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Explaining output volatility: The case of taxation

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Abstract

This paper studies the effects of taxation on output volatility in OECD countries to shed light on the sources of observed heterogeneity over time and across countries. To this end, we derive tax effects on macro aggregates in a stochastic neoclassical model. As a result, taxes are shown to affect the second moment of output growth rates without (long-run) effects on the first moment. Taking the model to the data, we exploit observed heterogeneity patterns to estimate effects of tax rates on macro volatility using panel estimation, explicitly modeling the unobserved variance process. We find a strong empirical link between effective tax rates and output volatility, with some evidence of a cointegrating relationship. In accordance with theory, taxes on labor income and corporate income empirically are found to be negatively related to volatility of macro aggregates whereas the capital tax ratio has positive effects.

JEL classification: E32; E62

Keywords: Macroeconomic volatility; Tax effects; Big moderation

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1 Introduction

Macroeconomic volatility is a complex phenomenon. Usually in stochastic models (Kydland and Prescott 1982, Long and Plosser 1983), the variance of the innovations to technology is considered to be exogenous by construction. However, it can be shown that the volatility of macro aggregates in these models is *not* purely exogenous, but explained by fundamentals. For illustration, any measure of dispersion of aggregate output is not only determined by the variance of some initial impulse, but also the outcome of an endogenous shock transmission. Intuitively, the variance of output growth rates depends on the variance of the growth rate of the underlying stochastic process (of the stochastic impulse) and the variance of the growth rate of factor inputs, which in turn depends on model parameters. In addition, the stochastic impulse itself might be the result of an endogenous decision problem as in the growing through cycles literature (Bental and Peled 1996, Matsuyama 1999, Francois and Lloyd-Ellis 2003, Wälde 2005) and thus endogenous by nature. In either case individual decisions affect output volatility. By changing incentives taxes affect individual decisions. Accordingly, taxes and output volatility may be linked.

Our empirical motivation stems from the fact that major US tax reforms took place around the point in time where the break in output volatility is usually identified.[1] In this period, the focus of US policy debates was on the Economic Recovery Tax Act (ERTA) of 1981, the first of the famous Reagan tax cuts (also known as Kemp-Roth Tax Cut). A second reform was announced in May 1984, with large economic effects (Auerbach and Slemrod 1997). Similarly, the moderation of output volatility in the UK was accompanied by massive tax cuts (Giles and Johnson 1995).[2] Effective tax rates indeed show abrupt changes during the volatility slowdown for both the US and the UK, and also differ substantially across countries (Mendoza et al. 1994, Carey and Rabesona 2004). The objective of this paper is to investigate whether there is a general link between taxes and output volatility.

While the heterogeneity of output volatility over time and across countries has been widely recognized in the literature, its cause remains subject to controversy (Stock and Watson 2002, 2005). Although there are a few exceptions, in general, little attention has been paid to the determinants of output volatility in this debate. Many economists refer to taxation as a major distortion in the economy. This makes it quite surprising that taxes have not been noticed among the potential candidates to explain volatility patterns.

The contribution of this paper is twofold. From a purely theoretical perspective, we show that in a stochastic version of the neoclassical model the (long-run) effect of distortionary

[1] The break for the US is often dated in 1984Q1 or 1984Q2 (Kim and Nelson 1999, McConnel and Perez-Quiros 2000) while other estimates range from 1982Q4 to 1985Q3 (Stock and Watson 2002).

[2] Cecchetti et al. (2006) identify two breaks in 1981Q2 and 1991Q4 for the UK.

taxation is on the second moment rather than on the first moment of output growth rates. In particular, we show that tax effects are not unidirectional specifying numerical results as per Greenwood and Huffman (1991). Using explicit solutions of the model, the tax on income is found to have a negative effect, whereas the tax on wealth amplifies output volatility measured by the standard deviation of output growth rates. Care has to be given to the underlying measure as effects on the volatility of variables in efficiency units are different. The consumption tax has no effect. Output volatility can be decomposed into the variance of the exogenous impulses and a component that is governed by fundamentals which reflects the variance of the growth rates of factor inputs. Taxes affect the latter by distorting the consumption-savings decision, which affects the variability of the rental rate of capital and finally translates into a change in macro volatility.

One of the most surprising findings of this paper is the strong empirical link between tax rates and output volatility. Using a panel of OECD countries from 1970 to 2004, our results demonstrate that the effects of taxes are robust and of economic relevance. Together with other controls, effective tax rates account for up to two thirds of the variation in output volatility. Conforming with theoretical results, taxes on labor income and corporate income are statistically significant and negatively correlated to output volatility, while the capital tax has the opposite effect. For the consumption tax we do not find statistically significant effects. These empirical results are found to be robust to the employed estimation method and potential non-normality of the residuals (bootstrapped errors).

There is now a large literature on macro volatility. Much of it focuses on less developed countries and financial development (Denizer et al. 2002, Lensink and Scholtens 2004) or institutions (Acemoglu et al. 2003). Our estimates confirm a robust link between output volatility and variables including the mean output growth, the variability of real effective exchange rates, measures of monetary policy and openness. Other controls are either not found to be statistically significant, such as variables based on government expenditures, or not robust, such as financial development among OECD countries.

This paper is most closely related to studies investigating why output growth has become less volatile in the US and many other OECD countries (among others McConnel and Perez-Quiros 2000, Stock and Watson 2002, 2005).[3] This literature emphasizes technological factors (e.g. improved inventory management) and improvements in central bank policy (e.g. credible monetary policy, inflation targeting). We are unaware of any empirical studies linking output volatility to tax rates. Our finding that taxation should be added to the potential explanations therefore is complementary to the previous work.

[3]The paper of Stock and Watson (2002) surveys a substantial literature on the big moderation. Recent work includes Kim et al. (2004), Cecchetti et al. (2006) and Justiniano and Primiceri (2006).

In the paper we proceed as follows. Section 2 studies tax effects on output volatility in a neoclassical model. Section 3 briefly describes the estimation strategy and the underlying measures. Section 4 presents the empirical results using various specifications. Section 5 provides a summary and concluding remarks.

2 Taxes and output volatility

This section provides a theoretical model for tax effects on output volatility. In order to save space, we relegate most of the derivations and proofs to the appendix.

2.1 The model

As the technological setup of the economy is close to (Posch and Wälde 2006, Posch 2007), we keep the first part brief. The introduction of government activities and the implications for household behavior are new and will be presented in more detail.

Production possibilities. The single production good is produced according to a standard Cobb-Douglas function,

$$Y_t = A_t K_t^{\alpha} (X_t L)^{1-\alpha}, \tag{1}$$

where L denotes total constant labor supply. In the tradition of standard macro models (King et al. 1988), A_t denotes total factor productivity and X_t labor augmenting technology. Output Y_t is used for producing consumption goods C_t and investment goods I_t. Aggregate capital stock increases if gross investment I_t exceeds depreciation δK_t,

$$dK_t = (I_t - \delta K_t)dt. \tag{2}$$

Uncertainty enters via two exogenous independent stochastic processes: a (geometric) diffusion with drift, A_t, driven by a standard Brownian motion z_t, and a (geometric) jump process, X_t, driven by a standard Poisson process q_t,

$$\begin{aligned} dA_t &= \mu A_t dt + \eta A_t dz_t, & (3) \\ dX_t &= \left((\exp(\nu))^{\frac{1}{1-\alpha}} - 1\right) X_{t-} dq_t, & (4) \end{aligned}$$

respectively.[4] We model the jump size proportional to its value an instant before the jump, X_{t-}, where $(\exp(\nu))^{\frac{1}{1-\alpha}} - 1$ specifies the constant jump size. As it will turn out below, ν denotes the size of the jump in output growth rates.

[4]Note that the standard Poisson process q_t can either be zero or one with mean and variance λt. Since z_t is a standard Brownian motion, $z_0 = 0$, $z_{t+\Delta} - z_t \sim \mathcal{N}(0, \Delta)$, $t \in [0, \infty[, \Delta > 0$.

Government. The government levies taxes on income, τ_i, on wealth, τ_a, on consumption expenditures, τ_c, and on investment expenditures, τ_k. It uses all revenues (cannot save or run debt) to provide basic government services G,

$$G_t = \tau_i(Y_t - \delta K_t) + \tau_k(I_t - \delta K_t) + \tau_c C_t + \tau_a(1+\tau_k)K_t \geq 0. \tag{5}$$

In this paper, we assume a myopic government simply providing basic government services without interest in neither stabilization policy nor optimal taxation. The tax structure thus is exogenously given to the model. Similarly, the absence of debt therefore is not relevant because we want to illustrate the incentive effects of distortionary taxation on output growth volatility of an elsewise frictionless economy. One could interpret the taxes as wedges between competitive prices and observed prices (Chari et al. 2007). Additional effects through the channel of fiscal debt might be interesting but beyond the scope of the paper.

Preferences. The economy is populated by a large number of infinitely-lived identical individuals, each sufficiently small to neglect effects on aggregate variables. Each consumer maximizes expected utility, U_0, given by the integral over instantaneous utilities, u, resulting from consumption flows, c_t, discounted at the rate of time preference, ρ,

$$U_0 = E_0 \int_0^\infty e^{-\rho t} u(c_t) dt, \tag{6}$$

where instantaneous utility is characterized by constant relative risk aversion,

$$u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma}, \quad \sigma > 0. \tag{7}$$

The budget constraint of the representative household reads (cf. Appendix A.1.1)

$$da_t = \left(\left(\frac{1-\tau_i}{1+\tau_k}(r_t - \delta) - \tau_a \right) a_t + \frac{1-\tau_i}{1+\tau_c} w_t - c_t \right) dt, \tag{8}$$

where w_t denotes the real wage rate, and r_t the rental rate of capital both before tax.

Equilibrium properties. In equilibrium, factors are rewarded by $w_t = Y_L$, and $r_t = Y_K$ (value marginal product), respectively. The market clearing condition demands

$$Y_t = C_t + I_t + G_t. \tag{9}$$

Note that the quantities C_t and I_t are after taxation. Since markets are perfectly competitive, the producer price of the production, consumption, and investment good will be identical,

$$p_t^y = p_t^c = p_t^k. \tag{10}$$

When consumption and investment goods are sold, they are taxed differently such that consumer prices are $(1+\tau_c)\, p_t^c$ and $(1+\tau_k)\, p_t^k$, respectively. In order to rule out arbitrage between different types of goods, we assume that once a unit of production is assigned for a special purpose it is useless for other purposes.

Solving the model requires the first order condition for consumption, the aggregate capital accumulation constraint (2), the goods market equilibrium (9), and optimality conditions of perfectly competitive firms. Thus we obtain a system of differential equations determining, given initial conditions, the time paths of C_t, K_t, Y_t, G_t, as well as of w_t and r_t.

2.2 Explicit solutions

Applying Itô's formula (or change of variable formula, cf. Sennewald 2007), the assumed production function in (1) implies that output evolves according to

$$\begin{aligned} dY_t &= Y_A dA_t + (Y_t - Y_{t-})\, dq + Y_K dK_t \\ &= (\mu + \alpha(dK_t/dt)/K_t)\, Y_t dt + \eta Y_t dz_t + (\exp(\nu) - 1) Y_t dq_t. \end{aligned} \tag{11}$$

It describes a stochastic differential equation (SDE), more precisely a jump-diffusion process which, for solving, demands more information about the behavior of households. In that the growth rate of the capital stock, $(dK_t/dt)/K_t$, is determined by households. We refer to this as the internal propagation mechanism. The impulses will be propagated contemporaneously as well as inter-temporally via capital accumulation.

The standard approach to solve the model is to consider a stationary system of equations and linearize the system to analyze transitional dynamics often around the non-stochastic steady state (among others King et al. 1988, Uhlig 1995). To illustrate tax effects on the volatility of macro aggregates, we restrict ourselves to particular parameter restrictions under which the model has explicit solutions. Based on them, simulations can be done without relying on the efficiency of numerical methods or linearization and certainty analysis.

It is well known from deterministic continuous-time models that at least for two cases we obtain unique analytical solutions. Note that restrictions on the parameter range are widely used in economics to study explicit dynamics (among others Xie 1991).

Theorem 2.1 *If the output elasticity of the capital stock equals the parameter of the utility function, $\alpha = \sigma$, consumption is a linear function of the capital stock, $C_t = \frac{1+\tau_k}{1+\tau_c}\phi K_t$, where*

$$\phi = \frac{\rho}{\sigma} + \frac{1-\sigma}{\sigma}\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right). \tag{12}$$

Proof. Appendix A.2.2. ■

Corollary 2.2 *The (before tax) rental rate of capital follows*

$$dr_t = c_1 r_t\, (c_2 - r_t)\, dt + \eta r_t dz_t + (\exp(\nu) - 1) r_{t-} dq_t, \tag{13}$$

where $c_1 \equiv \frac{1-\alpha}{\alpha}\frac{1-\tau_i}{1+\tau_k}$, *and* $c_2 \equiv \frac{1+\tau_k}{1-\tau_i}\left(\frac{\alpha}{1-\alpha}\mu+\rho+\frac{1-\tau_i}{1+\tau_k}\delta+\tau_a\right)$.

The SDE in (13) is a geometric mean-reverting jump-diffusion process and denotes a stochastic Verhulst equation (Sørensen 1991, p.97). Accordingly, c_2 defines the non-stochastic steady state or tendency parameter to which r_t reverts, and c_1 is the speed of reversion.

Corollary 2.3 *The growth rate of output per unit of time,* g_Δ*, reads*

$$\begin{aligned} g_\Delta &= \left(\mu-\rho-\tau_a-\frac{1-\tau_i}{1+\tau_k}\delta-\frac{1}{2}\eta^2\right)\Delta+\frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds \\ &\quad +\eta(z_t-z_{t-\Delta})+\nu(q_t-q_{t-\Delta}). \end{aligned} \tag{14}$$

Intuitively, the growth rate consists of a deterministic part and the integral over capital rewards (the memory of the stochastic process), the Brownian motion component, and the jump component. Another solution where $\sigma > 1$ gives exactly the same structure and is provided in the appendix. Note that the integral over capital rewards refers to the growth rate of the capital stock in (11) which in turn is determined by the investment decisions. The next corollary clearly demonstrates that this integral has an intuitive economic interpretation and indeed stems from the optimization problem of the representative household.

Corollary 2.4 *The growth rate of consumption per unit of time,* g^c_Δ*, reads*

$$g^c_\Delta = \frac{1}{\sigma}\frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds-\frac{1}{\sigma}\left(\rho+\tau_a+\frac{1-\tau_i}{1+\tau_k}\delta\right)\Delta. \tag{15}$$

It can be interpreted as the discrete version of the Euler equation the case of $\alpha = \sigma$. By implementing their optimal strategy, households affect the output growth rate in the short run by their consumption-saving decision. In what follows we show that (long-run) tax effects on the volatility of growth rates are due to this channel.

2.3 Theoretical effects of taxation

We are now interested in the tax effects on the output growth rate per unit of time. Clearly as a standard result, taxation affects growth rates in the short run directly as well as indirectly via capital accumulation as from (14) and (15), which has already been widely discussed in the literature. To derive effects of taxation on the distribution of growth rates, however, it will be necessary to look at long-run effects or moments of the growth rate.

It follows from the economy's resource constraint (9) that aggregate consumption in expectation can only grow at constant rates indefinitely if it grows at the same expected rate as output. In particular, we observe $Eg_\Delta = Eg^c_\Delta$, and obtain (see Appendix A.2.7)

$$E(g_\Delta) = \frac{1}{1-\alpha}\left(\mu - \frac{1}{2}\eta^2 + \nu\lambda\right)\Delta, \tag{16}$$

$$Var(g_\Delta) = Var\left(\frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds + \eta(z_t - z_{t-\Delta}) + \nu(q_t - q_{t-\Delta})\right). \tag{17}$$

On the one hand we obtain the standard result that in a model of exogenous growth taxes do not affect the (long-run) first moment of the growth rate (16). Comparing the result to a corresponding deterministic setup, two additional terms appear. First, a negative term, $-\frac{1}{2}\eta^2$, often referred to as precautionary savings component (or Jensen's inequality term). Second, an intuitive positive component, $\nu\lambda$, resulting from the discrete arrivals of new technologies, simply denoting the arrival rate times the size of the jumps. On the other hand, though completely neglecting transitional effects, taxes do affect the (long-run) variance of the growth rate indirectly by affecting the variance of the rental rate of capital, a result which has been neglected so far. Moreover, it is easily conceivable that if the variance, λ, and/or the size of impulses, ν, were endogenous as well (growing through cycles models), taxes could even directly affect the variability of the output growth rate.

Unfortunately, the analytic derivation of the second moment of r_t is tedious and thus omitted here (one may use the explicit solution of r_t to derive the moments).[5] We suffice to show tax effects on higher moments of r_t by demonstrating that - in contrast to the growth rate of output and consumption - its first moment depends on tax rates, and derive effects on the second moment by intuition as well as through simulations. Using (14) together with (16), the first moment of capital rewards can be derived as,

$$E\int_{t-\Delta}^{t} r_s ds = \frac{1+\tau_k}{1-\tau_i}\left(\rho + \tau_a + \frac{1-\tau_i}{1+\tau_k}\delta + \frac{\alpha}{1-\alpha}\mu - \frac{\alpha}{1-\alpha}\frac{1}{2}\eta^2 + \frac{\alpha}{1-\alpha}\nu\lambda\right)\Delta \tag{18}$$

$$\Leftrightarrow\ E(r_t) = \frac{1+\tau_k}{1-\tau_i}\left(\frac{\alpha}{1-\alpha}\mu + \rho + \frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) + \frac{1+\tau_k}{1-\tau_i}\frac{\alpha}{1-\alpha}\left(\nu\lambda - \frac{1}{2}\eta^2\right). \tag{19}$$

Recalling from (13) that innovations to r_t are *proportional* to the level, namely $\eta r_t dz_t$ and $(\exp(\nu)-1)r_{t-}dq_t$, an increase in the first moment also leads to a higher variability of r_t. Obviously, the first moment in (19) is positively affected by the investment tax, τ_k, the income tax, τ_i (neglecting Jensen's inequality term), as well as the tax on wealth, τ_a. Similarly as from (19), the first moment of the after-tax rental rate of capital, $\frac{1-\tau_i}{1+\tau_k}E(r_t)$ is negatively affected by τ_k and τ_i by lowering the effective depreciation rate, and positively affected by τ_a. Because the latter contributes to the variability of output growth in (17), tax effects on

[5] An analytical measure of macroeconomic volatility as well as analytical tax effects in an endogenous growing trough cycle model are contained in Posch and Wälde (2006).

the variance of output growth tend to be positive for τ_a, but negative for τ_i and τ_k, whereas the tax on consumption, τ_c, is neutral.[6]

Economically speaking, a positive tax on wealth, $\tau_a > 0$, distorts the consumption-saving decision. Incentives for capital accumulation will be lower since *net* capital returns decrease like the effect of an increased depreciation rate. Individuals prefer more consumption today than deferring it to the future. The non-stochastic steady state value for capital rewards increases (effective capital stock decreases) as less resources are used for capital accumulation. Because innovations increase proportionally, they result into a higher variance of capital rewards. As this variance contributes to the propagation component of output volatility, an increase in τ_a finally translates into higher output volatility in (17).

2.4 Simulated effects of taxation

In this section we derive qualitative and quantitative effects of tax rates on moments of different macro aggregates. Due to the simplicity of our model we do *not* aim to match the data. Our quantitative effects could be magnified by introducing various kinds of price rigidities or adjustment costs which are known to lower the dynamics of macro variables. These experiments are intended to serve as exercises that are illustrative of tax effects in the neoclassical stochastic growth model, abstracting from any further kinds of distortions.

There is a large literature studying the effects of fiscal policy on GDP and its components, e.g. Blanchard and Perotti (2002) analyze the effects of tax shocks on output. However, little attention has been given to study tax effects on the shock propagation. The empirical literature also suggests that the propagation component has changed substantially over time, contributing to the volatility decline after 1980 (see Perotti 2005 and the references therein). As shown above, taxes do not affect the (long-run) mean of the growth rate while affecting the variance of output growth by changing the propagation of shocks. Hence, our findings are consistent with the VAR evidence that on the one hand effects of fiscal policy on the mean output growth rate are generally small or temporary, and that on the other hand the propagation mechanism has changed substantially after 1980s.

Greenwood and Huffman (1991) find simulating a RBC model that distortional taxes (income taxes as well as a negative investment tax) tend to amplify technology shocks, relative to what would happen if there were no such taxes. Based on explicit solutions we confirm their numerical finding of an endogenous shock amplifier in the neoclassical model. However, as shown above, tax effects are more versatile, specifying and extending their numerical findings. For example, given our explicit solution, the income tax, τ_i, as well

[6]The covariance of capital rewards with the stochastic impulses from (13) tends to be positive as both increments increase r_t instantaneously. In our simulations, however, these effects are negligible.

