5. Other robustness tests

We first assess the effect of PIT progressivity on alternative measures of volatility. Then, we analyze the robustness of the results to alternative measures of the quality of monetary policy before we explore a different set of instruments. Finally, we present results for alternative lengths of sub-periods, as well as for the subsample 1982–2004.

5.1. *Alternative measures of volatility*

In this section, we analyze the sensitivity of our results to alternative definitions of output volatility. Moreover, we assess the effect of PIT progressivity on the volatility of consumption, investment and hours worked. Table 6 presents pooled OLS estimates using our baseline model. For comparison, column (1) replicates the benchmark model. In column (2), the dependent variable is the standard deviation of the output gap measured as deviations of (log) GDP from its linear trend. A quadratic or cubic trend yields similar results. Given an estimated autocorrelation of (log) GDP of nearly one, columns (1) and (2) are quantitatively similar. In column (3), we use the standard deviation of the output gap obtained from the HP-filtered (log) GDP series. As the HP filter removes a larger part of the high frequency movements the (absolute) coefficient on progressivity drops to -2.7 , but it remains significant. In column (4), the dependent variable is the standard deviation of log changes of GDP per capita. Since population growth is modest in most OECD countries, the results are similar to column (1).

In columns (5) to (7), we take a closer look at how tax progressivity affects the volatility of consumption, private non-residential investment and hours worked,

TABLE 6
Alternative measures of volatility, pooled OLS, sample 1982–2009

	<i>Dependent variable: Volatility of:</i>						
	(1) GDP	(2) GDPlin	(3) GDP _{hp}	(4) GDP _{pc}	(5) Cons.	(6) Inv.	(7) Hours
Progressivity	−4.08** (−2.53)	−3.81** (−2.38)	−2.65** (−2.36)	−4.07** (−2.54)	−5.66** (−2.40)	−15.07* (−1.82)	−0.97 (−1.05)
Openness	0.38* (1.81)	0.39* (1.88)	0.23 (1.27)	0.40* (1.93)	−0.29 (−0.74)	−0.99 (−0.69)	0.26 (1.06)
Expenditures	−3.07 (−1.54)	−2.37 (−1.17)	−1.55 (−1.06)	−2.78 (−1.46)	−2.79 (−0.81)	−4.38 (−0.56)	−1.06 (−1.39)
QMP	1.92* (1.84)	1.22 (0.99)	1.07 (1.35)	1.64* (1.73)	1.23 (0.67)	−2.67 (−0.35)	0.21 (0.36)
Credit	−0.78 (−0.28)	0.03 (0.01)	0.26 (0.13)	−0.99 (−0.36)	−1.33 (−0.32)	9.42 (0.74)	−0.29 (−0.15)
Cycl. FP	−0.61*** (−2.72)	−0.62*** (−2.86)	−0.47*** (−3.04)	−0.56** (−2.54)	−1.44*** (−4.22)	−2.43** (−2.44)	−0.22** (−2.06)
Discr. FP	20.91* (1.68)	18.78 (1.56)	7.59 (0.76)	14.60 (1.20)	88.17*** (4.01)	233.91*** (2.88)	4.37 (0.60)
GDP	−0.18** (−2.59)	−0.20*** (−2.86)	−0.15*** (−2.93)	−0.19** (−2.49)	−0.43*** (−3.53)	−2.13*** (−4.66)	−0.09 (−2.01)
Obs.	88	88	88	88	87	73	84
R ²	0.43	0.47	0.42	0.41	0.45	0.58	0.26

NOTES: Robust t-statistics in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. All models include period fixed effects, not reported in the table.

respectively. The correlation of each variable with the progressivity index is -0.15 , -0.10 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 the 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 the case of output volatility, it is significant at the 5% level, and the R^2 slightly increases relative to our benchmark model. Column (5) thereby lends further support to the idea of automatic stabilizers mainly working on the demand side of the economy. In the case of investment volatility in column (6), measured as the standard deviation of log changes of real private investment excluding dwellings, the coefficient on progressivity has again a negative sign, it increases (in absolute value) to -15.07 and remains statistically significant although the number of observations drops substantially. The R^2 increases even further. One possible explanation for the negative effect is that progressive taxes, by reducing output fluctuations, also stabilize private investment expenditures, which depend essentially on expectations about future growth (fluctuations).³⁰ Finally, in column (7), the dependent variable is

30 Moldovan (2010) provides another possible explanation for a negative effect. Progressive income taxes can reduce investment volatility through their dampening effect on fluctuations in hours worked. This is because, by stabilizing after-tax wage income, they mitigate substitution effects whereby households substitute current hours worked for future leisure. This reduces

the standard deviation of (linearly detrended) hours worked. The coefficient on progressivity is insignificant. By and large, table 6 shows that the stabilizing effect of PIT progressivity is robust to alternative measures of output volatility. In addition, the results indicate a negative impact of PIT progressivity on the volatility of consumption and investment.