Table 1: Qualitative tax effects on macro volatility

measure	income tax, τ_i	consumption tax, τ_c	investment tax, τ_k	tax on wealth, τ_a
$mean(g_\Delta)$	0	0	0	0
$sd(g_\Delta)$	$-$	0	$-$	$+$
$sd(y^c_{HP})$	$-$	0	$-$	$+$
$mean(r_t)$	$+$	0	$+$	$+$
$sd(r_t)$	$+$	0	$+$	$+$
$mean(g^c_\Delta)$	0	0	0	0
$sd(g^c_\Delta)$	$-$	0	$-$	$+$
$cv(\hat{u}_t)$	$+$	0	$+$	$-$
$sd(\hat{y}_t - \hat{y})$	$+$	0	$+$	$-$

Notes: This table shows the qualitative tax effects of time-invariant tax rates on macro variables. The measures include the mean and *sd* of output growth rates, the *sd* of HP-filtered cyclical components, the mean and *sd* of before-tax capital rewards, the mean and *sd* of consumption growth rates, the *cv* of cyclical utility, as well as the *sd* of cyclical output as percentage deviations from a steady state. Note that these are long-run effects, i.e. abstract from transitional dynamics after a tax change.

as the investment tax, τ_k, increase the volatility of macro aggregates in efficiency units by lowering the effective rate of depreciation (cf. also Posch and Wälde 2006), but decrease output and consumption growth volatility. The intuition behind this result is that variables in efficiency units tend to increase whenever (after-tax) capital rewards decrease.

In Table 1, we summarize qualitative tax effects on macro volatility. Given our explicit solution, as long as we have positive depreciation ($\delta > 0$) together with the presence of shocks, the qualitative effects are independent of model calibration and parametrization.[7] For comparison with previous work, two further measures are introduced. The first, $cv(\hat{u}_t)$, denotes a scale independent measure of dispersion based on the coefficient of variation (cv) of stochastically detrended instantaneous utility (Posch and Wälde 2006). The second measure, $sd(\hat{y}_t - \hat{y})$ is based on a widely used macro variable denoting percentage deviations of cyclical output from some steady state (Greenwood and Huffman 1991). Both measures are based on stationary cyclical components of a Beveridge-Nelson type decomposed series. In addition, qualitative effects on HP-filtered cyclical components based on simulations are reported.

To examine the quantitative effects of tax rates on macro volatility, we compute semi-elasticities in the appendix (Table A.1). For a plausible tax scenario (details are below), the predicted change in macro volatility is sizable. It ranges depending on the measure between -6.4% for output growth volatility to -22.8% for consumption growth volatility.[8]

[7] Note that from (19) the sign could flip for before-tax capital rewards if η is extremely large. In such an unusual case, Jensen's inequality term could exceed the other effects with no effects on the other measures.

[8] In contrast, measures based on variables in efficiency units (per effective labor) increase by 18.1% using the *cv* of cyclical utility, or by 17.9% using cyclical output as percentage deviations from the steady state.

2.5 Taking the model to the data

After having attained the theoretical effects as well as the simulated results, we want to obtain empirical estimates. To this end, we use our explicit solution for the growth rates to illustrate our empirical strategy. We rewrite (14) as

$$g_\Delta \equiv E(g_\Delta) + \varepsilon_\Delta, \tag{20}$$

where the residual variable, ε_Δ, reads after inserting (14) and (18),

$$\begin{aligned}\varepsilon_\Delta &= \left(\mu - \rho - \tau_a - \frac{1-\tau_i}{1+\tau_k}\delta - \frac{1}{2}\eta^2\right)\Delta + \frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds - E(g_\Delta) \\ &\quad + \eta(z_t - z_{t-\Delta}) + \nu(q_t - q_{t-\Delta}) \\ &= \frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds - E\left(\frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds\right) + \eta(z_t - z_{t-\Delta}) + \nu(q_t - q_{t-\Delta}),\end{aligned}$$

which has mean zero and tax-dependent variance. It simply denotes the deviation of the actual growth rate from its long-run mean, or capturing the transitional dynamics of the neoclassical model. If capital rewards are above average (technically if the capital stock is below its non-stochastic steady state), the growth rate is higher than its long-run mean.

From an econometric point of view, we can exploit the fact that ε_Δ is a residual term with mean zero and tax-dependent variance by explicitly modeling (and estimating) an *unobserved* heteroscedasticity process as follows,

$$\begin{aligned} g_\Delta &= \theta + \varepsilon_\Delta, \quad \text{where} \quad E(g_\Delta) = \theta,\ E(\varepsilon_\Delta) = 0,\ Var(\varepsilon_\Delta) = h_\Delta, \\ h_\Delta &= f(\text{taxes}). \end{aligned}$$

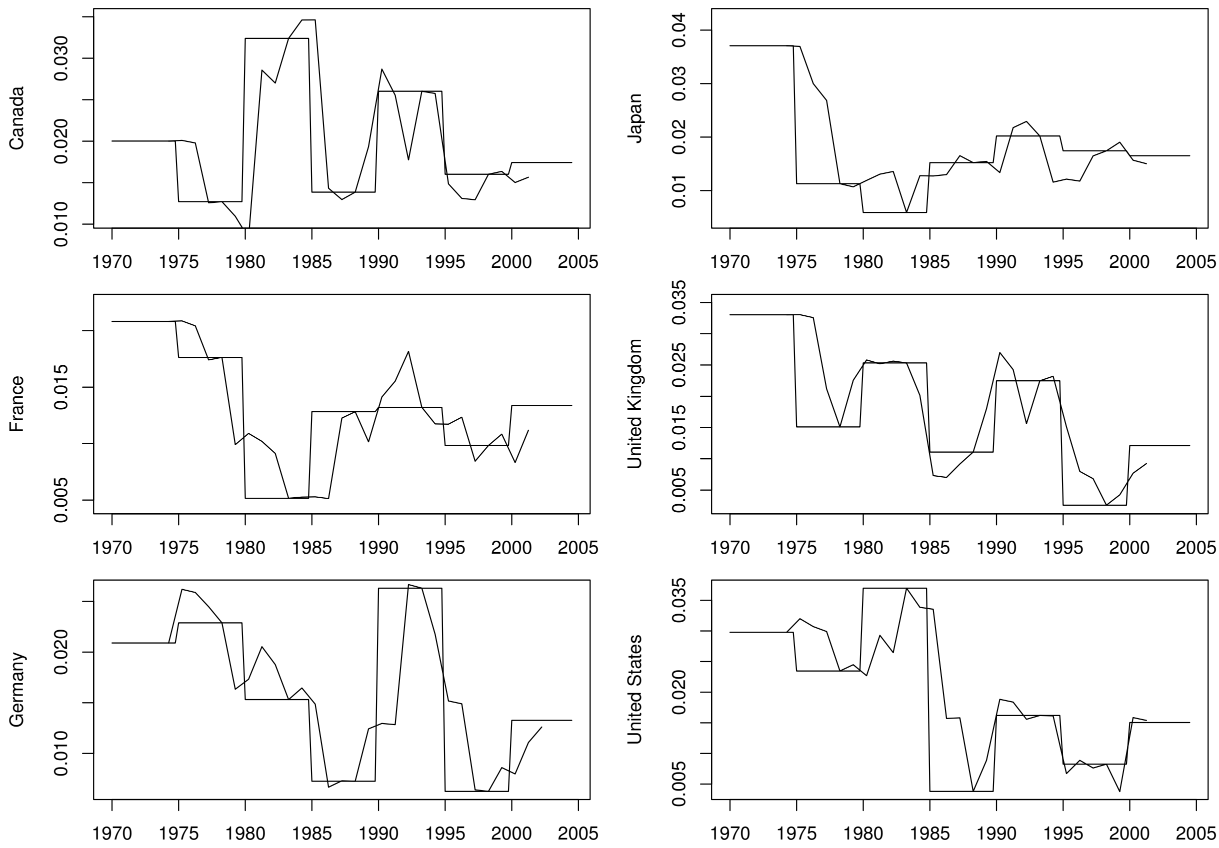
Simply neglecting transitional dynamics in the growth equation allows us to analyze the properties of a model where the second rather than the first moment depends on tax rates.

3 Data and estimation strategy

Our approach to studying differences in output volatility is to employ a panel of 20 OECD countries spanning the years 1970 to 2004. It provides the possibility of generating more accurate predictions for individual observations than time series data alone. If countries behave similar conditional on certain variables, as we would expect for incentives through tax rates, panel data provide the possibility of learning the behavior of a single country by observing the behavior of other countries (cf. Hsiao 2003).

Data. In what follows we construct empirical measures of output volatility as well as measures of the effective tax burden at the macro level. There seems to be a consensus in

Figure 1: Comparison of different *observed* volatility measures for key countries



Notes: These figures compare *observed* volatility measures for key countries starting in 1970. The first measure results from a fixed-window (five-years) approach gathering the period specific *sd* of annual growth rates of real GDP per capita, while the second measure is based on five-year rolling *sd* of annual growth rates of real GDP per capita.

the literature on the "Great Moderation" that an appropriate empirical measure of output volatility is based on the *sd* of the real GDP growth rate. As results are robust with respect to different measures, our focus is on the *sd* of annual growth rates per capita (APC).[9] Though the main reason for using data with annual frequency is the availability of tax measures, our results will not depend on a specific method of seasonal adjustment in the data which might be worrisome when analyzing volatility patterns.

In order to compute meaningful measures of output volatility, we need either to collapse several observations into one period using fixed windows *or* using a rolling window approach. While the first approach throws away a lot of information, the latter has some dubious statistical properties. Nonetheless they are useful for the purpose of illustration, and widely

[9]Similar results based on quarter-to-quarter growth rates (QGR) on four-quarter rolling growth rates (AGR), as well as on HP-filtered cyclical components (CYC) are provided in a separate appendix.

Table 2: Linking theoretical tax rates to tax ratios

	income tax, τ_i	consumption tax, τ_c	investment tax, τ_k	tax on wealth, τ_a
$LABOR$	×			
$CAPITAL$	×		×	×
$CORP$	×			
$CONS$		×		

Notes: Based on Mendoza et al.'s (1994) definitions (see Appendix A.4.2), $LABOR$ denotes the labor income tax ratio, $CAPITAL$ is capital tax ratio (including taxes on property), $CORP$ is the corporate income tax ratio, $CONS$ is the consumption tax ratio. Taxes on investment goods are included only in the Carey and Rabesona (2004) tax ratio.

used in the literature. To compare our results with other studies, it seems convenient to have both. For the first approach, we make use of two windows (five-years and ten-years), and gather the mean and the standard deviation of variables over the respective time periods starting in 1970. In the latter approach, we use the five-year rolling standard deviation of output growth rates as in Blanchard and Simon (2001). Both measures clearly indicate that output volatility differs substantially over time and across countries (cf. Figure 1).

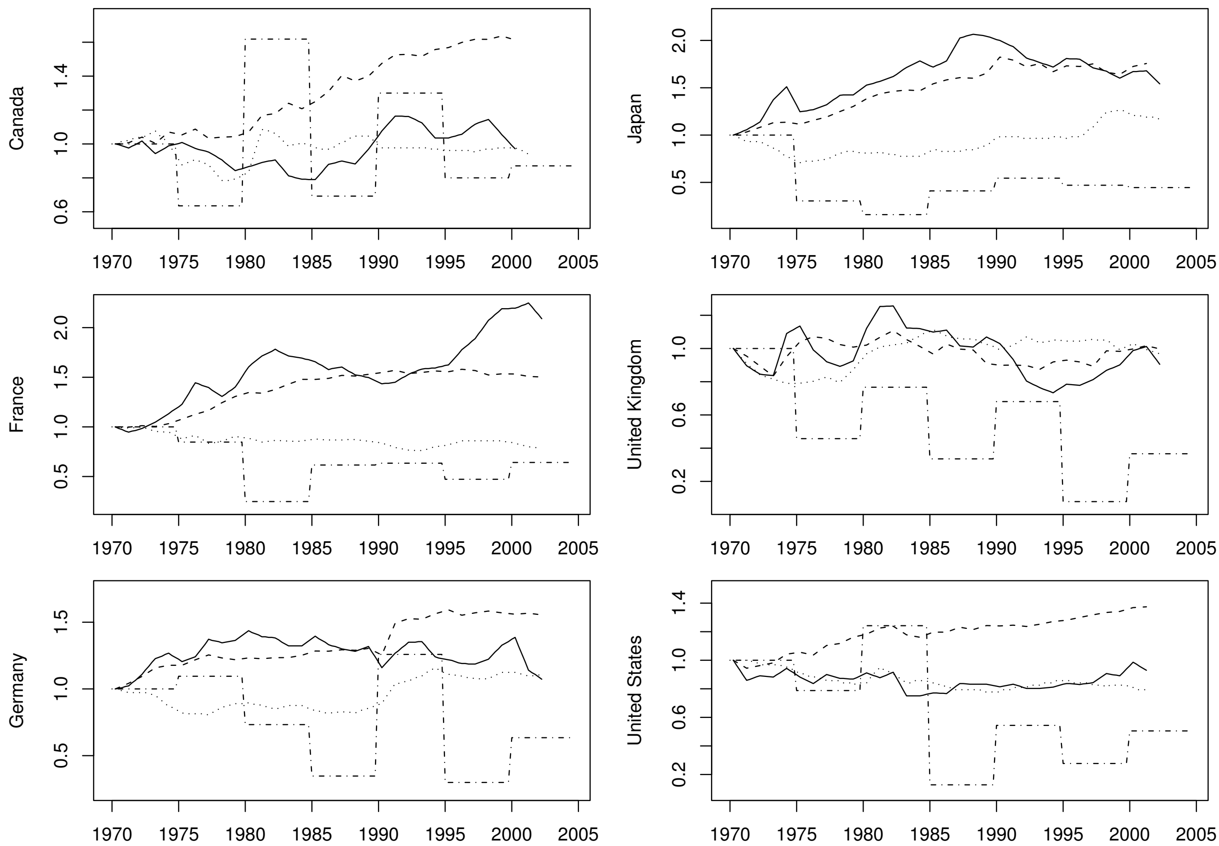
To measure the average tax burden of a representative household on the macro level we choose the approach of Mendoza et al. (1994).[10] Accordingly, we employ three different types of taxes, namely a labor income tax measuring the tax induced cost of dependent labor ($LABOR$), i.e. taxes on household labor income, security charges and payroll taxes; a capital tax measuring the cost of capital through taxation ($CAPITAL$), i.e. taxes on capital income, taxes on the capital stock as well as on capital transactions; a corporate income tax measuring the tax burden of corporations ($CORP$); and a consumption tax ($CONS$), i.e. taxes on goods and services and excise taxes. Most notably, though often labeled as an income tax, $CAPITAL$ contains taxes on property, including recurrent taxes on immovable property as well as taxes on financial and capital transactions.[11] This comprises inheritance taxes which, given an infinite horizon framework, rather could be interpreted as taxes on wealth than on income. To this end, the empirical tax ratios convey the meaning of theoretical tax rates as summarized in Table 2. In that view, $LABOR$ and $CORP$ are pure taxes on income, whereas $CAPITAL$ measures the tax burden associated with capital income, capital flows and the capital stock.

Figure 2 shows the time path of tax ratios and five-year standard deviation of output growth rates for major countries from 1970, illustrating the time dimension of our panel.

[10] We also used modifications of Carey and Rabesona (2004) for effective tax rates with similar results.

[11] Ideally the tax on the capital stock should be separated from the tax on capital income as effects on volatility are different. However due to missing data of the tax base for most countries, i.e. measures of the capital stock, we follow the common practice and allocate these taxes to the cost of capital ($CAPITAL$).

Figure 2: Tax ratios and *observed* volatility for key countries



Notes: These figures illustrate the time paths of tax ratios for capital ($CAPITAL$, solid), labor income ($LABOR$, dashed), and consumption ($CONS$, dotted) together with the *sd* of annual growth rates of real GDP per capita (dot-dashed) using the fixed-window (five-years) approach (cf. Figure 1, dot-dashed) for key countries (1970=1).

Its seems notable that abrupt changes of $CAPITAL$ as a result of major tax reforms that coincide with breaks in output volatility in the 1980s and the 1990s can be observed for the UK and the US, respectively. For illustration, the UK capital transfer tax (replaced by the inheritance tax in 1986) was cut from 75 percent in 1984 to 40 percent in 1988 accompanied by an increase of the threshold from $25,000$£ in 1980 to $200,000$£ in 1995. As a matter of fact, the contribution of property tax revenues to $CAPITAL$ in the UK substantially declined from 30.2 percentage points in 1981 to 13.8 percentage points in 1992. Similarly, there is considerable heterogeneity in the cross-sectional dimension of our panel as illustrated in scatter plots of output volatility versus tax rates (see Appendix A.5, Figures A.1 and A.3), respectively. Though there seem to be some regularities in the data, no clear cut conclusion can be drawn by simply looking at the graphs.

Other controls used in volatility estimations (cf. Blanchard and Simon 2001, Denizer et al. 2002, Lensink and Scholtens 2004, Cecchetti et al. 2006) include the average growth rate of real per capita output ($GROW$), the mean and *sd* of the inflation rate ($INFL$, $INFLSD$), the mean and *sd* of government final consumption expenditures as a share of output ($GGDP$, $GGDPSD$), the degree of openness of the economy as measured by the ratio of exports plus imports to output ($OPEN$), the *sd* of real effective exchange rates ($XRSD$), as well as the allocation of total credit to the private sector as percentage of GDP measuring financial development ($PRIVY$). Basically, it is assumed that financial systems that allocate more credit to the private sector are more engaged in providing risk management services.

Estimation strategy. We are now prepared to address our empirical question: conditional on other controls, does output volatility vary systematically with tax rates? To this end, we jointly estimate the parameters of the following system,[12]

$$\Delta y_{it} = \theta_i + \varepsilon_{it}, \quad \text{where} \quad \varepsilon_{it} \sim \mathcal{N}(0, \sigma_{it}^2), \tag{21a}$$

$$\log(\sigma_{it}) = \alpha_i + \lambda_t + \beta' x_{it} + \gamma' z_{it}. \tag{21b}$$

Here, Δy_{it} is the growth rate of output per capita for country $i = 1, ..., N$ and $t = 1, ..., T$, expressed in log differences. In that θ_i is a country-specific mean and σ_{it} denotes the *sd* of the residuals ε_{it}. Our primary focus is on the *unobserved* volatility process (21b) which models the log of σ_{it} as a linear function of country- and time-specific effects, $\alpha_i + \lambda_t$, as well as tax rates, x_{it}, and other controls, z_{it}. This specification simply ensures that σ_{it} is positive. Another convenient property is that semi-elasticities can easily be obtained for both the variance *and* the *sd* of output growth rates as they are proportional, $\log(\sigma_{it}^2) = 2\log(\sigma_{it})$.

In the terminology of Nelson (1991), our system (21a) to (21b) is nested in an exponential autoregressive conditional heteroscedasticity (ARCH) model. Our approach substantially extends the econometric framework of Ramey and Ramey (1995), giving more flexibility for the conditional variance to vary over time by including additional controls and D time dummies. The parameter vector $\vartheta = (\theta_1, ..., \theta_N, \lambda_1, ...\lambda_D, \beta, \gamma)'$ will be estimated jointly using maximum likelihood (ML) in which the variances are treated as parameters. It is straightforward to show that the log-likelihood function reads apart from a constant

$$\ell(\vartheta)_{NT} = -\sum_{t=1}^{T}\sum_{i=1}^{N} \log(\sigma_{it}) - \frac{1}{2}\sum_{t=1}^{T}\sum_{i=1}^{N} (\varepsilon_{it}/\sigma_{it})^2. \tag{22}$$

Moreover, under sufficient regularity conditions, the maximum likelihood estimator is consistent and asymptotic normal. We use this result to obtain asymptotic standard errors based on the information matrix using the outer product estimate.

[12]Comparing our model to Section 2.5, the assumption of normality seems not appropriate in the presence of jumps. A natural way to proceed is using either the correct (unknown) distribution or a quasi-maximum estimation technique. To start with, we simply assume normality and leave it for future research.

For a quick look at the data, we begin estimating the following econometric model,

$$\log(\sigma_{it}) = \alpha_i + \lambda_t + \beta' x_{it} + \gamma' z_{it} + u_{it}, \tag{23}$$

using *observed* volatility measures, σ_{it}, denoting the *sd* of annual output growth rates per capita in the fixed window $t = 1, ..., T$, where $T = 7$ (five-years) or $T = 4$ (ten-years), for country $i = 1, ..., N$.[13] Similar to (21b), the log of σ_{it} is modeled as a function of country- and time-specific effects, $\alpha_i + \lambda_t$, tax rates, x_{it}, other controls, z_{it}, and an uncorrelated error term with mean zero and equal variance, u_{it}. A straightforward strategy is to obtain parameter estimates using the least square dummy variable (LSDV) approach. To avoid that results are driven by few outliers, we also use iterated weighted least squares (IWLS) estimation.[14]

So far, we have treated our variables by country as $I(0)$. However, tax rates or other controls may be (locally) non-stationary. If tax rates and (unobserved) output volatility actually are $I(1)$, respectively, our results may be either spurious or superconsistent. The latter is true if there was a cointegrating relationship. Obviously, a formal test of cointegration cannot be applied to unobserved variables. Nevertheless, to strengthen our result of a long-run relationship between taxes and output volatility, we extend our analysis to a *dynamic* approach, assuming variables by country to be at least $I(1)$,

$$\Delta y_{it} = \theta_i + \varepsilon_{it}, \quad \text{where} \quad \varepsilon_{it} \sim \mathcal{N}(0, \sigma_{it}^2), \tag{24a}$$

$$\Delta \log(\sigma_{it}) = \alpha_i + \lambda_{t-1} + \beta' x_{i,t-1} + \gamma' z_{i,t-1} + \rho \log(\sigma_{i,t-1}), \tag{24b}$$

with given country-specific initial conditions $\sigma_{i,0}$. Obviously, the estimated parameters are not directly comparable with the *static* approach (21b) as long as $\rho \neq -1$. Note that our approach closely follows the cointegration idea similar to an error correction specification: Suppose that tax rates and output volatility are *not* cointegrated. In order to balance the time series property that the left-hand side of (24b) is stationary, β and γ as well as ρ cannot be different from zero to obtain stationarity on the right-hand side (note that if the controls were stationary before, there is no point in that extension).[15] Collecting terms in (24b), the system turns out to be nested in an exponential generalized autoregressive conditional heteroscedasticity (GARCH) model (Nelson 1991). Once we obtained the parameter estimates, we can actually check whether or not the conditional variance is $I(1)$.

[13] See Blanchard and Simon (2001) or a recent study by Jaimovich and Siu (2007) for a similar specification. One concern in this specification is that the results might be spurious. As the time horizon using the fixed-window specification is very short, this is not as problematic as using rolling-windows.

[14] It is well known that the least squares estimator is particularly sensitive to small numbers of atypical data points when the sample size is small or moderate. Using regression diagnostics for influential data points (leave-one-out deletion) suggests that a small number of observations have potentially large effects.

[15] We are not aware of any research on cointegration within the conditional variance equation. According to the standard cointegration principle, however, one should add an error term to equation (24b) as in (25). This would lead to a stochastic volatility model which might be an interesting path for future research.

As a quick check, we estimate an error correction specification similar to (24b),

$$\Delta \log(\sigma_{it}) \;\; = \;\; \alpha_i + \lambda_{t-1} + \beta' x_{i,t-1} + \gamma' z_{i,t-1} + \rho \log(\sigma_{i,t-1}) + v_{it}, \tag{25}$$

where σ_{it} denotes the observed sd of annual output growth rates per capita in the five-year fixed-window t for country i, and v_{it} again is an uncorrelated error term with mean zero and equal variance. A formal test of no cointegration amounts to testing the null hypothesis of the parameters in front of the controls to be zero (cf. Banerjee 1999).

4 Empirical results

This section gives the estimation results. Following our estimation strategy, we use observed volatility measures as initial estimates to get a general idea about effects present in the data. We then fully exploit the panel structure by treating unobserved variances as parameters.

4.1 Initial estimates

Static panel estimation. A quick answer to the empirical question is summarized in Table 3 which gives estimates for the semi-elasticities of various controls on *observed* output growth volatility (percentage change of σ_{it} given a percentage point increase of the control variable) for our model in (23). It shows that output volatility indeed can be explained by various fundamentals capturing roughly half of the variability of our volatility measure. Our key parameter vector of interest is β, which links our empirical tax ratios to volatility.

We find quite robust empirical evidence for tax effects on output volatility in line with our theoretical results (compare with Tables 1 and 2). Moreover, these effects are similar and about the same order of magnitude among different estimators, window spans, and various volatility measures (cf. also Appendix A.5). To summarize, effects of taxes on corporate income ($CORP$) and on labor income ($LABOR$) are statistically significantly different from zero and negative. Holding constant other variables, an increase of $LABOR$ by one percentage point decreases output volatility by five to eight percent. In contrast, the capital tax ratio ($CAPITAL$) is positively related whereas the consumption tax ($CONS$) has no clear effect. Figures A.2 and A.4 illustrate the relationship by plotting taxes against estimated volatility, after removing the effects of other controls. Estimates of the other controls are in line with the literature. The estimate for the mean growth rate ($GROW$) confirms a significantly negative effect on output volatility at least for the ten-year fixed-window. Similar to other studies, the effect is quite sizable: a percentage point increase in the mean growth rate is associated with a decrease in output volatility by twenty to thirty percent (Lensink and Scholtens 2004, Aghion and Howitt 2006). Measures of openness ($OPEN$),

Table 3: Static panel estimation, *observed* volatility measures (fixed-windows)

OECD		LSDV (five-year)	IWLS (five-year)	LSDV (ten-year)	IWLS (ten-year)
$LABOR_{it}$	β_1	−8.28 (2.03) ***	−7.83 (1.83) ***	−5.72 (1.92) **	−5.43 (1.94) **
$CAPITAL_{it}$	β_2	6.24 (1.46) ***	5.01 (1.43) **	5.54 (1.43) ***	4.55 (1.42) **
$CONS_{it}$	β_3	5.89 (2.40) *	4.79 (2.74) ·	−0.41 (2.68)	−0.48 (2.85)
$CORP_{it}$	β_4	−3.83 (0.90) ***	−3.15 (0.92) ***	−2.89 (1.08) **	−2.28 (0.98) *
$GROW_{it}$	γ_1	−8.18 (5.02)	−7.37 (4.89)	−29.77 (8.23) ***	−21.30 (7.49) **
$PRIVY_{it}$	γ_2	−0.30 (0.40)	−0.31 (0.41)	−0.47 (0.34)	−0.36 (0.41)
$INFL_{it}$	γ_3	−5.70 (2.00) **	−6.84 (2.05) ***	−4.86 (2.36) *	−3.71 (2.70)
$INFLSD_{it}$	γ_4	10.24 (3.83) **	10.72 (3.35) **	6.45 (2.78) *	5.93 (3.46) ·
$OPEN_{it}$	γ_5	2.61 (0.76) ***	2.43 (0.75) **	1.73 (0.58) **	1.21 (0.69) ·
$XRSD_{it}$	γ_6	1.30 (2.08)	3.13 (1.90) ·	2.90 (2.97)	3.61 (2.71)
$GGDP_{it}$	γ_7	−2.46 (3.64)	−1.45 (3.73)	−5.09 (3.38)	−2.59 (3.92)
$GGDPSD_{it}$	γ_8	48.84 (14.52) **	39.33 (14.92) *	−4.01 (11.33)	−7.82 (11.30)
Degrees of freedom		85	85	38	38
Adjusted R-squared		0.43		0.48	
F-statistic		3.53		2.95	
Country fixed effects	α_i	yes	yes	yes	yes
Time fixed effects	λ_t	yes	yes	yes	yes

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the fixed-effects model (23) using the least square dummy variable approach (LSDV) and iterated weighed least squares estimation (IWLS), explaining the *sd* of annual growth rates of real GDP per capita. Standard errors of White's heteroscedasticity-consistent covariance matrix estimators (HCCME) in the LSDV approach, and of $R = 4999$ model-based bootstrap replicates using the adjusted percentile method for IWLS estimates are in parentheses.

exchange rate volatility ($XRSD$), government expenditures volatility ($GGDPSD$), inflation rate volatility ($INFLSD$) are often positively related. Somewhat controversial, we find that the mean of inflation rate ($INFL$) is negatively related to output volatility. In other studies either no statistically significant effect (Denizer et al. 2002) or a positive effect (Lensink and Scholtens 2004) is found. The sign for the effect of government expenditures ($GGDP$) slightly indicates an active anti-cyclical government policy. However, the effects are fragile and insignificant in the specifications shown above. Similarly, in some specifications we find a significant negative effect of financial development ($PRIVY$) (see also Denizer et al. 2002, Cecchetti et al. 2006). This result is not found to be robust which puts into question the importance of financial development being among the explanatory variables for the OECD countries, rather suggesting that it is mainly driven by a few outliers.

Dynamic panel estimation. To avoid a spurious association, we quickly check our results estimating (25). Collecting terms gives the endogenous variable $\log(\sigma_{it})$ as a function of its lagged value and other controls. As is well known, the coefficients in dynamic panels are biased due to the presence of individual effects (Nickell 1981). Various solution techniques

Table 4: Dynamic panel estimation, *observed* variances (fixed-windows)

OECD		LSDV-BC (i) (five-year)	LSDV-BC (ii) (five-year)	LSDV-BC (iii) (five-year)	LSDV-BC (iv) (five-year)
$LABOR_{i,t-1}$	β_1	−3.37 (2.24)	−5.93 (3.35) ·	−8.24 (1.95) ***	−7.44 (3.14) *
$CAPITAL_{i,t-1}$	β_2	5.78 (1.94) **	7.40 (2.58) **	6.41 (2.03) **	8.42 (2.54) **
$CONS_{i,t-1}$	β_3	1.66 (3.21)	2.00 (4.85)	0.22 (2.99)	5.14 (4.34)
$CORP_{i,t-1}$	β_4	−2.49 (1.30) ·	−2.94 (1.66) ·	−2.97 (1.37) *	−3.55 (1.64) *
$GROW_{i,t-1}$	γ_1		−3.04 (7.82)		11.08 (6.68)
$PRIVY_{i,t-1}$	γ_2		0.20 (0.76)		0.22 (0.68)
$INFL_{i,t-1}$	γ_3		2.61 (3.25)		3.79 (3.01)
$INFLSD_{i,t-1}$	γ_4		−3.23 (5.85)		−1.28 (5.30)
$OPEN_{i,t-1}$	γ_5		0.79 (1.54)		−0.04 (1.30)
$XRSD_{i,t-1}$	γ_6		−2.21 (3.08)		1.09 (2.98)
$GGDP_{i,t-1}$	γ_7		1.79 (6.25)		−2.39 (5.57)
$GGDPSD_{i,t-1}$	γ_8		28.63 (24.62)		49.37 (23.74) *
$\sigma_{i,t-1}$	$1+\rho$	−0.15 (0.11)	−0.21 (0.15)	−0.23 (0.13) *	−0.32 (0.13) *
Country fixed effects	α_i	yes	yes	yes	yes
Time fixed effects	λ_{t-1}	yes	yes	no	no
Degrees of freedom		89	68	94	73
Adjusted R-squared		0.26	0.19	0.11	0.13
F-statistic		2.43	1.67	1.63	1.51

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the *dynamic* model specification (25) using the least square dummy variable approach (LSDV) with the proposed bias correction for dynamic panel models of Bun and Carree (2005), explaining the *sd* of annual growth rates of real GDP per capita. Biased-corrected standard errors are in parentheses.

have been proposed in the literature. Most approaches themselves have important drawbacks as they may require additional decisions regarding which and how many instruments to use or the performance may depend on model specific properties (see Bun and Carree 2005). In what follows, we use a bias-correction for the LSDV estimator as proposed by Bun and Carree. As a result we find only a small bias due the fact that the parameter of the lagged endogenous variable in the model, $1+\rho$, is close to zero (see Table 4). Our key parameter, ρ, therefore is estimated between -1.15 (0.11) and -1.32 (0.13) with associated biased corrected standard deviation in parentheses. A formal test of no cointegration, $\rho = 0$, would be rejected at any conventional significance level. An important caveat is that Monte Carlo experiments suggest that a time dimension ($T = 6$) is too short for residual-based tests for the null of no cointegration in order to draw meaningful inference (see Pedroni 2004).

4.2 A thorough investigation

We further examine the relationship between output growth volatility and various control variables including taxes by fully taking advantage of the panel structure of our data set.

Static panel estimation. We start estimating (21a) and (21a) without additional controls, then proceed using a similar specification as in Table 3. However, we need to change the nature of the variables included in the z_{it} vector as follows. To obtain volatility measures of shocks to the inflation rate, government expenditures, and the real effective exchange rate, respectively, we follow Ramey and Ramey (1995) and use the innovations to country-specific one-step ahead forecasting equations that include a constant, a linear time trend, a quadratic time trend, and specific controls. Instead of squared residuals we use absolute values for better interpretation. For the innovations to the inflation forecast ($INFLFI$) we make use of a generalized Phillips curve based on measures of aggregate activity (see Stock and Watson 1999). Accordingly, we add two lags of HP-filtered cyclical component of real GDP per capita as well as two lags of the inflation rate to the deterministic trends. As in Ramey and Ramey, shocks to the forecast of government-spending growth ($DGFI$) are based on two lags of the log level of real GDP per capita and two lags of the log level of government spending per capita. Finally, the forecast for the real effective exchange rate ($XRFI$) is based on two lags of the real effective exchange rate.[16]

Observing a break in volatility in every year, that is $D = T$ as for fixed-windows, does not seem plausible nor is computationally feasible. Nevertheless, there seems to be a consensus that we observe breaks in volatility over time. These events might not be fully captured by our controls. We therefore allow for time-specific breaks in the conditional variance by setting time dummies based on confidence intervals borrowed from Stock and Watson (2005) such that major breaks in volatility and other major events occurring broadly across countries are taken into account. Note that the assumption that these breaks occurred at the same time for all countries is strong.[17] However, it seems reasonable to account for the possibility that effects of important events spread over to other countries. To this end, we also include $D = 5$ time dummies for the period until 1979 (through the breaks around 1980 in the UK 1979:4-82:1 and Italy 1979:3-82:4), for 1980-83 (until the break around 1984 in the US 1982:4-85:3), for 1984-86 (until the stock market crash in 1987), for 1987-1992 (ending with breaks around 1993 in Germany 1992:3-95:2 and Canada 1990:4-93:1), and for 1993-2000 (until the new economy bubble burst in 2001).

Because we want to address possible endogeneity problems arising with contemporaneous explanatory variables, we use one-period lagged values (cf. Table 5). As a result, we obtain similar tax effects on output volatility as above (compare to Table 3). Note that

[16]We exclude $OPEN$ which turned out to be insignificant and uninformative for the whole estimation approach, while its effect seems to be fully captured by $XRFI$. Moreover, for technical reasons we have to drop $GROW$ as an explanatory variable. We refer to the growth-volatility link in the next section.

[17]Note that Stock and Watson (2005) only test for a single break date. Multiple break dates are e.g. in Cecchetti et al. (2006) suggesting that our dummies indeed capture breaks occurring broadly across countries.

Table 5: Static panel estimation, treating variances as parameters

OECD		MLE (i)	MLE (ii)	MLE (iii)	MLE (iv)
$LABOR_{i,t-1}$	β_1	−4.23 (1.52) **	−4.76 (2.35) *	−6.15 (1.18) ***	−4.80 (1.87) *
$CAPITAL_{i,t-1}$	β_2	4.17 (1.29) **	6.03 (1.92) **	4.04 (1.21) ***	6.83 (1.79) ***
$CONS_{i,t-1}$	β_3	2.25 (1.91)	3.31 (2.87)	0.41 (1.66)	2.80 (2.50)
$CORP_{i,t-1}$	β_4	−1.78 (0.65) **	−2.54 (0.96) **	−1.69 (0.61) **	−2.74 (0.89) **
$PRIVY_{i,t-1}$	γ_1		0.11 (0.55)		0.09 (0.44)
$INFL_{i,t-1}$	γ_2		3.14 (1.77) ·		3.74 (1.53) *
$INFLI_{i,t-1}$	γ_3		9.21 (3.72) *		9.85 (3.68) **
$GGDP_{i,t-1}$	γ_4		0.89 (4.35)		−1.36 (4.09)
$DGFI_{i,t-1}$	γ_5		0.02 (0.04)		0.02 (0.04)
$XRFI_{i,t-1}$	γ_6		2.58 (1.04) *		2.42 (0.97) *
Degrees of freedom		584	452	589	457
Log-likelihood		1605.6	1326.4	1594.0	1320.5
Country fixed effects	α_i	yes	yes	yes	yes
Time fixed effects	λ_t	yes	yes	no	no

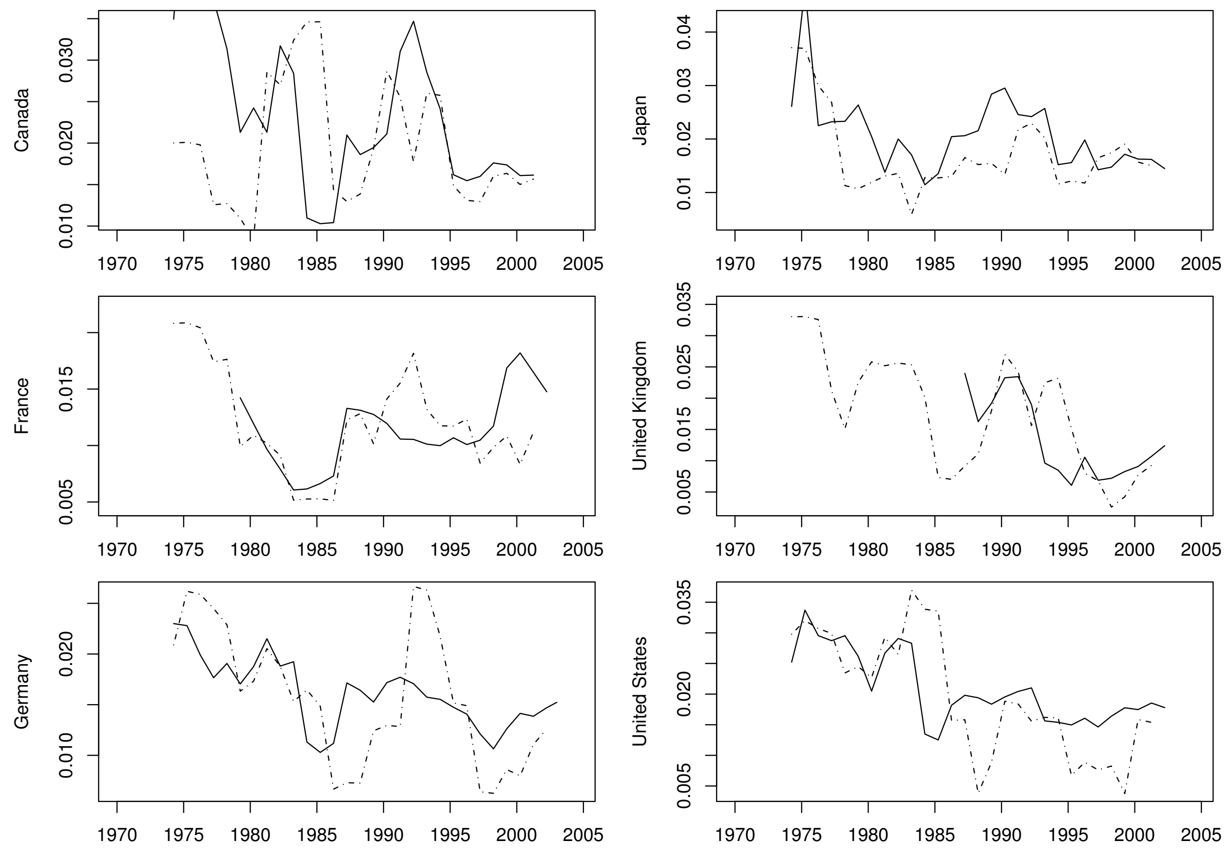
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the joint estimation of (21a) and (21b) using maximum likelihood, explaining the conditional *sd* of annual growth rates of real GDP per capita. Asymptotic standard errors are in parentheses.

the similarity is striking as the result is based on a completely different estimation method. Moreover, even the order of magnitude for tax rates is roughly comparable to that of initial estimates obtained before. In that taxes on labor income ($LABOR$) and corporate income ($CORP$) decrease output volatility, whereas the tax on capital ($CAPITAL$) is associated with higher volatility. For example, a percentage point increase in $CAPITAL$ increases output volatility roughly about five percent, which again is substantially higher than simulated semi-elasticities just under one percent (cf. Table A.1). As already mentioned, due to the simple structure of the neoclassical model without any rigidities and constant labor supply, this result is not as surprising.[18] Beside tax effects, other controls that significantly contribute to output volatility are innovations to the forecast of the real effective exchange rate ($XRFI$), innovations to the inflation forecast ($INFLFI$), and the inflation rate ($INFL$). Interestingly, the latter result resolves the controversial negative effect obtained by our initial estimates for $INFL$. Accordingly, a monetary authority focusing on a stable *and* low inflation rate removes output volatility. This could be explained from the forecasting equations, because $INFL$ significantly increases $INFLFI$ for most countries (see also Ball 1992). Similar to the initial estimates, financial development is not statistically significantly contributing to volatility. In contrast to Ramey and Ramey (1995), the

[18] Bilbiie et al. (2006) stress a negative correlation of output volatility and 'asset market participation'. As already mentioned, $CAPITAL$ includes taxes on financial and capital transaction, suggesting a negative correlation: a lower tax increases participation in asset markets causing lower output volatility.

Figure 3: Static panel, observed and estimated volatility for key countries, model (ii)



Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 5, model (ii)).

innovations to government expenditures are not significant.[19]

For illustration, Figure 3 reports the estimated volatility patterns for key countries. It seems remarkable that the time paths as well cross country patterns are captured by the model. Interestingly, there are some differences in the explanatory power of control variables among countries. While for the UK and France taxes account for most of the variation (compare to Figures B.2 and B.3), the time path for the other countries are captured only after including additional control variables. Note that including time-specific dummies improves the fit for some countries, but does not change the overall pattern.