5.2. *Alternative measures of monetary policy quality*

Instead of the IMF measure, in this section, we use several alternative measures of the quality (or independence) of monetary policy. Column (1) of table 7 replicates the benchmark model for convenience. In column (2), we use the turnover rate of the governor of the central bank, as in Crowe and Meade (2007). In column (3), we employ a measure of the independence of the central bank, following Debrun and Kapoor (2010). In column (4), we use the inflation rate directly instead of its exponential deviation from a 2% target. In column (5), we add its standard deviation. Across all specifications, the index of PIT progressivity remains significant and similar in size.

5.3. *Alternative set of instruments*

In this section, we use an alternative set of two instruments to further address potential problems of endogeneity. First, exploiting the time dimension of the data, we use the first lag of the potentially endogenous variable. Since this approach considerably reduces the number of observations, we now construct all variables over windows of five years to increase the efficiency of the estimation. The first-order autocorrelation of progressivity, expenditures, credit and quality of monetary policy are 0.84, 0.86, 0.81 and 0.69, respectively. For discretionary fiscal policy the autocorrelation is substantially smaller at 0.20, whereas the measure of cyclical fiscal policy is time invariant. For these two variables, we thus keep the set of instruments unchanged.

Second, for those variables, which we instrument with their first lag, we in addition use a dummy variable equal to one if a country is Anglo-American, and zero otherwise. In this group of countries, the role of the state is typically smaller and financial markets tend to be more developed. These country characteristics are mirrored in the correlation between the indicator variable and, respectively, progressivity, expenditures, credit and quality of monetary policy. It is -0.31 , -0.35 , 0.19 and 0.14 , respectively.

Table 8 contains the results. The weak identification F-statistics increase. The index of progressivity remains statistically significant in all models. The absolute size of its point estimate slightly decreases compared to table 5. Most importantly, the Wu–Hausman test again does not reject the hypothesis of weak exogeneity of progressivity (see bottom of column (1)). Then, the OLS estimator is more efficient.

employment fluctuations and curbs the cyclical response of the marginal product of capital, which depends positively on hours worked. Ultimately, progressive taxes thereby lower the volatility of the rate of return on capital and hence of investment.

TABLE 7
Alternative measures of monetary policy quality, pooled OLS, sample 1982–2009

<i>Dependent variable is the standard deviation of log changes of real GDP</i>					
	(1)	(2)	(3)	(4)	(5)
Progressivity	−4.08** (−2.53)	−2.96** (−2.09)	−3.66** (−2.37)	−4.74*** (−2.99)	−4.87*** (−3.12)
Expenditures	−3.07 (−1.54)	−2.89 (−1.54)	−1.84 (−0.91)	−3.36* (−1.68)	−3.10 (−1.66)
Openness	0.38* (1.81)	0.42* (1.84)	0.42* (1.67)	0.34* (1.68)	0.32 (1.50)
Credit	−0.78 (−0.28)	1.06 (0.37)	−1.44 (−0.44)	−2.47 (−0.84)	−2.31 (−0.81)
Cycl. FP	−0.61*** (−2.72)	−0.44 (−1.45)	−0.27 (−1.27)	−0.72*** (−3.18)	−0.88*** (−3.37)
Discr. FP	20.91* (1.68)	13.18 (1.01)	−15.34 (−0.93)	26.13** (2.11)	22.71* (1.89)
GDP	−0.18** (−2.59)	−0.14* (−1.92)	−0.04 (−0.45)	−0.21*** (−2.96)	−0.16** (−2.22)
QMP	1.92* (1.84)				
Central bank independence		0.27 (0.40)			
Turnover CB governor			2.67* (1.86)		
Inflation				−0.11*** (−2.76)	−0.17*** (−3.32)
SD Inflation					0.23** (2.13)
Obs.	88	88	77	88	88
R ²	0.43	0.41	0.35	0.45	0.49

NOTES: Robust t-statistics in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. All models include period fixed effects, not reported in the table.