Dynamic panel estimation. As explained above, estimating (24a) to (24b) jointly, by using the panel structure of our data more efficiently, we address the issue whether or not

[19] Contemporaneous estimates which are available in a separate appendix suggest that $INFL$ and $GGDP$ are significantly contributing to output volatility. We also experimented with excluding $GGDP$ and $INFL$ as their lagged values are included in the forecasting equations; however, it does not change the results.

Table 6: Dynamic panel estimation, treating variances as parameters

OECD		MLE (i)	MLE (ii)	MLE (iii)	MLE (iv)
$LABOR_{i,t-1}$	β_1	−1.47 (2.17)	−2.82 (1.34) *	−2.78 (0.90) **	−2.97 (1.05) **
$CAPITAL_{i,t-1}$	β_2	3.96 (2.00) *	4.72 (1.46) **	2.33 (0.84) **	2.10 (0.86) *
$CONS_{i,t-1}$	β_3	4.82 (2.72) ·	2.63 (1.76)	1.70 (1.12)	0.92 (0.84)
$CORP_{i,t-1}$	β_4	−1.46 (1.05)	−2.06 (0.75) **	−1.24 (0.51) *	−1.25 (0.49) *
$PRIVY_{i,t-1}$	γ_1	0.53 (0.50)	0.03 (0.28)		
$INFL_{i,t-1}$	γ_2	0.90 (1.84)	1.85 (1.22)		
$INFLFI_{i,t-1}$	γ_3	8.73 (3.86) *	9.97 (3.52) **	10.43 (2.84) ***	
$GGDP_{i,t-1}$	γ_4	−3.99 (4.11)	−3.26 (2.53)		
$DGFI_{i,t-1}$	γ_5	0.02 (0.04)	0.05 (0.04)	0.05 (0.03)	
$XRFI_{i,t-1}$	γ_6	1.95 (1.14) ·	1.44 (1.07)	1.83 (0.98) ·	
$\sigma_{i,t-1}$	$1+\rho$	0.05 (0.09)	0.21 (0.07) **	0.26 (0.06) ***	0.31 (0.08) ***
Country fixed effects	α_i	yes	yes	yes	yes
Time fixed effects	λ_{t-1}	yes	no	no	no
Degrees of freedom		451	456	534	588
Log-likelihood		1337.8	1323.8	1496.1	1598.1

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the joint estimation of (21a) and (21b) using maximum likelihood, explaining the conditional *sd* of annual growth rates of real GDP per capita. Asymptotic standard errors are in parentheses.

our results are based on a cointegrating relationship. Note that our conclusions do not depend on time-fixed effects which may account for the non-stationarity to some extent. Conversely, especially for the case *without* time-specific effects the estimated values should not be different from zero unless there was cointegration. To start up the recursion, we need pre-sample estimates for σ^2_{it} for $t \leq 0$. As a natural choice, we use country-specific sample analogues $\sigma^2_{i,0} = T^{-1}\sum_t \varepsilon^2_{it}$ (see Bollerslev 1986).

As a result, estimated parameters are confirmative of a long-run relationship between taxes and output volatility: the lagged endogenous parameter in the *dynamic* G(AR)CH formulation, $1+\rho$, virtually is zero when including time-specific effects, implying that our key parameter is between $\hat{\rho} = -0.95$ (0.09) with asymptotic standard error in parenthesis (see Table 6). Without the additional time dummies, the estimated value of ρ is between $0.21 - 1 = -0.79$ (0.07) and $0.31 - 1 = -0.69$ (0.08), again significantly different from zero. From the other controls, only the measure of inflation rate variability ($INFLFI$) accentuates as a potential variable for a cointegrating relationship with output volatility. To compare the order of magnitude to the static approach (see Table 5), we have to scale the estimates for model (ii) and model (iv) by a factor of roughly 1.3 and 1.5 as from (24b), respectively, which then gives similar point estimates for the semi-elasticities.

For example, the parameter vector linking output volatility and tax rates, β, remains significantly different from zero for $LABOR$ with an associated (long-run) semi-elasticity of $-2.82/(1-0.21) = -3.6$, for $CAPITAL$ with $4.72/(1-0.21) = 6.0$, and for $CORP$ with a (long-run) semi-elasticity of -2.6 (referring to the model (ii) of Table 6).

4.3 The link between volatility and growth

In a seminal paper, Ramey and Ramey (1995) study the link between volatility and growth. Their basic econometric framework is nested in a conditional heteroscedasticity in mean (GARCH-M) model without autoregressive components. In general the GARCH-M model, in which the conditional variance appears in the conditional mean, has an important drawback as no sufficient conditions for consistency and asymptotic normality are yet known. Following common practice, we assume that the maximum likelihood estimator is consistent and asymptotic normal (see Nelson 1991).

To address the empirical link between volatility and growth, we jointly estimate the following system using maximum likelihood,

$$\Delta y_{it} = \theta_i + \nu\sigma_{it} + \varepsilon_{it}, \quad \text{where} \quad \varepsilon_{it} \sim \mathcal{N}(0, \sigma_{it}^2), \tag{26a}$$

$$\log(\sigma_{it}) = \alpha_i + \lambda_t + \beta' x_{it} + \gamma' z_{it}, \tag{26b}$$

where Δy_{it} is the growth rate of output per capita for country i in year t, expressed as log difference; σ_{it} is the sd of the residuals ε_{it}; whereas θ_i allows for country-specific effects in the growth equation (26a), and $\alpha_i + \lambda_t$ are country- and time-specific effects in the variance equation (26b). Observe that compared to the system (21a) and (21b), only the conditional variance appears as an additional control in the growth equation.

The results are shown in Table 7. Our estimates suggest that not only the identified measures remain significantly related to output volatility (cf. Table 5), but volatility has a negative partial correlation with output growth. We compare a specification where similar to Ramey and Ramey (1995) government-spending induced volatility is used as a control (iv) to specifications where we include tax rates (iii), volatility patterns from forecasting equations for the inflation rate as well as for the real effective exchange rate (ii), and all variables that have been identified as potential controls (i). Our results confirm a robust empirical link between volatility and growth. Accounting for more heterogeneity indeed strengthens the relationship between volatility and growth among OECD countries.

5 Conclusions

The aim of this paper was to shed light on the link between tax rates and output volatility. We start from a purely theoretical perspective showing that in a stochastic version of the

Table 7: Static panel estimation, the link between volatility and growth

OECD		MLE (i)		MLE (ii)		MLE (iii)		MLE (iv)	
$LABOR_{i,t-1}$	β_1	−1.34 (1.22)		−3.8900 (1.20)	**	−3.96 (1.44)	**		
$CAPITAL_{i,t-1}$	β_2	3.33 (1.05)	**	3.6400 (1.07)	***	4.32 (1.20)	***		
$CONS_{i,t-1}$	β_3	1.40 (1.45)		−0.1300 (1.42)		1.72 (1.81)			
$CORP_{i,t-1}$	β_4	−1.43 (0.49)	**	−1.4800 (0.53)	**	−1.77 (0.58)	**		
$PRIVY_{i,t-1}$	γ_1								
$INFL_{i,t-1}$	γ_2	4.01 (1.00)	***						
$INFLI_{i,t-1}$	γ_3	6.93 (2.26)	**	9.5000 (2.80)	***				
$GGDP_{i,t-1}$	γ_4								
$DGFI_{i,t-1}$	γ_5	0.05 (0.03)	·	0.0700 (0.03)	*	0.05 (0.03)	·	0.09 (0.03)	**
$XRFI_{i,t-1}$	γ_6	1.99 (0.67)	**	1.6500 (0.66)	*				
$\sigma_{i,t}$	ν	−1.40 (0.30)	***	−0.9700 (0.29)	***	−0.69 (0.17)	***	−0.85 (0.47)	·
Degrees of freedom		528		534		549		566	
Log-likelihood		1531.0		1501.3		1538.2		1514.5.7	
Country fixed effects	α_i	yes		yes		yes		yes	
Time fixed effects	λ_t	yes		no		yes		no	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the joint estimation of (26a) and (26b) using maximum likelihood, explaining the conditional *sd* of annual growth rates of real GDP per capita. Asymptotic standard errors are in parentheses.

neoclassical growth model distortional taxes affect the variability of macro aggregates. Using explicit solutions, we identify the channels through which aggregate volatility is affected by optimizing households. We show that against conventional perceptions rather the second moment than the first moment of output growth rates is affected by taxes. In these models, individual decisions matter for macro volatility indirectly by affecting the variability of the rental rate of capital, which corresponds to the volatility of the growth rate of the capital stock, through their consumption-savings decision. There is also a potentially direct link by affecting the variance of the stochastic impulses (growing through cycles literature). In addition, the model was calibrated and simulated with tax semi-elasticities on different volatility measures of macro aggregates being derived.

Taking the model to the data, we make use of heterogeneity patterns in output volatility and tax rates to estimate tax effects on macro volatility using panel estimation. Our study brings out some strong empirical regularities in output volatility among OECD countries. Using several measures of volatility and various estimation techniques we find that taxes are important determinants in explaining differences across countries and over time. Tax rates are able to capture sometimes substantial parts of volatility patterns. Accounting for possible non-stationarity of our measures, we find empirical evidence for a cointegrating relationship between taxes and output volatility.

In particular, conforming with theoretical results we find that tax effects are not unidirectional: while the labor income tax as well as the corporate income tax are negatively correlated, the capital tax is positively correlated with output volatility. Accounting for potential outliers even strengthens the case for taxes. Indeed taxes are among other robust determinants such as inflation and effective exchange rate variability. In contrast, financial development was not found to be robust. We also confirm a strong empirical link between volatility and growth (Ramey and Ramey 1995). Allowing for more flexible heterogeneity patterns among countries indeed strengthens the observed empirical link.

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A Appendix

Appendices to "Explaining output volatility: The case of taxation" by Olaf Posch.

Contents

A.1 The model

A.1.1 The household's budget constraint (8)

Nominal wealth is given by $(1+\tau_c)p_t^c a_t = k_t v_t$ where k_t is the individual's physical capital stock and v_t is the value of one unit of the capital stock, and p_t^c is the producer price of the consumption good. As long as investment is positive, the price of an installed good equals the price of a new investment good, so that $v_t = (1+\tau_k)p_t^k$. Then, real wealth, a_t, is

$$a_t = \frac{1+\tau_k}{1+\tau_c} k_t. \tag{27}$$

Households receive net capital payments $(1-\tau_i)p_t^y w_t^k k_t$, that means net dividends per unit of capital (value marginal productivity) times the amount k_t and net labor income $(1-\tau_i)p_t^y w_t$ used for saving and consumption purposes. Thus, nominal savings are $s_t = (1-\tau_i)p_t^y(w_t^k k_t + w_t) - (1+\tau_c)p_t^c c_t$. Saving will be used for accumulating capital. Beside a tax on wealth, τ_a, a fraction $\frac{1-\tau_i}{1+\tau_k}\delta$ of the capital stock disappears as a result of depreciation, which implies that only net (and not gross) capital rewards are taxed,

$$dk_t = \left\{ \frac{s_t}{(1+\tau_k)p_t^k} - \frac{1-\tau_i}{1+\tau_k}\delta k_t - \tau_a k_t \right\} dt. \tag{28}$$

The relationship in (28) shows that a positive tax on wealth ($\tau_a > 0$) simply increases the rate of effective depreciation. We will see later that this tax really applies to wealth, a_t, and not the number of machines or stocks, k_t. Using (27), the budget constraint reads

$$da_t = \frac{1+\tau_c}{1+\tau_k} \left\{ \frac{s_t}{(1+\tau_k)p_t^k} - \frac{1-\tau_i}{1+\tau_k}\delta k_t - \tau_a k_t \right\} dt. \tag{29}$$

Inserting s_t, replacing k_t with the definition in (27) and using (10) gives

$$\begin{aligned}
da_t &= \frac{1+\tau_k}{1+\tau_c} \left\{ \frac{(1-\tau_i)p_t^y(w_t^k k_t + w_t) - (1+\tau_c)p_t^c c_t}{(1+\tau_k)p_t^k} - \frac{1-\tau_i}{1+\tau_k}\delta k_t - \tau_a k_t \right\} dt, \\
&= \frac{1+\tau_k}{1+\tau_c} \left\{ \frac{1-\tau_i}{1+\tau_k} w_t^k k_t + \frac{1-\tau_i}{1+\tau_k} w_t - \frac{1+\tau_c}{1+\tau_k} c_t - \frac{1-\tau_i}{1+\tau_k}\delta k_t - \tau_a k_t \right\} dt, \\
&= \left\{ \frac{1-\tau_i}{1+\tau_k} w_t^k a_t + \frac{1-\tau_i}{1+\tau_c} w_t - c_t - \frac{1-\tau_i}{1+\tau_k}\delta a_t - \tau_a a_t \right\} dt, \\
&\equiv \left\{ \left(\frac{1-\tau_i}{1+\tau_k}(r_t - \delta) - \tau_a \right) a_t + \frac{1-\tau_i}{1+\tau_c} w_t - c_t \right\} dt,
\end{aligned}$$

where we defined factor rewards,

$$w_t = \frac{\partial Y_t}{\partial L} \equiv Y_L = (1-\alpha)Y_t/L, \quad r_t = \frac{\partial Y_t}{\partial K_t} \equiv Y_K = \alpha Y_t/K_t.$$

A.1.2 The budget constraint of the government (5)

We start by summing up the budget constraint (8) using $\sum_{i=1}^{L} a_{t,i} = La_t$ to obtain

$$Lda_t = \left\{ L \left(\frac{1-\tau_i}{1+\tau_k}(r_t - \delta) - \tau_a \right) a_t + L \frac{1-\tau_i}{1+\tau_c} w_t - C_t \right\} dt,$$

where C_t denotes $C_t = Lc_t$. Transforming a_t into units of the capital stock from (27),

$$a_t = \frac{1+\tau_k}{1+\tau_c} Lk_t/L \equiv \frac{1+\tau_k}{1+\tau_c} K_t/L, \tag{30}$$

and insert it in the aggregated budget constraint yields

$$\begin{aligned}
d\left(\frac{1+\tau_k}{1+\tau_c}K_t\right) &= \left\{ \frac{1+\tau_k}{1+\tau_c}K_t \left(\frac{1-\tau_i}{1+\tau_k}(r_t-\delta) - \tau_a \right) + L\frac{1-\tau_i}{1+\tau_c} w_t - C_t \right\} dt, \\
\Leftrightarrow\ dK_t &= \frac{1+\tau_c}{1+\tau_k} \left\{ \frac{1+\tau_k}{1+\tau_c}K_t \left(\frac{1-\tau_i}{1+\tau_k}(Y_K-\delta) - \tau_a \right) + L\frac{1-\tau_i}{1+\tau_c} Y_L - C_t \right\} dt \\
&= \left\{ \frac{1-\tau_i}{1+\tau_k}\left(Y_K K_t + Y_L L\right) - \left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a \right) K_t - \frac{1+\tau_c}{1+\tau_k} C_t \right\} dt, \\
&= \left\{ \frac{1-\tau_i}{1+\tau_k} Y_t - \left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a \right) K_t - \frac{1+\tau_c}{1+\tau_k} C_t \right\} dt,
\end{aligned}$$

where we used Euler's theorem, that is $Y_t = Y_K K_t + Y_L L$ in the last step. Finally, we rewrite $I_t^n = \dot{K}_t$ with $I_t^n = I_t - \delta K_t$, multiply by $(1+\tau_k)$ and insert $G_t = Y_t - C_t - I_t$ from (9),

$$\begin{aligned}
(1+\tau_k)I_t^n &= (1-\tau_i)\left(Y_t - \delta K_t\right) - \tau_a(1+\tau_k)K_t - (1+\tau_c)C_t \\
\Leftrightarrow\ I_t^n + \tau_k I_t^n + \tau_i\left(Y_t - \delta K_t\right) &= Y_t - \delta K_t - \tau_a(1+\tau_k)K_t - (1+\tau_c)C_t \\
\Leftrightarrow\ Y_t - C_t - I_t &= \tau_k(I_t - \delta K_t) + \tau_i\left(Y_t - \delta K_t\right) + \tau_a(1+\tau_k)K_t + \tau_c C_t \\
\Leftrightarrow\ G_t &= \tau_i(Y_t - \delta K_t) + \tau_k I_t^n + \tau_c C_t + \tau_a(1+\tau_k)K_t.
\end{aligned}$$

As the interpretation is straightforward, aggregation is convincing.

A.1.3 The evolution of log-output

Using the definition, G_t, the market clearing condition in (9) can be written as

$$\begin{aligned}
Y_t &= \tau_i(Y_t - \delta K_t) + \tau_k(I_t - \delta K_t) + \tau_c C_t + \tau_a(1+\tau_k)K_t + C_t + I_t \\
\Leftrightarrow\ (1-\tau_i)Y_t &= (1+\tau_k)I_t + (1+\tau_c)C_t + (\tau_a(1+\tau_k) - (\tau_i+\tau_k)\delta)K_t \\
\Leftrightarrow\ I_t &= \frac{1-\tau_i}{1+\tau_k}Y_t - \frac{1+\tau_c}{1+\tau_k}C_t - \left(\tau_a - \frac{\tau_i+\tau_k}{1+\tau_k}\delta\right) K_t
\end{aligned}$$

Inserting this into (11) recalling that $(dK_t/dt)/K_t = I_t/K_t - \delta$ from (2), output follows

$$\begin{aligned}
dY_t &= (\mu + \alpha(I_t/K_t - \delta))Y_t dt + Y_t \eta dz_t + (\exp(\nu) - 1)Y_{t-} dq_t \\
&= \left(\mu + \alpha \left(\frac{1-\tau_i}{1+\tau_k} Y_t/K_t - \frac{1+\tau_c}{1+\tau_k} C_t/K_t - \tau_a - \frac{1-\tau_i}{1+\tau_k}\delta \right) \right) Y_t dt + Y_t \eta dz_t \\
&\quad + (\exp(\nu) - 1)Y_{t-} dq_t.
\end{aligned}$$

Now define log-output, $y_t \equiv \ln Y_t$, and use Itô's formula to compute the differential dy_t,

$$dy_t = \left(\mu + \alpha\left(\frac{1-\tau_i}{1+\tau_k} r_t/\alpha - \frac{1-\tau_i}{1+\tau_k}\delta - \tau_a - \frac{1+\tau_c}{1+\tau_k} C_t/K_t\right) - \frac{1}{2}\eta^2\right) dt + \eta dz_t + \nu dq_t. \quad (31)$$

where we also inserted capital rewards, $r_t = Y_K = \alpha Y_t/K_t$.

A.1.4 The evolution of capital rewards

Using Itô's formula (change of variables), capital rewards, $r_t = \alpha A_t (X_t L/K_t)^{1-\alpha}$, follow

$$\begin{aligned} dr_t &= r_A dA_t + (r_t - r_{t-})\, dq_t + r_K dK_t, \\ &= r_t \mu dt + r_t \eta dz_t + (\exp(\nu) - 1) r_{t-} dq_t + r_K (I_t - \delta K_t) dt, \end{aligned}$$

Now inserting $r_K = -(1-\alpha) r_t/K_t$, and replacing $Y_t/K_t = r_t/\alpha$, we obtain

$$\begin{aligned} dr_t &= r_t \mu dt + r_t \eta dz_t + (\exp(\nu) - 1) r_{t-} dq_t - (1-\alpha)(I_t/K_t - \delta) r_t dt, \\ &= \left(\mu - (1-\alpha)\left(\frac{1-\tau_i}{1+\tau_k} r_t/\alpha - \frac{1-\tau_i}{1+\tau_k}\delta - \tau_a - \frac{1+\tau_c}{1+\tau_k} C_t/K_t\right)\right) r_t dt \\ &\quad + r_t \eta dz_t + (\exp(\nu) - 1) r_{t-} dq_t. \end{aligned} \quad (32)$$

following the same steps for $(I_t/K_t - \delta)$ needed to obtain (31).

A.2 Explicit solutions

A.2.1 The maximized Bellman equation

The value of an optimal program of (6) is defined by

$$V(a(0), A(0), X(0)) = \max_{c(t)} \{U_0\},$$

which denotes the present discounted value of utility evaluated along the optimal program. Following the same steps as in Posch (2007), the Bellman equation reads

$$\begin{aligned} \rho V(a(0), A(0), X(0)) &= \max_{c_0} \left\{ u(c_0) + V_a \left(\left(\frac{1-\tau_i}{1+\tau_k}(r_0 - \delta) - \tau_a \right) a_0 + \frac{1-\tau_i}{1+\tau_c} w_0 - c_0 \right) \right. \\ &\quad \left. + V_A A_t \mu + \frac{1}{2} V_{AA} A_t^2 \eta^2 + \lambda \left(V(a_0, A_0, X_0) - V(a_0, A_0, X_{0-}) \right) \right\}, \end{aligned}$$

where the level of X_t immediately after a jump is $X_t = (\exp(\nu))^{\frac{1}{1-\alpha}} X_{t-}$.