5.4. Alternative fixed-windows and subsample estimates

In this section, we assess the robustness of our results: (i) considering only the cross-section dimension of our data; (ii) splitting the sample into time intervals of five years; (iii) excluding the updated years of the progressivity index; and (iv) excluding individual countries or groups of countries. Table 9 reports the (pooled) OLS results for cases (i) to (iii). In columns (1) to (3), we compute country-specific means and standard deviations over the whole sample period. This reduces the number of observations to 28. To save degrees of freedom, column (1) begins with a parsimonious specification, where we drop credit and the quality of monetary policy from our benchmark model. These two variables are re-introduced in columns (2) and (3), respectively. At the other extreme, in columns (4) to (6), we split the sample into windows of five years. We estimate the same three models as in columns (1) to (3), augmented by (statistically significant) time dummies. Finally, in columns (7) to (9), we exclude the years 2005–2009, where we updated the progressivity index to check whether the results are sensitive

TABLE 8
Alternative set of instruments, sample 1982–2009

	<i>Dependent variable: Standard deviation of log changes real GDP</i>					
	Instrumented variable					
	(1) Prog.	(2) Expend.	(3) Cycl. FP	(4) Discr. FP	(5) Credit	(6) QMP
Progressivity	−2.61* (−1.93)	−2.15* (−1.66)	−4.33*** (−3.27)	−3.80** (−2.03)	−3.64*** (−2.64)	−3.68*** (−2.59)
Openness	0.45** (2.33)	0.46** (2.27)	0.44** (2.06)	0.64 (1.52)	0.50** (2.45)	0.51** (2.50)
Expenditures	0.02 (0.02)	0.05 (0.04)	−3.61* (−1.83)	−5.05* (−1.74)	−2.58 (−1.14)	−2.18 (−0.98)
QMP	−0.49 (−0.85)	−0.88 (−0.44)	0.65 (1.08)	2.38 (1.43)	0.74 (1.11)	0.85 (0.78)
Credit	3.27 (1.51)	3.24 (1.42)	2.83 (1.28)	−7.63 (−0.89)	−1.71 (−0.53)	1.37 (0.53)
Cycl. FP	−0.36** (−2.07)	−0.29 (−1.42)	−0.62** (−2.28)	−0.99* (−1.85)	−0.40** (−1.97)	−0.41** (−2.09)
Discr. FP	7.70 (0.90)	6.29 (0.63)	5.34 (0.53)	125.75 (1.51)	14.45 (1.19)	10.34 (0.99)
GDP	−0.21*** (−2.87)	−0.22*** (−3.09)	−0.24*** (−3.38)	0.06 (0.29)	−0.17** (−2.27)	−0.20*** (−2.66)
Obs.	93	85	105	105	96	96
R ²	0.63	0.64	0.55	0.05	0.52	0.53
Weak ident. F-stat.	51.45	80.06	7.70	0.83	115.56	18.35
Wu–Hausm. p-value	0.745	0.895	0.420	0.087	0.033	0.423
Overid. p-value	0.157	0.210	0.315	0.648	0.099	0.079

NOTES: Robust t-statistics in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. All models include period fixed effects, not reported in the table.

to the extension. The sample is split into windows of 7, 7 and the remaining nine years. Except for column (8), progressivity stays significant at least at the 10% level across models and the point estimates are similar to the main results.

Returning to our benchmark windows of seven years, we next assess whether our results are unduly influenced by an individual country, groups of countries or individual outlying observations.³¹ Again, we resort to our benchmark model. First, we exclude one country at a time. Then, we exclude, one group at a time, Scandinavian, Anglo-American, oil-producing and euro-area member countries. Finally, we investigate whether our results are driven by a few outlying observations with regard to output volatility and/ or the progressivity index (see figure 2). Therefore, we exclude all observations where: (i) output volatility is larger than 4, (ii) progressivity is larger than 0.3 and (iii) either (i) or (ii) applies. In all cases, the coefficient on progressivity remains statistically significant (at least at the 5% level) and similar in size.