The first order condition reads

$$u'(c_0) = V_a(a_0, A_0, X_0), \quad (33)$$

making consumption a function of the state variables. The maximized Bellman equation is

$$\begin{aligned} \rho V(a(0), A(0), X(0)) &= u(c(a_0)) + \left(\frac{1-\tau_i}{1+\tau_k}(r_0 - \delta) a_0 - \tau_a a_0 + \frac{1-\tau_i}{1+\tau_c} w_0 - c_0 \right) V_a + V_A A_0 \mu \\ &\quad + \frac{1}{2} V_{AA} A_0^2 \eta^2 + \lambda \left(V(a_0, A_0, X_0) - V(a_0, A_0, X_{0-}) \right). \end{aligned} \quad (34)$$

A.2.2 Proof of Theorem 2.1

The idea of this proof is to show that together with an educated guess of the value function, both the maximized Bellman equation (34) and first order condition (33) are fulfilled. We may guess that the value function reads

$$V(a_t, A_t, X_t) = \frac{\phi^{-\sigma} a_t^{1-\sigma}}{1-\sigma} + f(A_t, X_t). \tag{35}$$

To start with we rewrite the policy function using the transformation in (30) as

$$C_t = \frac{1+\tau_k}{1+\tau_c}\phi K_t \;\Leftrightarrow\; Lc_t = \phi L a_t \;\Leftrightarrow\; c_t = \phi a_t. \tag{36}$$

Using (33) together with (7), and (36), we obtain $V_a = (\phi a_t)^{-\sigma}$. Moreover, our guess in (35) implies $V_A = f_A$, $V_{AA} = f_{AA}$, $V_X = f_X$. Inserting everything into (34) gives

$$\begin{aligned} \rho\frac{\phi^{-\sigma} a_t^{1-\sigma}}{1-\sigma} + \rho f(A_t, X_t) &= \frac{(\phi a_t)^{1-\sigma}}{1-\sigma} + (a_t\phi)^{-\sigma}\left(\frac{1-\tau_i}{1+\tau_k}(r_t-\delta)a_t - \tau_a a_t + \frac{1-\tau_i}{1+\tau_c}w_t - \phi a_t\right) \\ &\quad + g(A_t, X_t), \end{aligned}$$

where we defined $g(A_t, X_t) \equiv f_A A_t \mu + \frac{1}{2} f_{AA} A_t^2 \eta^2 + \lambda(f(A_t, X_t) - f(A_t, X_{t-}))$. Inserting factor rewards together with $K_t \equiv Lk_t = \frac{1+\tau_c}{1+\tau_k} L a_t$ from (27), we obtain after some algebra,

$$\begin{aligned} \rho\frac{\phi^{-\sigma} a_t^{1-\sigma}}{1-\sigma} + \rho f(A_t, X_t) &= \left(\frac{1-\tau_i}{1+\tau_c}\alpha A_t X_t^{1-\alpha}\left(\frac{1+\tau_c}{1+\tau_k}\right)^{\alpha} a_t^{\alpha} - \frac{1-\tau_i}{1+\tau_k}\delta a_t - \tau_a a_t\right)(a_t\phi)^{-\sigma} \\ &\quad + \frac{(\phi a_t)^{1-\sigma}}{1-\sigma} + \frac{1-\tau_i}{1+\tau_c}(1-\alpha)A_t X_t^{1-\alpha}\left(\frac{1+\tau_c}{1+\tau_k}\right)^{\alpha} a_t^{\alpha}(a_t\phi)^{-\sigma} \\ &\quad - \phi a_t (a_t\phi)^{-\sigma} + g(A_t, X_t), \\ &= \frac{(\phi a_t)^{1-\sigma}}{1-\sigma} + \frac{1-\tau_i}{1+\tau_c}A_t X_t^{1-\alpha}\left(\frac{1+\tau_c}{1+\tau_k}\right)^{\alpha} a_t^{\alpha}(a_t\phi)^{-\sigma} \\ &\quad - \frac{1-\tau_i}{1+\tau_k}\delta a_t (a_t\phi)^{-\sigma} - \tau_a a_t (a_t\phi)^{-\sigma} - \phi a_t (a_t\phi)^{-\sigma} + g(A_t, X_t). \end{aligned}$$

Using the condition $\alpha = \sigma$ with $\rho f(A_t, X_t) = \frac{1-\tau_i}{1+\tau_c} A_t X_t^{1-\alpha}\left(\frac{1+\tau_c}{1+\tau_k}\right)^{\alpha}\phi^{-\sigma} + g(A_t, X_t)$ it becomes

$$\begin{aligned} \rho\frac{\phi^{-\sigma} a_t^{1-\sigma}}{1-\sigma} &= \frac{(\phi a_t)^{1-\sigma}}{1-\sigma} - \frac{1-\tau_i}{1+\tau_k}\delta a_t^{1-\sigma}\phi^{-\sigma} - \tau_a a_t^{1-\sigma}\phi^{-\sigma} - (\phi a_t)^{1-\sigma} \\ \Leftrightarrow \rho &= \phi - (1-\sigma)\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - (1-\sigma)\phi, \end{aligned}$$

which we finally can solve for ϕ in (12).

A.2.3 Proof of Corollary 2.2

Inserting $C_t = \frac{1+\tau_k}{1+\tau_c}\phi K_t$ in the evolution of capital rewards (32), we obtain

$$dr_t = \left(\mu - (1-\alpha)\left(\frac{1-\tau_i}{1+\tau_k}r_t/\alpha - \frac{1-\tau_i}{1+\tau_k}\delta - \tau_a - \phi\right)\right)r_t dt + r_t\eta dz_t + (\exp(J_t)-1)r_{t-}dq_t.$$

We now rewrite the equation by using the condition $\alpha = \sigma$, and inserting ϕ from (12) to

$$\begin{aligned} dr_t &= \left(\mu - \frac{1-\alpha}{\alpha}\left(\frac{1-\tau_i}{1+\tau_k}r_t - \alpha\left(\frac{1-\tau_i}{1+\tau_k}\delta+\tau_a\right) - \rho - (1-\sigma)\left(\frac{1-\tau_i}{1+\tau_k}\delta+\tau_a\right)\right)\right)r_t dt \\ &\quad + r_t\eta dz_t + (\exp(\nu)-1)r_{t-}dq_t, \\ &= \frac{1-\alpha}{\alpha}\left(\frac{\alpha}{1-\alpha}\mu - \frac{1-\tau_i}{1+\tau_k}r_t + \frac{1-\tau_i}{1+\tau_k}\delta + \tau_a + \rho\right) r dt + r_t\eta dz_t + (\exp(\nu)-1)r_{t-}dq_t \\ &= \frac{1-\alpha}{\alpha}\frac{1-\tau_i}{1+\tau_k}r_t\left(\frac{1+\tau_k}{1-\tau_i}\left(\frac{\alpha}{1-\alpha}\mu + \rho + \frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - r_t\right)dt \\ &\quad + r_t\eta dz_t + (\exp(\nu)-1)r_{t-}dq_t. \end{aligned}$$

Using the definitions c_1 and c_2 we finally obtain (13).

A.2.4 An explicit solution for capital rewards

The geometric jump-diffusion in (13) is a reducible jump-diffusion process with polynomial drift of degree $n = 2$. Thus, it can be solved explicitly (cf. Posch 2007),

$$r_t = \Theta_t\left(r_0^{-1} + c_1\int_0^t \Theta_s ds\right)^{-1} \tag{37}$$

with

$$\Theta_t = \exp\left(\left(c_1c_2 - \frac{1}{2}\eta^2\right)t + \eta z_t + \nu(q_t - q_0)\right).$$

Given the realization of stochastic processes, r_t is known explicitly.

A.2.5 Proof of Corollary 2.3

Inserting the policy function $C = \frac{1+\tau_k}{1+\tau_c}\phi K$ into (31) gives

$$dy_t = \left(\mu + \alpha\left(\frac{1-\tau_i}{1+\tau_k}r_t/\alpha - \frac{1-\tau_i}{1+\tau_k}\delta - \tau_a - \phi\right) - \frac{1}{2}\eta^2\right)dt + \eta dz_t + \nu dq_t.$$

It denotes an affine SDE which explicit solution is given by (cf. Posch 2007),

$$\begin{aligned} y_t &= y_{t_0} + \int_{t_0}^t\left(\mu + \frac{1-\tau_i}{1+\tau_k}r_s - \alpha\frac{1-\tau_i}{1+\tau_k}\delta - \alpha(\tau_a+\phi) - \frac{1}{2}\eta^2\right)ds + \eta(z_t - z_0) + \nu(q_t - q_0), \\ &= y_{t_0} + (t-t_0)\left(\mu - \rho - \tau_a - \frac{1-\tau_i}{1+\tau_k}\delta - \frac{1}{2}\eta^2\right) + \frac{1-\tau_i}{1+\tau_k}\int_{t_0}^t r_s ds \\ &\quad + \eta(z_t - z_0) + \nu(q_t - q_0), \end{aligned} \tag{38}$$

where r_s is known explicitly from its solution in (37). Now use $y_t - y_{t-\Delta}$ to obtain (14).

A.2.6 Proof of Corollary 2.4

Using (1), logarithmic output, $y_t \equiv \ln Y_t$, is

$$\begin{aligned} y_t &= \ln A_t + \alpha \ln K_t + (1-\alpha)(\ln X_t + \ln L) \\ \Leftrightarrow \ \alpha \ln K_t &= y_t - \ln A_t - (1-\alpha)(\ln X_t + \ln L) \end{aligned}$$

Now inserting the solution $C_t = \frac{1+\tau_k}{1+\tau_c}\phi K_t$ from Theorem 2.1 yields for the growth rates

$$\alpha(\ln C_t - \ln C_{t-\Delta}) = y_t - y_{t-\Delta} - (\ln A_t - \ln A_{t-\Delta}) - (1-\alpha)(\ln X_t - \ln X_{t-\Delta})$$

Inserting the solutions to the SDEs in (4) and (3), $\ln A_t - \ln A_{t-\Delta} = (\mu - \frac{1}{2}\eta^2)\Delta + \eta(z_t - z_{t-\Delta})$, and $\ln X_t - \ln X_{t-\Delta} = \frac{1}{1-\alpha}\nu(q_t - q_{t-\Delta})$, respectively, as well as (14) we obtain

$$\begin{aligned} \alpha(\ln C_t - \ln C_{t-\Delta}) &= \left(\mu - \rho - \tau_a - \frac{1-\tau_i}{1+\tau_k}\delta - \frac{1}{2}\eta^2\right)\Delta + \frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds \\ &\quad + \eta(z_t - z_{t-\Delta}) - \left(\left(\mu - \frac{1}{2}\eta^2\right)\Delta + \eta(z_t - z_{t-\Delta})\right) \\ &= -\left(\rho + \tau_a + \frac{1-\tau_i}{1+\tau_k}\delta\right)\Delta + \frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds. \end{aligned}$$

which for $\alpha = \sigma$ is (15).

A.2.7 The expected growth rate

Using the expectation operator with (14) yields

$$E(g_\Delta) = \left(\mu - \rho - \tau_a - \frac{1-\tau_i}{1+\tau_k}\delta - \frac{1}{2}\eta^2 + \nu\lambda\right)\Delta + \frac{1-\tau_i}{1+\tau_k}E\int_{t-\Delta}^{t} r_s ds,$$

which can be simplified using our explicit solution in (15) to

$$E(g_\Delta) = \alpha E(g_\Delta^c) + \left(\mu - \frac{1}{2}\eta^2 + \nu\lambda\right)\Delta. \tag{39}$$

It follows from the economy's resource constraint (9) that aggregate consumption in expectation can only growth at constant rates indefinitely if it grows at the same expected rate as output. In particular, we observe $Eg_\Delta = Eg_\Delta^c$, and conclude from (39) that

$$E\left(g_\Delta\right) = E(g_\Delta^c) = \left(\frac{\mu}{1-\alpha} - \frac{1}{1-\alpha}\frac{1}{2}\eta^2 + \frac{1}{1-\alpha}\nu\lambda\right)\Delta.$$

A.2.8 An alternative solution

The proofs for the following Theorem A.1, Corollary A.2, and Corollary A.3 are analogue to Section A.2.2, Section A.2.3, and Section A.2.5, respectively, and are contained in the Referees' appendix available on request.

Theorem A.1 *If $\sigma > 1$ and the condition*

$$\rho = (\alpha\sigma - 1)\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - \sigma\mu + \frac{1}{2}(1+\sigma)\sigma\eta^2 + \lambda\left(\exp(\nu)^{-\sigma} - 1\right)$$

is fulfilled, consumption is a constant fraction of income, $C_t = \left(\frac{1+\tau_k}{1+\tau_c}\right)^{\alpha}\vartheta Y_t$, where

$$\vartheta = \frac{\sigma-1}{\sigma}\frac{1-\tau_i}{1+\tau_c}\left(\frac{1+\tau_c}{1+\tau_k}\right)^{\alpha}. \tag{40}$$

Corollary A.2 *The (before tax) rental rate of capital follows*

$$dr_t = c_3 r\,(c_4 - r_t)\,dt + \eta r_t dz_t + (\exp(\nu) - 1)r_{t-}dq_t \tag{41}$$

where $c_3 \equiv \frac{1-\alpha}{\alpha\sigma}\frac{1-\tau_i}{1+\tau_k}$, and $c_4 \equiv \frac{\alpha\sigma}{1-\alpha}\frac{1+\tau_k}{1-\tau_i}\mu + \alpha\sigma\frac{1+\tau_k}{1-\tau_i}\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right)$.

Corollary A.3 *The growth rate of output per unit of time, $g_\Delta \equiv y_t - y_{t-\Delta}$, reads*

$$\begin{aligned} g_\Delta &= \left(\mu - \alpha\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - \frac{1}{2}\eta^2\right)\Delta + 1/\sigma\frac{1-\tau_i}{1+\tau_k}\int_{t-\Delta}^{t} r_s ds \\ &\quad + \eta(z_t - z_{t-\Delta}) + \nu(q_t - q_{t-\Delta}). \end{aligned} \tag{42}$$

Similarly to the derivation of the first moment of capital rewards in (19), the first moment of capital rewards in the constant savings-rate solution reads

$$\begin{aligned} \frac{1-\tau_i}{1+\tau_k}E\int_{t-\Delta}^{t} r_s ds &= \left(\sigma\alpha\tau_a + \sigma\alpha\frac{1-\tau_i}{1+\tau_k}\delta + \frac{\sigma\alpha}{1-\alpha}\mu - \frac{\sigma\alpha}{1-\alpha}\frac{1}{2}\eta^2 + \frac{\sigma\alpha}{1-\alpha}\nu\lambda\right)\Delta \\ &= \left(\frac{1-\tau_i}{1+\tau_k}c_4 + \frac{\sigma\alpha}{1-\alpha}\left(\nu\lambda - \frac{1}{2}\eta^2\right)\right)\Delta \\ \Leftrightarrow\; E(r) &= c_4 + \frac{1+\tau_k}{1-\tau_i}\frac{\sigma\alpha}{1-\alpha}\left(\nu\lambda - \frac{1}{2}\eta^2\right) \end{aligned}$$

Again, the term $\frac{\sigma\alpha}{1-\alpha}$ refers to the speed of reversion for the after-tax rental rate of capital. Similar results using uncertain population growth can be found in Merton (1999).

A.3 Simulation results

Table A.1: Effects of an percentage point increase in the tax rate relative to the zero-tax model (semi-elasticities in brackets).

measure	no taxes	τ_i	τ_c	τ_k	τ_a
$mean(g_\Delta)$	.038015	.038013	.038015	.038013	.038029
		(−0.0%)	(+0.0%)	(−0.0%)	(+0.0%)
$sd(g_\Delta)$	.023285	.023263	.023285	.023263	.023511
		(−0.1%)	(+0.0%)	(−0.1%)	(+1.0%)
$sd(y^c_{HP})$	.018812	.0188	.018812	.0188	.018944
		(−0.1%)	(+0.0%)	(−0.1%)	(+0.7%)
$mean(r_t)$	.15837	.15896	.15837	.15895	.16838
		(+0.4%)	(+0.0%)	(+0.4)	(+6.3%)
$sd(r_t)$	.0091389	.009195	.0091389	.0091944	.0094916
		(+0.6%)	(+0.0%)	(+0.6%)	(+3.9%)
$cv(r_t)$	.057707	.057846	.057707	.057845	.05637
		(+0.2%)	(+0.0%)	(+0.2%)	(−2.3%)
$mean(g^c_\Delta)$	.037833	.037831	.037833	.037831	.037852
		(−0.0%)	(+0.0%)	(−0.0%)	(+0.1%)
$sd(g^c_\Delta)$	.012046	.011999	.012046	.011999	.012504
		(−0.4%)	(+0.0%)	(−0.4%)	(+3.8%)
$cv(\hat{u}_t)$	.057792	.057935	.057792	.057933	.056419
		(+0.3%)	(+0.0%)	(+0.2%)	(−2.4%)
$sd(\hat{y}_t - \hat{y})$	.17317	.17359	.17317	.17359	.16911
		(+0.2%)	(+0.0%)	(+0.2%)	(−2.3%)

Notes: This table reports simulated tax effects on macro variables for technology parameters $(\rho, \alpha, \sigma, \delta) = (.03, .75, .75, .1)$, other parameters $(\mu, \eta, \lambda, \nu) = (.01, .02, 0, 0, 0)$, and taxes $(\tau_i, \tau_c, \tau_k, \tau_a) = (0, 0, 0, 0)$. We used $N = 4000$ $(\Delta = 1/4)$ where we cut off the first 199 observations. The measures include the mean and *sd* of annual output growth rates, the *sd* of HP-filtered cyclical components, the mean and *sd* of before-tax capital rewards, the mean and *sd* of consumption growth rates, the *cv* of cyclical utility, as well as the *sd* of cyclical output as percentage deviations from a steady state.

Table A.2: Overall tax effects and a plausible tax scenario (relative effects in brackets).

		$(\tau_i, \tau_c, \tau_k, \tau_a) =$	
	$(.0, .0, .0, .0)$	$(.3, .1, .075, .075)$	$(.5, .1, .075, .025)$
measure	no taxes	base line	after reform
$mean(g_\Delta)$	.038015	.038067	.037968
	(-0.1%)		(-0.3%)
$sd(g_\Delta)$	.023285	.02418	.022642
	(-3.7%)		(-6.4%)
$sd(y^c_{HP})$	.018812	.019377	.018474
	(-2.9%)		(-4.7%)
$mean(r_t)$	.15837	.30489	.27914
	(-48.1%)		(-8.5%)
$sd(r_t)$	.0091389	.016112	.017353
	(-43.3%)		$(+7.7\%)$
$cv(r_t)$	.057707	.052845	.062164
	$(+9.2\%)$		$(+17.6\%)$
$mean(g^c_\Delta)$	.037833	.037902	.03777
	(-0.2%)		(-0.4%)
$sd(g^c_\Delta)$	.012046	.013801	.010653
	(-12.7%)		(-22.8%)
$cv(\hat{u}_t)$	.057792	.052824	.062403
	$(+9.4\%)$		$(+18.1\%)$
$sd(\hat{y}_t - \hat{y})$	.17317	.15844	.18676
	$(+9.3\%)$		$(+17.9\%)$

Notes: This table reports tax effects on macro variables for a plausible tax scenario in the UK from the 1980s to the 1990s (cf. Figure 2) as well as overall tax effects for technology parameters $(\rho, \alpha, \sigma, \delta) = (.03, .75, .75, .1)$, other parameters $(\mu, \eta, \lambda, \nu) = (.01, .02, 0, 0, 0)$, and taxes $(\tau_i, \tau_c, \tau_k, \tau_a) = (.3, .1, .075, .075)$. The tax scenario encompasses a tax cut in τ_a, as well as an increase in the income tax, τ_i. We used $N = 4000$ $(\Delta = 1/4)$ where we cut off the first 199 observations. The measures include the mean and *sd* of annual output growth rates, the *sd* of HP-filtered cyclical components, the mean and *sd* of before-tax capital rewards, the mean and *sd* of consumption growth rates, the *cv* of cyclical utility, as well as the *sd* of cyclical output as percentage deviations from a steady state.

A.4 Data appendix

A.4.1 Data sources

The following databases from SourceOECD (http://new.sourceoecd.org) have been used:

- Revenue Statistics (1965 onwards; SourceOECD Vol 2003 release 01)
- Quarterly National Accounts (1955 onwards; SourceOECD Vol 2004 release 05)
- Annual National Accounts (1970 onwards, SourceOECD Vol 2004 release 02)
- Main Economic Indicators (1960 onwards; SourceOECD Vol 2004 release 06)

A.4.2 Effective tax rates

For ease of comparison with Mendoza et al. (1994) and Carey and Rabesona (2004), we retain the variables names based on the definitions in SNA68/ESA79, though the variables are from SNA93/ESA95. In what follows we use the following abbreviations:

Revenue Statistics

1000	Taxes on income, profits and capital gains
1100	Taxes on income, profits and capital gains of individuals
1200	Taxes on income, profits and capital gains of corporations
1300	Unallocable between 1100 and 1200
2000	Social security contributions
2100	Employee's contribution to social security
2200	Employer's contribution to social security
2300	Contribution of self-employed or non-employed to social security
2400	Unallocable as between 2100, 2200 and 2300
3000	Taxes on payroll and workforce
4000	Taxes on property
4100	Recurrent taxes on immovable property
4400	Taxes on financial and capital transactions
5110	General taxes on goods and services
5120	Taxes on specific goods and services
5121	Excise taxes
5122	Profits of fiscal monopolies
5123	Customs and import duties
5125	Taxes on investment goods
5126	Taxes on specific services
5128	Other taxes
5200	Taxes on use of goods and perform activities
5212	Paid by others: motor vehicles
6100	Other taxes paid solely by business

National Accounts

For reasons of comparability, in what follows we use the following abbreviations.

EA	Table 1. Gross Domestic Product: Expenditure Approach
IA	Table 3. Gross Domestic Product: Income Approach
GA	Table 12. Simplified General Government Accounts
HC	Table 13. Simplified Accounts for Households and NPISH and for Corporations

C	Private final consumption expenditure (EA)
G	Government final consumption expenditure (EA)
CoE	Compensation of employees (IA)
GW	Compensation of employees paid by producers of government services (GA)
OS	Operating surplus of the economy; includes statistical discrepancy (IA)
$OSPUE$	Operating surplus and mixed income of private unincorporated enterprises (HC)
PEI	Household's property income (HC)
W	Wages and salaries (IA)

Note that total operating surplus (OS) and operating surplus of private unincorporated enterprises ($OSPUE$) is *net*, that is gross operating surplus minus consumption of fixed capital. Moreover, OS includes the statistical discrepancy.

Mendoza et. al (1994) tax ratios

The household income tax ratio is equal to personal income tax receipts (1100) divided by household income. Household income comprises operating surplus plus mixed income of the private unincorporated sector ($OSPUE$), property income[20] (PEI), and dependent wage income (W). Given this, the personal income tax reads

$$\tau_h = \frac{1100}{OSPUE + PEI + W}.$$

The labor income tax ratio relates individual labor income tax to total labor costs. Note that $\tau_h W$ allocates household income taxes to labor. All social security charges (2000) and payroll taxes (3000) are also allocated to labor income. Total labor costs consists of compensation from dependent employment, including employers' social security contributions (2200),

$$LABOR = \frac{\tau_h W + 2000 + 3000}{W + 2200}.$$

The capital tax ratio relates individual capital income (including corporations) and other capital costs to total capital income. Here, $\tau_h(OSPUE + PEI)$ denotes household income taxes related to capital income. The taxes paid directly out of capital income are corporate

[20] PEI corresponds to interest, dividends, and investment receipts in SNA93/ESA95.

income taxes (1200), recurrent taxes on immovable property (4100) and taxes on financial and capital transactions (4400),

$$CAPITAL = \frac{\tau_h(OSPUE + PEI) + 1200 + 4100 + 4400}{OS}.$$

The consumption tax ratio is calculated as the sum of general consumption taxes on goods and services (5110) and excise taxes (5121) over the sum of private consumption (C) and government non-wage consumption ($G - GW$) at producer costs,

$$CONS = \frac{5110 + 5121}{C + G - GW - 5110 - 5121}.$$

The effective tax of corporate income relates the taxes paid by corporations (1200) to operating surplus of the corporate sector (obtained as a residual $OS - OSPUE$),

$$CORP = \frac{1200}{OS - OSPUE},$$

which indicates the average tax burden of corporations.

Due to data availability, we make use of reasonable assumptions. The main modifications include on the one hand to approximate $OSPUE$ and PEI by the first 5-year average share of the respective entry on OS that is available.[21] On the other hand, we approximate W by CoE less employer's social security contributions (2200). Overall, our tax ratios are highly correlated with Mendoza et al. tax ratios and modified Carey and Rabesona tax ratios (Tables A.3 and B.1). The detailed tax tables are in a separate appendix.

Table A.3: Correlation of tax ratios with Mendoza et al. (1994)

	$CAPITAL$	$LABOR$	$CONS$
Canada	0.98	1.00	0.81
France	0.96	0.98	**0.72**
Germany	0.96	0.89	**0.79**
Italy	0.99	1.00	1.00
Japan	1.00	1.00	0.99
United Kingdom	0.97	0.85	0.95
United States	0.92	0.92	1.00

Notes: This table reports the correlation coefficients of computed tax ratios with original tax ratios of Mendoza et al. (1994). The values are based on the time period 1970-1996 under consideration for the (updated) Mendoza et al. (1994) tables (http://www.bsos.umd.edu/econ/mendoza/pdfs/newtaxdata.pdf). Correlation coefficients less than 0.8 are in boldface.

[21] While $OSPUE$ is included in OS, the assumption that PEI was a constant proportion of $OSPUE$ is not obvious. Nevertheless, for almost all countries the two series are highly correlated with constant ratios. An alternative assumptions setting PEI to zero for the whole time period which does not change our results.

A.4.3 Volatility measures

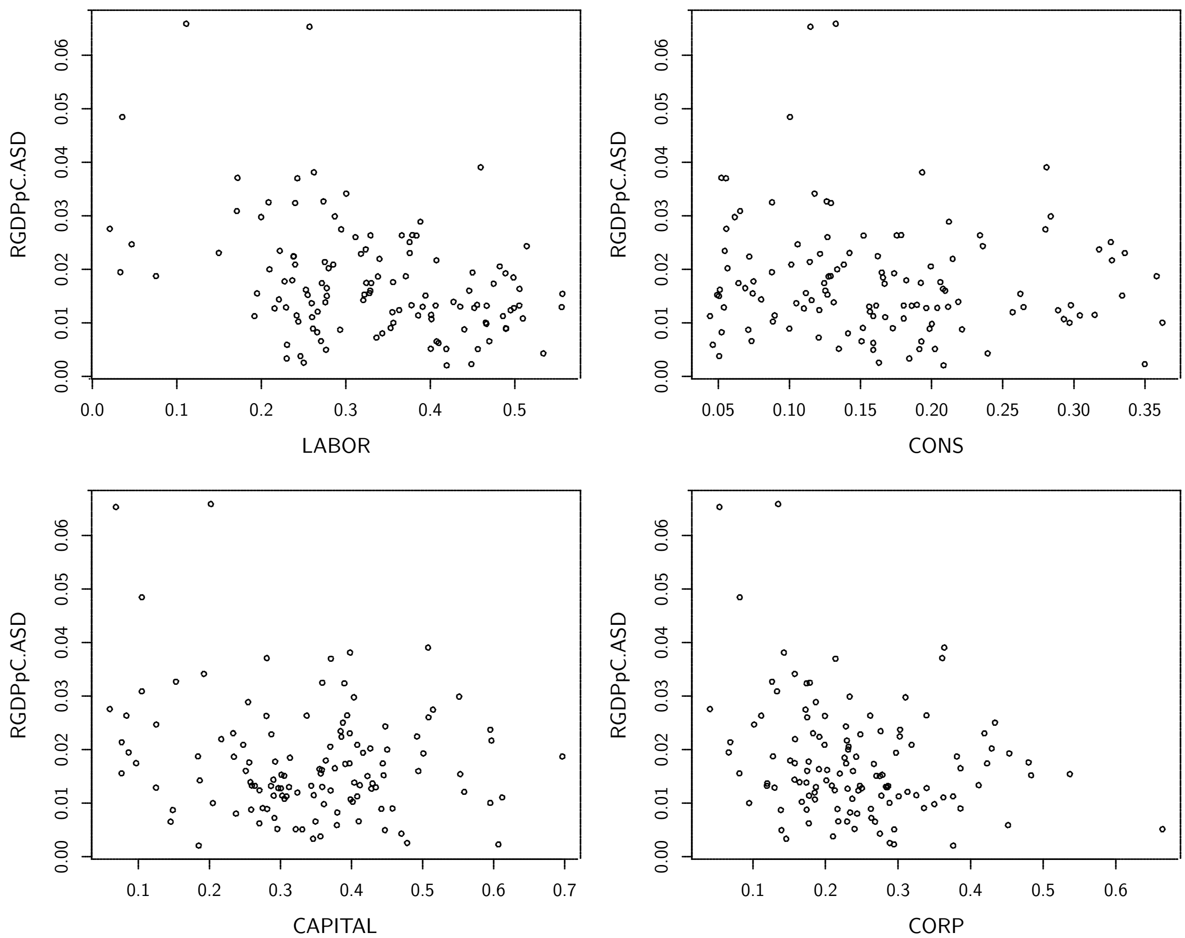
Table A.4: Volatility tables, *sd* of annual growth rates of real GDP per capita (*APC*)

	1970-1979	1980-1989	1990-1999	2000-2004
Australia	0.0152	0.0233	0.0185	0.0089
Austria	0.0219	0.0124	0.0128	0.0128
Belgium	0.0231	0.0162	0.0138	0.0193
Canada	0.0154	0.0247	0.0248	0.0174
Czech Republic			0.0483	0.0062
Denmark	0.0259	0.0204	0.0153	0.0101
Finland	0.0266	0.0115	0.0423	0.0177
France	0.0154	0.0115	0.0124	0.0134
Germany	0.0191	0.0137	0.0185	0.0133
Greece	0.0479	0.0237	0.0173	0.0021
Hungary			0.0281	0.0096
Iceland	0.0318	0.0336	0.0294	0.0283
Ireland	0.0210	0.0243	0.0336	0.0218
Italy	0.0258	0.0114	0.0107	0.0132
Japan	0.0258	0.0164	0.0184	0.0165
Korea	0.0396	0.0403	0.0477	0.0231
Luxembourg	0.0388	0.0366	0.0268	0.0394
Mexico	0.0221	0.0415	0.0329	0.0465
Netherlands	0.0146	0.0180	0.0124	0.0162
New Zealand	0.0317	0.0159	0.0286	0.0034
Norway	0.0106	0.0232	0.0128	0.0115
Poland			0.0434	0.0147
Portugal	0.0523	0.0331	0.0225	0.0161
Slovak Republic			0.0192	0.0148
Spain	0.0287	0.0201	0.0165	0.0091
Sweden	0.0170	0.0119	0.0261	0.0155
Switzerland	0.0296	0.0187	0.0154	0.0209
Turkey	0.0375	0.0332	0.0515	0.0845
United Kingdom	0.0267	0.0235	0.0175	0.0121
United States	0.0261	0.0258	0.0148	0.0150

A.5 Empirical results

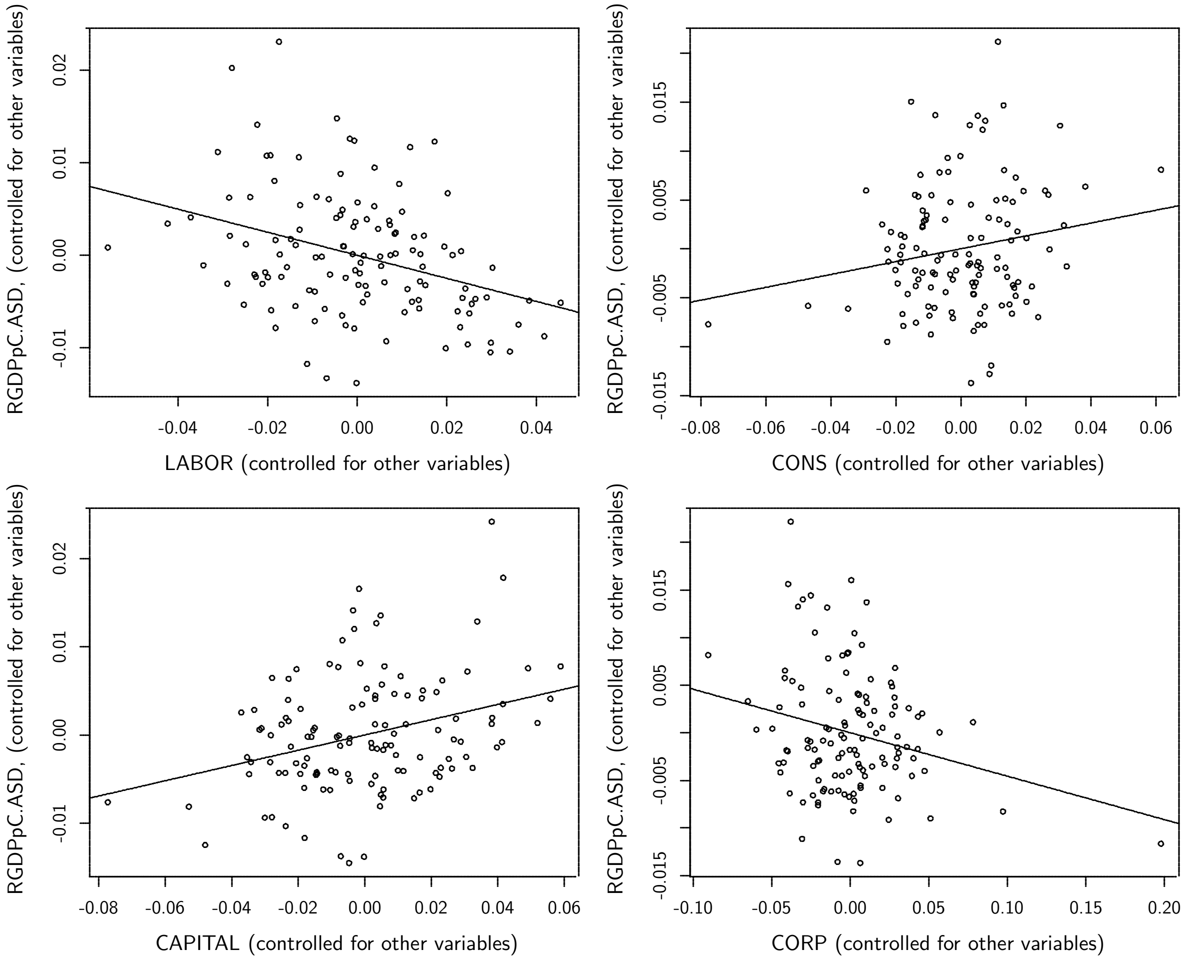
A.5.1 Simple and partial correlation of taxes and output volatility

Figure A.1: Simple correlation of taxes and *observed* volatility (five-year fixed-windows)



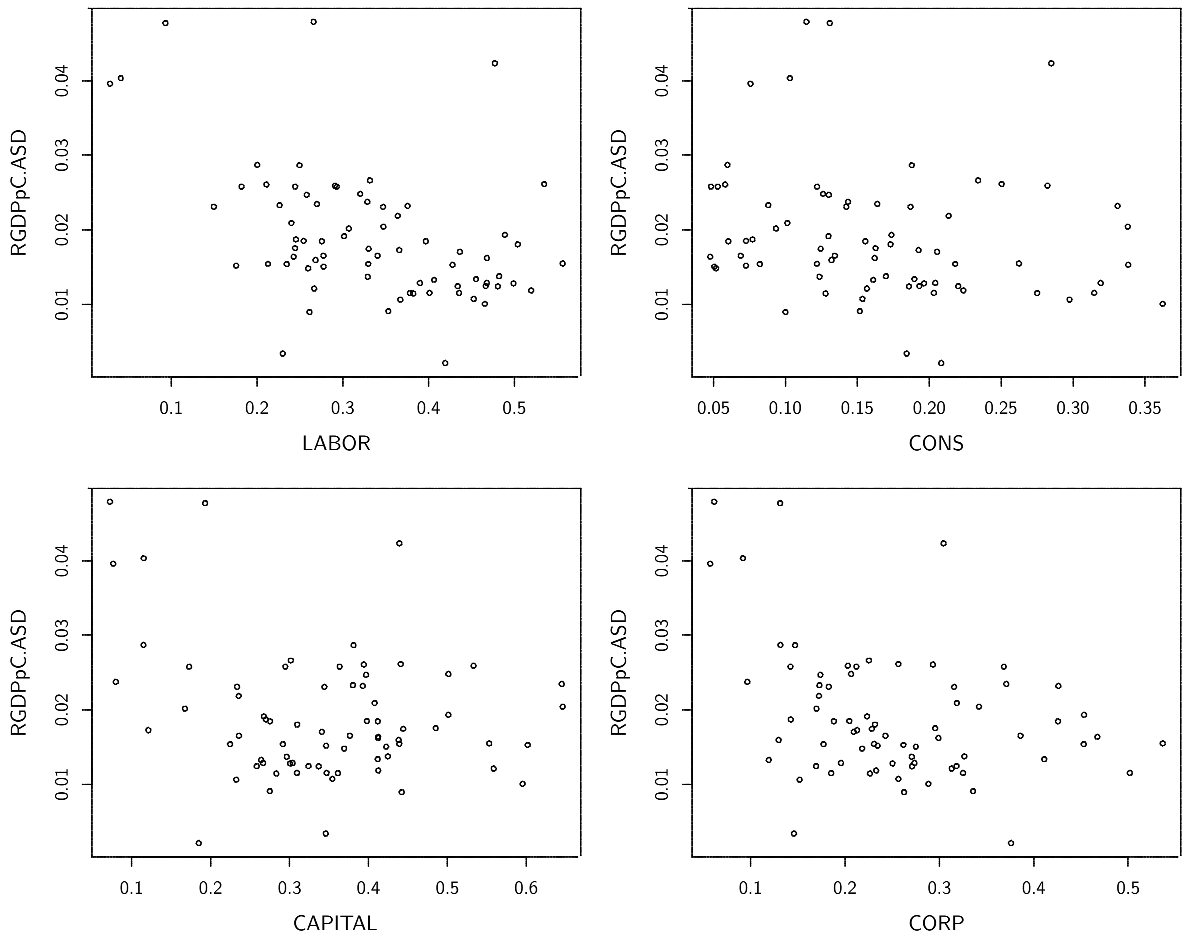
Notes: These figures give scatter plots of *observed* volatility measured as the *sd* of annual growth rates of real GDP per capita against tax rates using the fixed-window (five-year) panel approach.

Figure A.2: Partial correlation of taxes and *observed* volatility (five-year fixed-windows)



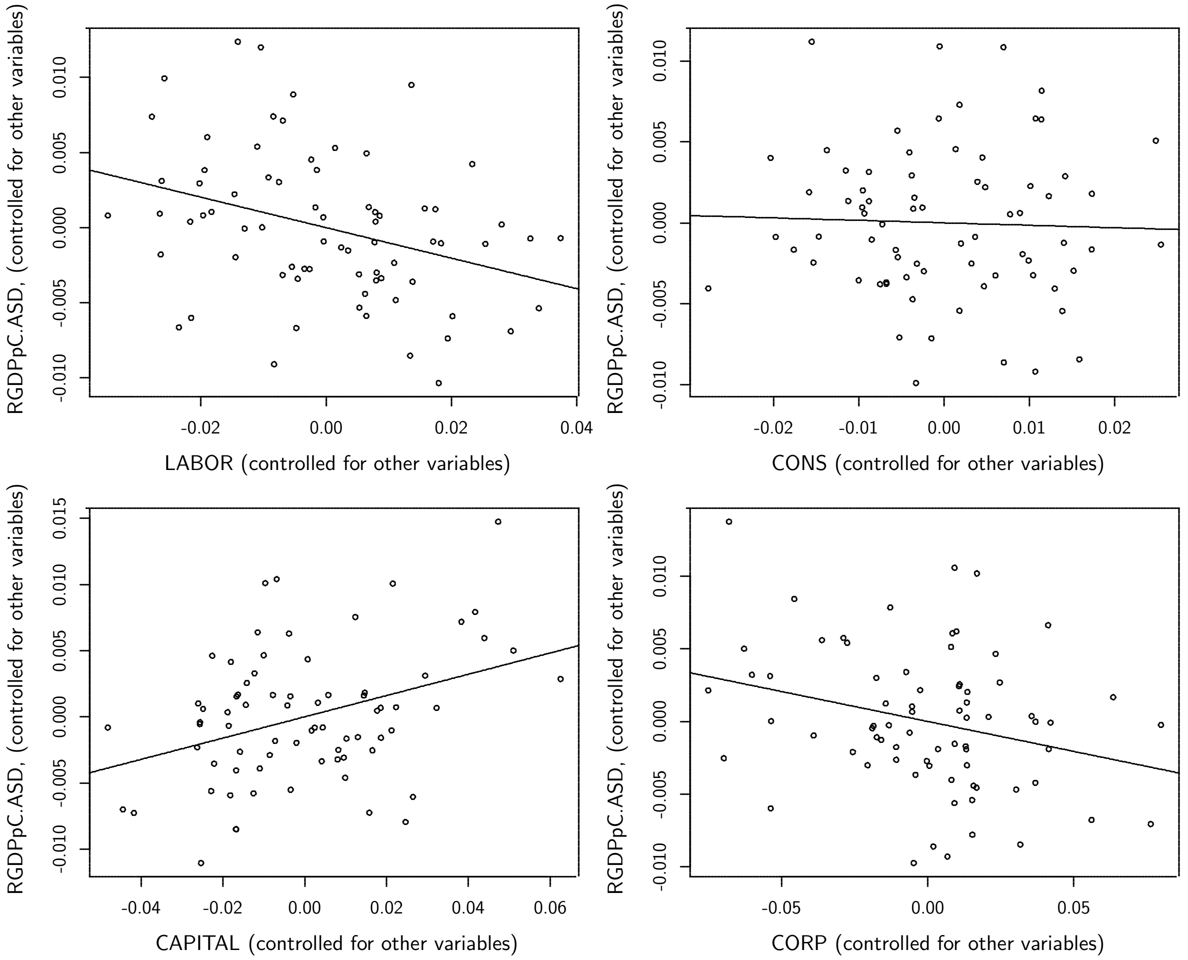
Notes: These figures give scatter plots of *observed* volatility measured as the *sd* of annual growth rates of real GDP per capita against tax rates using the fixed-window (five-year) panel approach controlling for other effects (cf. Table 3, first column).