31 The results are not reported in the table, but they are available from the authors upon request.

TABLE 9
Alternative fixed-windows and subsample estimates, pooled OLS

	<i>Dependent variable: Standard deviation of log changes real GDP</i>								
	Cross-section			5-year windows			Progressivity not updated		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Progressivity	-4.88* (-2.02)	-5.11** (-2.15)	-5.02** (-2.22)	-3.01*** (-3.07)	-3.48*** (-2.92)	-3.66*** (-2.75)	-2.19* (-1.71)	-2.46 (-1.60)	-3.94** (-2.47)
Openness	0.58 (1.25)	0.61 (1.41)	0.62 (1.20)	0.48** (2.19)	0.50** (2.36)	0.48** (2.32)	0.36 (1.38)	0.35 (1.25)	0.21 (0.77)
Expenditures	-1.70 (-0.79)	-2.23 (-1.24)	-2.21 (-1.16)	-3.14* (-1.70)	-2.85 (-1.44)	-2.98 (-1.43)	-3.80* (-1.97)	-3.68* (-1.77)	-3.96* (-1.95)
Cycl. FP	-0.73*** (-3.50)	-0.68*** (-2.94)	-0.67** (-2.14)	-0.49** (-2.32)	-0.38** (-1.95)	-0.40** (-1.96)	-0.25 (-1.03)	-0.28 (-1.12)	-0.48* (-1.76)
Discr. FP	25.26 (1.32)	26.06 (1.50)	25.22 (1.24)	9.63 (0.76)	7.59 (0.70)	8.69 (0.79)	-9.11 (-0.48)	-7.16 (-0.35)	7.18 (0.35)
GDP	-0.14 (-1.16)	-0.09 (-0.75)	-0.09 (-0.59)	-0.15** (-2.13)	-0.18** (-2.37)	-0.19** (-2.52)	-0.10 (-1.53)	-0.11 (-1.47)	-0.17** (-2.66)
Credit		-5.22 (-1.14)	-4.98 (-0.76)		1.86 (0.82)	1.56 (0.63)		0.48 (0.15)	-1.60 (-0.43)
QMP			-0.15 (-0.07)			0.38 (0.66)			2.01* (1.82)
Obs.	28	28	28	115	110	110	65	63	63
R ²	0.44	0.48	0.48	0.51	0.52	0.52	0.29	0.30	0.33

NOTES: Cross-section in models 1 to 3; fixed windows of five years in models 4 to 6; models 7 to 9 exclude years 2005–2009, where progressivity index was updated. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. Models 4 to 9 include period fixed effects, not reported. Robust t-statistics in parentheses.

6. Conclusions

According to the standard Keynesian view, the size of automatic stabilizers depends on two main factors: the size of the government and the cyclical responsiveness of the government budget. In the latter category, an important role is played by tax progressivity. In this paper, we use macro data from a sample of OECD countries over the period 1982–2009 and present empirical support for the hypothesis that higher PIT progressivity leads to lower output volatility. Our contribution rests on three pillars. First, we employ a direct measure of PIT progressivity. Second, we present cross-country evidence using macro data. Third, this measure can be considered exogenous. Moreover, we find supportive evidence for a negative relationship between government size and output volatility once we control for the composition of government revenues or expenditures. Our results are robust to several robustness checks. The stabilizing effect of PIT progressivity seems to work by smoothing private consumption and investment.

Overall, the empirical results of our paper allow us to conclude that, *ceteris paribus*, more progressive income tax systems are better able to stabilize output. The magnitude of this effect is similar to that of government size. As such, they represent a powerful tool of automatic stabilization which, however, is largely unintended as income tax systems are typically designed to meet redistributive goals. Hence, our results indicate the possibility of a complementarity between the public goals of equity and stabilization.

Appendix: Data and sources

TABLE A1
Data description and sources.

Variable	Description	Source
Expenditures	Total expenditures excluding interest (% of GDP)	AMECO
Growth	Growth rate of GDP at constant market prices	"
Cons.	Private final consumption expenditures, constant prices	"
Inv.	Gross fixed capital formation, constant prices	"
Priv. Investment	GFCF, current prices: private sector	"
Dwellings	GFCF, current prices: dwellings	"
Openness	Exports plus imports (% of GDP)	"
Inflation	Annual inflation rate	"
Hours	Average annual hours worked per worker	OECD
Revenue shares	Share corporate, personal income, indirect taxes, SSC	"
Expend. shares	Share health, total social security, pension related, unempl.	"
GDPpc	GDP per capita, adjusted for PPP	Penn World Table (6.3)
GDP	Total GDP, adjusted for PPP	"
Credit	Credit to private sector (% of GDP)	WDI, World Bank (continued)

TABLE A1
(Continued)

Variable	Description	Source
Urban	Urban population (% of total population)	"
Dependency	Age dependency ratio (% working-age population)	"
System	Dummy: Presidential vs. parliamentary	PI, World Bank
Checks	Checks and balances	"
Pr.	Dummy electoral system; representative vs. other	"
IT progressivity	Index of progressivity	OECD; own calculations
VAT progressivity	Index of VAT progressivity 1–3	"
VAT rev. ratio	VAT revenue ratio	OECD (2012)
Vola	S.d. of GDP at constant market prices	AMECO; own calculations
QMP	Quality monetary policy; see IMF (2007)	Own calculations
Cycl. FP	Cyclical fiscal policy; see Debrun and Kapoor (2010)	"
Discr. FP	Discretionary fiscal policy; see Debrun and Kapoor (2010)	"
CBI	Central bank independence	Crowe and Meade (2007)
Turnover	Turnover rate central bank governor	Crowe and Meade (2007)
Crisis	Dummy for crisis episodes	Laeven and Valencia (2010)

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