Figure A.3: Simple correlation of taxes and *observed* volatility (ten-year fixed-windows)



Notes: These figures give scatter plots of *observed* volatility measured as the *sd* of annual growth rates of real GDP per capita against tax rates using the fixed-window (ten-year) panel approach.

Figure A.4: Partial correlation of taxes and *observed* volatility (ten-year fixed-windows)



Notes: These figures give scatter plots of *observed* volatility measured as the *sd* of annual growth rates of real GDP per capita against tax rates using the fixed-window (ten-year) panel approach controlling for other effects (cf. Table 3, third column).

B Referees' appendix (on request)

Referee's appendix to "Explaining output volatility: The case of taxation" by Olaf Posch.

B.1 Explicit solutions

B.1.1 Proof of Theorem A.1

The idea of this proof is to show that together with an educated guess of the value function, both the maximized Bellman equation (34) and first order condition (33) are fulfilled. We may guess that the value function reads

$$V(a_t, A_t, X_t) = \frac{(A_t X_t^{1-\alpha}\vartheta)^{-\sigma} a_t^{1-\alpha\sigma}}{1-\alpha\sigma}. \tag{43}$$

To start with we rewrite the policy function using the transformation in (30) as

$$C_t = \left(\frac{1+\tau_k}{1+\tau_c}\right)^{\alpha} \vartheta Y_t \;\Leftrightarrow\; Lc_t = \left(\frac{1+\tau_k}{1+\tau_c}\right)^{\alpha} \vartheta A_t K_t^{\alpha}(X_t L)^{1-\alpha} \;\Leftrightarrow\; c_t = A_t X_t^{1-\alpha}\vartheta a_t^{\alpha}. \tag{44}$$

Using (33) together with (7), and (44), we obtain $V_a = (\phi a_t)^{-\sigma}$. Moreover, our guess in (43) implies $V_A = -\sigma A_t^{-1} V$, $V_{AA} = (1+\sigma)\sigma A_t^{-2} V$, $V_X = -(1-\alpha)\sigma X_t^{-1} V$. Inserting in (34) gives

$$\begin{aligned}
\rho\frac{(A_t X_t^{1-\alpha}\vartheta)^{-\sigma} a_t^{1-\alpha\sigma}}{1-\alpha\sigma} &= (A_t X_t^{1-\alpha}\vartheta)^{-\sigma} a_t^{-\alpha\sigma}\left(\left(\frac{1-\tau_i}{1+\tau_k}(r_t-\delta)-\tau_a\right)a_t + \frac{1-\tau_i}{1+\tau_c}w_t - \vartheta A_t X_t^{1-\alpha} a_t^{\alpha}\right) \\
&+ \frac{(A_t X_t^{1-\alpha}\vartheta a_t^{\alpha})^{1-\sigma}}{1-\sigma} - \frac{\sigma}{1-\alpha\sigma}(A_t X_t^{1-\alpha}\vartheta)^{-\sigma} a_t^{1-\alpha\sigma}\mu \\
&+ \frac{1}{2}\frac{(1+\sigma)\sigma}{1-\alpha\sigma}(A_t X_t^{1-\alpha}\vartheta)^{-\sigma} a_t^{1-\alpha\sigma}\eta^2 + \lambda\left((\exp(\nu))^{-\sigma}-1\right)\frac{(A_t X_t^{1-\alpha}\vartheta)^{-\sigma} a_t^{1-\alpha\sigma}}{1-\alpha\sigma}.
\end{aligned}$$

Collecting terms we obtain

$$\begin{aligned}
&\left(\rho + \sigma\mu - \frac{1}{2}(1+\sigma)\sigma\eta^2 - \lambda\left((\exp(\nu))^{-\sigma}-1\right)\right)\frac{a_t^{1-\alpha\sigma}}{1-\alpha\sigma} \\
&= \frac{(A_t X_t^{1-\alpha}\vartheta) a_t^{\alpha(1-\sigma)}}{1-\sigma} + a_t^{-\alpha\sigma}\left(\left(\frac{1-\tau_i}{1+\tau_k}(r_t-\delta)-\tau_a\right)a_t + \frac{1-\tau_i}{1+\tau_c}w_t - \vartheta A_t X_t^{1-\alpha} a_t^{\alpha}\right).
\end{aligned}$$

Inserting $r_t = Y_K$ and $w_t = Y_L$ together with $K_t \equiv Lk_t = \frac{1+\tau_c}{1+\tau_k} La_t$ from (27), we obtain

$$\begin{aligned}
&\left(\rho + \sigma\mu - \frac{1}{2}(1+\sigma)\sigma\eta^2 - \lambda\left((\exp(\nu))^{-\sigma}-1\right)\right)\frac{a_t^{1-\alpha\sigma}}{1-\alpha\sigma} = \\
&\frac{(A_t X_t^{1-\alpha}\vartheta) a_t^{\alpha(1-\sigma)}}{1-\sigma} + a_t^{-\alpha\sigma}\left(\frac{1-\tau_i}{1+\tau_c}A_t X_t^{1-\alpha} K_t^{\alpha} L^{-\alpha} - \frac{1-\tau_i}{1+\tau_k}\delta a_t - \tau_a a_t - \vartheta A_t X_t^{1-\alpha} a_t^{\alpha}\right) \\
\Leftrightarrow\; &\frac{1-\sigma}{1-\alpha\sigma}\Theta a_t^{1-\alpha\sigma} = \left((1-\sigma)\frac{1-\tau_i}{1+\tau_c}\left(\frac{1+\tau_c}{1+\tau_k}\right)^{\alpha} + \sigma\vartheta\right) a_t^{\alpha(1-\sigma)} A_t X_t^{1-\alpha},
\end{aligned}$$

where we defined in the last step,

$$\Theta \equiv \rho + \sigma\mu - \frac{1}{2}(1+\sigma)\sigma\eta^2 - \lambda\left(\exp(\nu)^{-\sigma} - 1\right) + (1-\alpha\sigma)\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right).$$

Inserting conditions, $\Theta = 0$, and ϑ from (40) is sufficient to proof that our guess is a solution.

B.1.2 Proof of Corollary A.2

Inserting $c_t = A_t X_t^{1-\alpha}\vartheta a_t^\alpha$ from (44) in the evolution of capital rewards (32), we obtain

$$\begin{aligned} dr_t &= \left(\mu - (1-\alpha)\left(\frac{1-\tau_i}{1+\tau_k}r_t/\alpha - \frac{1-\tau_i}{1+\tau_k}\delta - \tau_a - A_t X_t^{1-\alpha} a_t^{\alpha-1}\vartheta\right)\right) r_t dt \\ &\quad +\eta r_t dz_t + (\exp(\nu) - 1)\, r_{t-} dq_t, \\ &= \left(\mu - (1-\alpha)\left(\frac{1-\tau_i}{1+\tau_k} - \vartheta\left(\frac{1+\tau_c}{1+\tau_k}\right)^{1-\alpha}\right) r_t/\alpha + (1-\alpha)\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right)\right) rdt \\ &\quad +\eta r_t dz_t + (\exp(\nu) - 1)\, r_{t-} dq_t. \end{aligned}$$

where using (30) we replaced $A_t X_t^{1-\alpha} a_t^{\alpha-1} = \left(\frac{1+\tau_c}{1+\tau_k}\right)^{1-\alpha} r_t/\alpha$ in the last step. We now rewrite the equation by inserting ϑ from (40), and collecting terms to

$$\begin{aligned} dr_t &= \left(\mu + (1-\alpha)\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - \frac{1-\alpha}{\alpha}\left(\frac{1-\tau_i}{1+\tau_k} - \vartheta\left(\frac{1+\tau_c}{1+\tau_k}\right)^{1-\alpha}\right) r_t\right) r_t dt \\ &\quad +\eta r_t dz_t + (\exp(\nu) - 1)\, r_{t-} dq_t, \\ &= \left(\mu + (1-\alpha)\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - \frac{1-\alpha}{\alpha\sigma}\frac{1-\tau_i}{1+\tau_k} r_t\right) r_t dt + \eta r_t dz_t + (\exp(\nu) - 1)\, r_{t-} dq_t, \\ &= \frac{1-\alpha}{\alpha\sigma}\frac{1-\tau_i}{1+\tau_k} r_t \left(\frac{\alpha\sigma}{1-\alpha}\frac{1+\tau_k}{1-\tau_i}\mu + \alpha\sigma\frac{1+\tau_k}{1-\tau_i}\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - r_t\right) dt \\ &\quad +\eta r_t dz_t + (\exp(\nu) - 1)\, r_{t-} dq_t. \end{aligned}$$

Using the definitions c_3 and c_4 we finally obtain (41).

B.1.3 Proof of Corollary A.3

Inserting the policy function $C_t = \frac{\sigma-1}{\sigma}\frac{1-\tau_i}{1+\tau_c} Y_t$ with $r_t = \alpha Y_t/K_t$ into (31) gives

$$dy_t = \left(\mu + \frac{1-\tau_i}{1+\tau_k} r_t/\sigma - \alpha\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - \frac{1}{2}\eta^2\right) dt + \eta dz_t + \nu dq_t.$$

It denotes an affine SDE which explicit solution is given by (cf. Posch 2007),

$$\begin{aligned} y_t &= y_{t_0} + (t - t_0)\left(\mu - \alpha\left(\frac{1-\tau_i}{1+\tau_k}\delta + \tau_a\right) - \frac{1}{2}\eta^2\right) + \frac{1-\tau_i}{1+\tau_k} 1/\sigma \int_{t_0}^t r_s ds \\ &\quad +\eta(z_t - z_0) + \nu(q_t - q_0) \end{aligned}$$

where r_s is known explicitly solving (41). Defining the growth rate of output per unit of time, $g_\Delta \equiv y_t - y_{t-\Delta}$ finally gives (42).

B.2 Deriving the iterated weighted least-square (IWLS) estimator

Using (23), the M-estimator minimizes the objective function

$$\sum_{i=1}^{N}\sum_{t=1}^{T}\rho(u_{it}) = \sum_{i=1}^{N}\sum_{t=1}^{T}\rho\left(\log(\sigma_{it}) - \alpha_i - \lambda_t - \beta' x_{it} - \gamma' z_{it}\right)$$

where ρ gives the contribution of each residual to the objective function. Let ψ denote the total derivative of ρ with respect to estimates α_i, λ_t, β', γ', and $\Xi_{NT} = \alpha_i + \lambda_t + \beta' x_{it} + \gamma' z_{it}$. A reasonable M-estimator should be location-and-scale-equivariant. While this class by construction is location-equivariant, we need an auxiliary estimator for the scale-equivariant-property of Ξ_{NT}. If the auxiliary estimator S_{NT} is scale-equivariant, any M-estimator of location defined as the solution of

$$\sum_{i=1}^{T}\sum_{t=1}^{T}\psi\left(\frac{\log(\sigma_{it}) - \Xi_{NT}}{cS_{NT}}\right) = 0 \tag{45}$$

is location-and-scale-equivariant where c denotes a constant.[22]

The unboundedness of ψ is responsible for the lack of resistance of the LS approach. As the classical robust estimator, the least absolute deviation (LAD) estimator treats observations on each side of the estimate symmetrically. However, it is sensitive to changes of the middle observations since it is determined by only one or two observations. The ψ-function of a Huber estimator (Huber 1981) is linear in the center and constant in the tails.

We follow Hoaglin et al. (1983) by defining the weight function $w\left(u_{it}(cS_{NT})^{-1}\right) \equiv \psi\left(u_{it}(cS_{NT})^{-1}\right) / \left(u_{it}(cS_{NT})^{-1}\right)$, we obtain from equation (45) after collecting terms

$$\Xi_{NT} = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}\log(\sigma_{it})w\left((\log(\sigma_{it}) - \Xi_{NT})(cS_{NT})^{-1}\right)}{\sum_{i=1}^{N}\sum_{t=1}^{T} w\left((y_{it} - \Xi_{NT})(cS_{NT})^{-1}\right)}. \tag{46}$$

An explicit solution to (46) is rarely available. Ξ_{NT} is a weighted mean of $\log(\sigma_{it})$ where the weights again depend on the estimator, thus often defined iteratively is called the W-estimate based on the weight function w or iterates weighted least square (IWLS) estimator. Each weight depends on the residual at the preceding iteration. The iteration continues until the sequence of estimates has converged to the desired accuracy, using the formula

$$\Xi_{NT}^{(m+1)} = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}\log(\sigma_{it})w\left(\left(\log(\sigma_{it}) - \Xi_{NT}^{(m)}\right)(cS_{NT})^{-1}\right)}{\sum_{i=1}^{N}\sum_{t=1}^{T} w\left(\left(\log(\sigma_{it}) - \Xi_{NT}^{(m)}\right)(cS_{NT})^{-1}\right)}.$$

[22] The constant parameter c is known as the *tuning constant* because it can be chosen so that the estimator has a specified asymptotic efficiency at a chosen distribution (cf. Hoaglin et al. 1983, p.345).

B.3 Detailed tax tables

The new classification of the OECD Revenue Statistics and OECD National Accounts databases based on the international manual "A System of National Accounts, 1993" (SNA 1993) or the European equivalent "European System of Accounts, 1995" (ESA95) provides a composition of national accounts into household and corporations (see Table 13. simplified accounts for households and NPISH and for corporations) covering the time period 1955-2004. Although Revenue Statistics are available from 1965 onwards, our tax ratios will be computed from 1970 onwards only, as exchange rates until 1970 are not readily available in the new (SNA93/ESA95) National Accounts.

Modifications based on Carey et al. 2004

The main changes are that deductibility of social security contributions (SSCs) is taken into account, labor income is enlarged to include employer contributions to pension funds, and the definition of capital taxes is widened to include a number of property taxes.[23] For the revised tax rates, we implement the suggestions in Carey and Rabesona (2004, Table 7.1). Precisely the following changes have been conducted:

1. Household income tax ratio, τ_h: Mendoza et al. (1994) assume that households are not able to deduct SSCs from their taxable income; as suggested we allow Germany, Ireland, Poland, and Turkey for deductions; not allocated tax revenues (1300) are allocated to either households or companies on the basis of what seems most appropriate; note that we allocate 1300 for Portugal and New Zealand similar to the proposed procedure for Greece according the relative weights of households (1100) and companies (1200) on income, profits, and capital gains (1000)

2. Labor income tax ratio ($LABOR$), capital tax ratio ($CAPITAL$): see below

3. Consumption tax ratio ($CONS$): a number of other indirect taxes are taken into account, see below for revisions

For convenience, revised tax ratios are reproduced below. For the reasoning behind some assumptions, the interested reader is referred to Carey and Rabesona (2004, pp.216-229).

For countries where SSCs are deductible, the revised household income tax ratio reads

$$\tau_h^d = \frac{1100}{OSPUE + PEI + W - 2100 - 2300 - 2400}.$$

Note that for all other countries, the average household income tax ration remains τ_h.

[23]For a discussion on the Mendoza et al. methodology see Carey and Rabesona (2004, pp.215-216)

For countries where SSCs are *not* deductible, the tax base of the revised labor income tax ratio now includes compensation of employees (CoE) and taxes on payroll and workforce (3000). Moreover they allocate 2400 according to the share of labor income in household income, $\alpha = W/(OSPUE + PEI + W)$, to labor income taxes,

$$LABOR^n = \frac{\tau_h W + 2100 + 2200 + \alpha \times 2400 + 3000}{CoE + 3000}.$$

Similarly, for countries where SSCs are deductible, the revised labor income tax ratio reads

$$LABOR^d = \frac{\tau_h^d (W - 2100 - \alpha \times 2400) + 2100 + 2200 + \beta \times 2400 + 3000}{CoE + 3000},$$

where $\beta = (W - 2100)/(OSPUE + PEI + W - 2100 - 2300)$ denotes the share of labor income in household income used to allocate 2400 for countries with SSCs deductible.

The revised capital tax ratio now considers all property taxes (4000), taxes on payroll and workforce (3000) in the tax base, as well as recurrent taxes on motor vehicles paid by others than households (5125), taxes on investment goods (5125), and other taxes paid solely by business (6100). For countries with SSCs *not* deductible it reads

$$CAPITAL^n = \frac{\tau_h (OSPUE + PEI) + 1200 + 2300 + (1 - \alpha) \times 2400 + 4000 + 5125 + 5212 + 6100}{OS - 3000}.$$

For countries with SSCs deductible the capital tax ratio becomes

$$CAPITAL^d = \frac{\tau_h^d (OSPUE + PEI - 2300 - (1 - \beta) \times 2400)}{OS - 3000} + \frac{1200 + 2300 + (1 - \beta) \times 2400 + 4000 + 5125 + 5212 + 6100}{OS - 3000}.$$

The revised consumption tax ratio now considers profits of fiscal monopolies (5122), customs and import duties (5123), taxes on specific services (5126), other taxes on specific goods and services (5128), taxes on use of goods and perform activities (5200) less recurrent taxes on motor vehicles paid by others than households (5212),

$$CONS = \; = \frac{5110 + 5121 + 5122 + 5123 + 5126 + 5128 + 5200 - 5212}{C + G - GW}.$$

The following updated tax ratios based on Mendoza et al. (1994) and modified tax ratios as suggested by Carey and Rabesona (2004) are available on request from the author. They may be used without explicit permission provided that full credit is given to the source.

Table B.1: Correlation of revised tax ratios with Carey and Rabesona (2004)

	CAPITAL	*LABOR*	*CONS*
Australia	0.95	0.94	0.93
Austria	0.89	0.99	1.00
Belgium	0.93	0.97	1.00
Canada	0.99	1.00	1.00
Czech Republic	0.97	0.88	0.98
Denmark	1.00	1.00	0.98
Finland	1.00	1.00	1.00
France	1.00	1.00	0.99
Germany	**0.73**	0.96	0.86
Greece	**0.71**	**0.74**	1.00
Hungary			1.00
Iceland			
Ireland			1.00
Italy	1.00	1.00	1.00
Japan	0.99	1.00	0.99
Korea	1.00	1.00	0.97
Luxembourg			
Mexico			
Netherlands	1.00	1.00	0.99
New Zealand	0.99	0.97	1.00
Norway	1.00	0.95	1.00
Poland			1.00
Portugal	0.93	**-0.07**	1.00
Slovak Republic			
Spain	1.00	0.99	1.00
Sweden	0.9	0.89	**0.55**
Switzerland	0.87	**-0.01**	1.00
Turkey			
United Kingdom	0.99	0.98	1.00
United States	**0.79**	1.00	0.99

Notes: This table reports the correlation coefficients of computed tax ratios with revised tax ratios of Carey and Rabesona (2004). The values are based on the time period 1975-2000 under consideration for the Carey and Rabesona (2004) tax ratios tables. Correlation coefficients less than 0.8 are in boldface.

	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	GRC	HUN	ISL	IRL	ITA	JPN
1970	7.2	21.0	20.9	13.0				23.5	14.5	11.5		12.0	22.5	13.5	5.8
1971	7.3	21.3	20.6	13.3		28.5		23.2	14.1	11.4			22.0	13.1	5.4
1972	6.9	22.1	19.1	13.5		29.2		23.5	14.1	11.9			20.5	12.0	5.4
1973	7.3	22.0	18.6	14.0		28.5		22.4	13.8	12.1			20.9	11.8	5.0
1974	6.7	21.0	18.5	13.0		25.8		22.3	12.6	10.5			18.5	12.7	4.5
1975	7.4	20.3	17.2	11.4		24.6	21.6	20.6	11.9	11.6		18.1	18.7	11.3	4.1
1976	6.9	21.5	18.4	11.8		26.1	21.6	21.5	11.8	11.7			21.2	11.9	4.2
1977	6.8	20.8	18.0	11.4		28.0	24.0	19.6	11.7	11.6			19.8	12.7	4.3
1978	7.6	21.5	18.2	10.2		30.7	24.8	20.1	12.5	11.7			20.0	11.6	4.7
1979	8.4	22.0	17.5	10.3		32.5	25.0	21.3	12.9	10.6			18.3	11.4	4.8
1980	8.5	21.8	17.0	10.8		31.6	25.1	20.8	13.0	9.3		20.6	19.7	11.9	4.7
1981	8.2	22.3	16.6	14.1		31.3	25.8	19.9	12.7	9.6		21.4	20.9	11.4	4.8
1982	8.6	21.2	16.4	13.8		30.6	25.1	20.3	12.3	11.4		21.7	24.6	11.5	4.6
1983	9.1	21.1	16.4	12.8		32.3	25.1	20.1	12.7	11.7		20.1	25.8	12.8	4.5
1984	9.5	23.0	16.1	13.1		33.1	27.4	20.1	12.7	13.8		20.0	26.1	12.9	4.5
1985	9.3	22.5	15.7	12.7		33.3	27.5	20.6	12.1	15.0		19.5	24.5	12.0	4.9
1986	9.0	22.3	15.5	12.6		37.0	28.3	20.4	11.9	18.4		19.4	24.7	13.5	4.8
1987	9.0	22.3	15.8	13.1		36.5	28.6	20.4	12.0	20.2		19.9	24.0	13.6	4.8
1988	8.6	22.0	16.1	13.6		37.2	30.5	20.5	11.9	18.3		22.4	25.1	14.4	4.9
1989	8.3	21.6	16.4	13.6		35.1	31.6	20.1	12.4	15.8		22.3	24.4	13.9	5.2
1990	7.8	21.0	16.7	12.7		34.2	31.2	19.7	12.9	17.9		19.1	24.0	15.4	5.7
1991	6.8	20.8	16.3	12.7		33.0	28.3	18.6	15.1	19.2		18.2	23.1	15.5	5.7
1992	6.6	21.1	16.5	12.7		32.3	26.9	18.0	15.4	20.5		18.5	23.0	15.3	5.6
1993	7.2	20.3	16.6	12.7	21.7	31.5	26.8	17.9	15.9	19.6		20.7	22.2	15.3	5.6
1994	7.5	21.6	17.4	12.6	20.9	32.4	27.2	18.8	16.8	19.0		23.2	23.9	16.6	5.7
1995	7.7	18.5	16.8	12.5	21.1	33.3	26.7	19.3	16.1	18.6	23.6	24.1	24.6	15.8	5.6
1996	7.6	20.2	17.1	12.5	20.5	34.5	28.4	20.2	15.9	18.8	24.7	26.5	25.0	14.8	5.7
1997	7.3	20.1	17.3	12.4	19.8	34.7	29.2	20.2	15.6	19.4	26.8	26.5	25.6	14.5	6.3
1998	7.2	20.1	17.4	12.6	19.0	36.0	29.8	20.2	15.6	19.5	27.6	26.5	26.3	15.4	7.2
1999	6.9	20.4	17.8	12.7	20.5	36.4	30.4	20.2	16.3	20.1	28.6	28.3	25.0	14.9	7.3
2000	9.9	20.0	18.0	12.7	19.9	36.1	29.3	19.6	16.3	20.9	29.6	27.7	25.8	15.8	7.0
2001	10.1	19.4	17.0	12.2	19.1	36.2	28.1	18.8	15.9	21.0	27.7	25.5	24.5	14.7	6.9
2002		19.5	17.1		18.5	36.4	27.9	18.5	16.1	20.6	25.3	26.4		14.5	6.8
2003															

Table B.2: Consumption tax ratio (in percent) 1/2

	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	SVK	ESP	SWE	CHE	TUR	GBR	USA
1970		9.2		15.6	8.7	29.1		6.7		6.9	19.0	7.1	3.9	15.7	6.3
1971		10.2		16.5	8.9	30.3		6.1		6.5	23.0	6.9	4.3	14.3	6.3
1972	5.1	11.8		17.5	8.8	31.0		6.0		6.5	22.6	7.3	4.1	13.2	6.1
1973	5.2	12.5		17.4	8.6	29.9		5.8		6.7	21.9	7.1	4.1	12.8	6.1
1974	6.4	11.6		16.3	8.1	28.2		5.9		6.1	19.3	6.8	3.1	12.4	6.0
1975	7.3	12.5		16.3	9.4	27.8		6.9		5.6	18.8	6.8	3.9	12.4	5.7
1976	8.0	12.1		16.5	9.3	29.8		8.6		5.3	20.4	7.0	4.1	12.6	5.6
1977	8.8	11.6		17.3	9.3	30.1		9.3		5.2	20.1	7.2	3.2	13.0	5.4
1978	9.6	12.0		17.2	9.8	31.2		9.6		5.6	20.4	7.5	2.7	12.5	5.4
1979	10.2	11.4		16.8	9.8	30.1		9.9		5.3	20.0	7.3	2.7	13.7	5.2
1980	10.1	13.8	5.9	16.9	9.4	31.5		12.7		5.8	20.2	7.4	2.7	15.2	5.3
1981	9.7	14.9	5.7	16.5	10.3	32.9		12.2		6.4	20.5	7.4	3.1	15.8	6.0
1982	9.6	17.5	6.6	16.0	10.7	32.1		12.4		6.7	19.7	7.3	3.1	16.0	5.7
1983	10.5	18.7	9.2	16.4	10.8	32.9		13.5		7.5	21.3	7.4	2.8	16.2	5.3
1984	10.3	18.5	8.9	17.1	11.3	33.6		12.6		9.2	22.3	7.5	2.2	16.9	5.4
1985	10.0	18.1	7.9	17.1	9.9	35.7		12.0		9.1	23.7	7.6	6.0	17.5	5.3
1986	10.4	18.2	8.5	17.8	12.3	35.2		19.8		11.5	23.1	7.9	6.3	16.9	5.1
1987	10.0	17.9	8.6	18.6	19.6	35.2		17.9		12.2	24.0	8.1	7.0	16.6	5.0
1988	10.7	17.7	8.7	18.9	18.1	31.7		17.7		12.5	24.0	8.3	7.0	16.6	5.0
1989	11.8	18.4	8.2	17.8	19.6	30.1		17.7		12.5	24.9	8.2	6.2	16.1	4.9
1990	12.8	18.9	7.6	18.1	19.1	30.2		17.1		12.4	26.0	8.0	6.3	15.6	4.9
1991	12.4	20.2	7.1	18.0	19.3	29.2	10.7	17.1		12.8	24.7	7.6	7.2	16.0	5.1
1992	13.2	22.3	6.4	18.2	19.7	30.0	13.0	19.8		13.5	22.0	7.2	8.0	16.8	5.1
1993	13.1	24.5	6.1	18.0	19.5	30.3	16.7	17.9		12.0	22.8	7.3	8.8	16.2	5.2
1994	13.0	25.2	6.9	17.9	19.1	32.4	16.5	20.5		13.1	22.5	7.3	10.5	16.5	5.3
1995	12.8	23.7	6.5	18.3	18.9	33.3	17.3	21.9		13.1	27.8	8.8	10.9	16.4	5.4
1996	13.4	22.9	6.4	18.9	17.9	33.4	17.9	21.6		13.4	26.2	8.5	13.9	16.4	5.3
1997	13.7	24.5	7.3	19.1	18.0	34.4	18.6	21.6		13.9	26.0	8.6	14.7	16.6	5.2
1998	12.8	24.6	8.0	19.4	18.2	33.5	18.6	22.7	17.5	14.7	26.3	9.1	13.9	16.5	5.1
1999	13.6	27.2	8.9	20.0	18.1	32.4	19.3	23.0	17.3	15.5	26.0	9.8	14.6	15.6	5.2
2000	13.6	29.4	7.8	20.3	17.8	32.6	18.2	22.4	18.6	15.5	26.3	10.2	18.1	16.2	5.1
2001	14.5	26.1	8.4	20.6	18.6	32.0	17.9	21.6	17.1	15.0	26.0	10.3	18.5	15.6	5.0
2002	14.6	26.5		20.3	18.9	29.8	18.6		17.9	15.0	26.4	9.9	22.3	15.2	
2003															

Table B.3: Consumption tax ratio (in percent) 2/2

	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	GRC	HUN	ISL	IRL	ITA	JPN
1970	13.7	33.1	30.1	20.5		26.7	26.6	30.0	26.0	26.5					16.0
1971	15.2	33.4	30.8	20.6		30.5	28.6	30.0	27.1	26.1					16.5
1972	14.7	34.1	31.4	21.3		29.9	29.6	30.4	28.5	25.7					17.3
1973	16.0	34.3	32.1	20.5		28.5	31.6	30.2	30.2	25.1				26.2	18.0
1974	18.4	35.0	33.3	21.9		31.6	32.0	31.0	30.7	25.1				28.5	18.1
1975	19.0	34.6	36.5	21.6		29.1	35.1	32.4	30.7	25.4				29.9	17.8
1976	19.9	37.9	36.1	22.3		28.0	38.7	33.9	31.7	27.2				30.5	18.4
1977	19.9	38.9	38.0	21.2		27.9	39.4	35.0	32.7	27.9				29.7	19.0
1978	18.9	41.5	39.1	21.3		28.8	35.5	37.4	32.1	28.1				30.1	19.9
1979	19.7	41.2	39.6	21.4		29.7	34.4	39.3	31.7	28.9				30.1	20.8
1980	20.1	42.1	42.4	21.9		31.5	34.5	40.4	32.1	30.2				34.0	22.1
1981	20.9	42.8	43.3	23.9		31.4	36.5	40.3	31.9	30.1				34.3	22.9
1982	20.8	42.6	45.4	24.1		31.4	35.1	41.4	32.2	33.6				37.0	23.3
1983	20.4	42.5	46.0	25.4		33.6	34.8	43.0	32.2	34.9				38.5	23.5
1984	22.0	43.7	47.9	24.7		33.9	36.7	44.4	32.6	35.2				37.8	23.4
1985	22.0	44.5	48.3	25.6		35.7	38.9	44.4	33.4	34.9				37.9	24.6
1986	25.2	44.4	48.5	26.8		35.4	41.0	44.7	33.4	35.6				40.5	25.3
1987	25.6	44.0	49.7	28.7		37.3	38.1	45.6	33.7	34.3				40.1	25.6
1988	25.4	44.5	49.1	28.1		38.3	41.4	45.4	33.6	30.1				40.5	25.5
1989	23.7	42.7	47.4	28.7		38.8	41.3	45.9	34.0	29.7				41.3	26.4
1990	23.8	43.1	47.2	30.2		38.2	43.1	46.5	32.7	30.3				41.6	29.1
1991	23.2	43.4	46.9	31.2		38.9	42.9	47.2	38.9	30.9				42.2	28.6
1992	23.1	44.6	47.6	31.3		40.0	43.9	46.2	39.8	31.2				43.5	27.5
1993	24.0	45.7	47.2	31.1	44.3	41.5	47.1	46.5	39.7	34.4				45.9	28.0
1994	24.9	46.2	48.6	31.9	43.6	45.0	52.8	47.0	40.7	35.3				44.5	26.6
1995	25.6	47.2	48.7	32.1	42.7	43.9	50.2	46.7	41.5	39.0	41.8			45.9	27.6
1996	26.7	48.3	48.8	32.7	43.2	44.5	51.1	47.5	40.4	40.6	40.4			48.1	27.5
1997	27.4	49.7	49.2	33.1	43.1	45.0	48.8	47.1	40.9	40.6	41.1			49.3	28.0
1998	27.3	49.7	49.3	33.1	43.8	44.4	48.9	45.8	41.2	41.4	41.1			45.5	26.5
1999	28.3	49.9	48.8	33.5	44.3	46.5	48.6	46.1	40.9	42.1	41.4			46.1	26.2
2000	25.2	49.0	48.9	33.0	44.3	46.7	48.9	46.1	40.6	40.7				44.5	27.5
2001	27.0	50.4	48.6			46.6	47.8	45.3	40.8	43.1					28.0
2002		50.3	49.2			46.4	48.1	45.2	40.5	42.0					
2003															

Table B.4: Labor income tax ratio (in percent) 1/2

	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	SVK	ESP	SWE	CHE	TUR	GBR	USA
1970				38.0	16.5	31.1				15.5	37.1	18.4		26.6	20.3
1971				40.0	18.0	33.4				16.4	37.3	18.2		25.3	19.1
1972	2.2			41.5	18.4	36.2				17.5	39.3	18.3		23.8	19.5
1973	2.1			43.5	19.5	38.9				17.9	39.4	21.7		22.2	19.9
1974	1.9			44.7	22.2	38.5				18.2	42.4	23.0		25.3	21.1
1975	2.1			45.2	21.8	38.0				20.4	43.4	24.8		27.7	21.4
1976	3.8			45.3	22.3	37.7				19.8	47.7	26.4		28.5	21.0
1977	3.5			45.0	25.3	37.4				23.3	50.6	27.1		28.2	22.4
1978	3.5			45.8	24.3	37.1				25.0	50.4	26.9		27.2	22.6
1979	3.7			46.8	24.7	38.7				26.1	49.0	26.5		26.8	23.5
1980	3.4			47.2	26.2	38.4				27.1	49.5	26.2		27.1	24.0
1981	3.5			47.7	26.5	38.4				28.3	51.0	26.3		28.3	24.8
1982	3.7			49.2	26.9	37.3				28.9	49.8	26.7		29.4	25.1
1983	3.6			53.1	25.5	37.4				30.5	51.3	27.4		28.0	23.9
1984	3.5			52.0	24.7	36.2				31.8	51.2	28.2		26.9	23.5
1985	3.9			51.1	27.7	35.9				31.2	50.3	21.7		25.7	24.2
1986	4.0			50.2	28.9	36.3				30.7	52.7	22.3		27.3	24.2
1987	4.3			51.5	26.3	37.2				32.6	54.1	22.0		26.5	24.9
1988	5.2			52.4	27.8	38.6				32.2	54.3	22.4		26.3	24.6
1989	5.8			49.6	27.6	39.8		23.4		33.6	55.5	22.0		24.2	25.2
1990	7.0			48.5	26.7	39.0		24.4		32.6	55.6	22.3		23.9	25.1
1991	6.4			51.4	25.2	39.3		25.2		33.0	52.5	21.9		23.9	25.2
1992	7.2			51.0	25.9	38.6	33.5	26.6		34.5	50.4	22.2		23.8	25.0
1993	8.6			51.6	26.6	37.2	35.9	26.0		34.4	48.4	23.3		23.2	25.4
1994	8.4			50.2	26.7	38.7	35.0	26.7		34.5	50.2	24.0		24.4	25.7
1995	8.2			49.2	26.1	38.6	34.6	28.9		34.6	51.6	23.9		24.7	25.9
1996	8.7			46.2	23.7	39.2	33.8	28.5		34.1	53.7	24.6		24.4	26.3
1997	11.4			46.8	23.8	39.7	33.4	28.5		34.2	55.5	24.0		23.7	26.7
1998	13.6			42.3	22.1	39.6	32.8	28.7	41.1	34.2	57.3	24.5		26.2	27.0
1999	13.6			43.6	22.6	40.0	29.5	28.9	40.4	34.5	59.6	23.8		26.1	27.2
2000	14.2			43.8	23.0	39.7	29.9	29.3	40.3	34.5	58.2	24.6		26.5	27.7
2001	15.2			40.4		40.5	29.6	29.4	41.0	35.6	54.9	23.4		27.0	27.8
2002	15.5			40.4			29.9			35.8	53.8			26.5	
2003															

Table B.5: Labor income tax ratio (in percent) 2/2

	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	GRC	HUN	ISL	IRL	ITA	JPN
1970	30.9	19.9	25.8	45.7		46.2	24.3	18.9	22.0	6.5				14.3	23.1
1971	32.0	21.2	27.3	44.6		52.0	25.9	17.9	22.5	6.9				15.9	24.4
1972	30.9	21.8	28.8	46.5		49.2	26.7	18.6	24.4	7.2				17.3	26.3
1973	33.5	21.7	31.2	43.1		51.3	28.1	19.8	27.0	6.2				14.3	31.7
1974	40.6	23.8	34.0	45.2		58.6	28.1	21.4	27.9	7.4				14.7	34.9
1975	40.2	25.7	37.7	46.1		55.0	31.4	23.2	26.5	7.1				15.7	28.8
1976	37.3	23.8	36.9	44.5		53.5	39.6	27.3	27.3	7.4				17.7	29.3
1977	37.0	24.4	39.2	43.5		52.8	39.4	26.4	30.2	8.1				19.9	30.5
1978	32.1	27.6	41.1	41.4		56.0	31.4	24.7	29.6	8.1				22.1	32.8
1979	31.8	25.8	42.1	38.5		58.5	26.7	26.5	30.0	7.7				20.8	32.9
1980	36.1	26.6	41.3	39.6		62.3	28.6	30.3	31.6	7.8				22.5	35.3
1981	36.0	27.9	40.3	40.7		62.5	33.8	32.4	30.6	7.4				25.3	36.2
1982	38.7	24.9	43.0	41.4		56.2	32.7	33.7	30.4	8.3				28.0	37.4
1983	33.4	23.8	41.5	37.1		56.3	32.5	32.4	29.1	7.0				30.3	39.6
1984	35.3	25.7	42.1	36.2		60.4	34.4	32.0	29.1	7.7				29.2	41.2
1985	37.0	26.7	43.7	36.1		61.0	37.9	31.3	30.7	7.6				27.9	39.7
1986	41.1	26.7	42.9	40.2		68.7	41.3	29.8	29.3	8.5				30.5	41.2
1987	40.0	25.8	42.6	41.1		70.5	37.4	30.3	28.6	8.8				29.5	46.8
1988	40.5	25.8	38.4	40.3		78.2	40.3	28.8	28.2	8.4				29.2	47.7
1989	42.2	24.4	36.4	44.3		70.0	42.5	28.3	29.0	8.3				30.8	47.2
1990	43.0	24.1	36.9	49.2		61.9	50.1	27.1	25.5	11.0				32.6	46.2
1991	39.0	24.8	37.8	53.2		61.2	70.6	27.4	27.9	9.5				33.4	44.7
1992	36.6	26.7	37.8	53.1		57.7	61.4	28.9	29.7	9.1				37.2	41.9
1993	35.6	26.4	40.3	51.4	39.8	61.5	37.8	29.9	29.8	8.9				40.9	40.8
1994	38.7	23.7	42.9	47.3	35.6	56.2	34.0	30.1	27.3	9.9				35.4	39.7
1995	40.1	24.8	43.3	47.3	29.6	56.5	32.5	30.7	26.8	11.7	12.8			34.4	41.8
1996	40.9	27.7	44.5	48.3	26.8	57.8	37.6	33.6	26.2	12.0	12.8			35.1	41.6
1997	38.9	29.9	45.8	51.0	25.0	58.4	38.6	35.7	26.1	13.4	11.7			37.2	39.5
1998	41.2	29.5	48.2	52.3	24.1	66.4	36.9	39.2	26.9	16.5	12.1			32.9	38.7
1999	44.0	28.8	47.1	48.2	24.4	64.3	39.8	41.4	29.2	19.1	12.7			35.1	37.0
2000	49.1	27.9	47.6	44.4	25.2	53.6	42.5	41.5	30.5	21.5				33.1	38.6
2001	39.3	33.8	50.3			63.4	40.3	42.5	25.1	18.1				35.2	38.8
2002		28.5	52.5			61.6	36.9	39.5	23.6	15.9				33.5	35.6
2003															

Table B.6: Capital tax ratio (in percent) 1/2

	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	SVK	ESP	SWE	CHE	TUR	GBR	USA
1970				24.6	41.3	19.9				9.6	31.1	17.5		57.7	44.1
1971				27.4	37.9	21.1				10.0	31.0	17.8		51.7	37.9
1972	6.1			28.1	35.8	21.6				10.6	32.7	18.5		48.8	39.3
1973	5.5			29.1	37.6	19.1				11.1	31.3	20.0		48.3	38.9
1974	6.4			30.0	46.3	20.8				11.2	29.9	21.5		62.9	41.6
1975	6.4			33.5	45.4	20.4				12.1	34.2	23.8		65.5	38.9
1976	8.6			31.8	42.3	24.0				12.5	36.9	25.0		57.2	36.9
1977	8.8			33.3	46.2	27.0				12.5	39.2	24.5		53.1	39.7
1978	9.4			34.0	41.8	29.9				12.5	38.6	24.1		51.5	38.5
1979	10.1			34.4	45.2	28.6				12.8	36.2	23.2		53.4	38.3
1980	9.9			35.1	45.3	35.9				13.5	33.3	23.1		64.7	40.2
1981	10.0			33.6	44.2	41.5				14.4	36.4	23.9		72.3	38.7
1982	10.9			33.1	45.2	42.0				14.0	35.6	25.3		72.5	40.4
1983	11.2			29.2	39.1	37.4				15.8	35.8	26.7		64.8	33.1
1984	10.5			25.8	41.0	37.2				16.6	36.4	26.0		64.6	33.1
1985	10.9			26.8	44.3	40.5				14.9	38.8	26.3		63.4	34.0
1986	10.2			29.3	41.4	49.8				14.7	46.3	28.8		64.1	33.8
1987	11.8			33.3	48.4	39.6				19.8	48.4	29.4		58.6	36.9
1988	13.1			32.9	42.8	39.2				19.7	52.0	30.5		58.2	36.7
1989	16.6			30.5	46.6	29.7		12.0		24.1	49.6	30.1		61.7	36.7
1990	18.2			32.4	41.6	32.9		17.9		24.5	53.1	28.7		59.4	35.9
1991	17.2			35.1	40.2	33.0		21.3		24.3	48.5	29.3		53.9	36.7
1992	18.6			34.6	39.5	28.4	19.8	23.7		24.3	39.2	30.9		46.4	35.4
1993	18.6			37.9	38.3	28.1	21.0	20.7		22.7	42.7	29.4		44.1	35.4
1994	19.4			31.7	39.4	28.9	18.4	19.8		21.5	40.3	28.0		42.3	35.8
1995	20.9			29.8	39.9	29.5	18.1	24.5		22.0	35.9	27.8		45.3	36.9
1996	21.4			32.9	36.2	29.0	17.8	27.0		22.0	42.3	28.2		44.9	36.6
1997	19.7			33.3	36.3	31.5	17.7	28.0		24.7	45.1	27.2		46.9	37.2
1998	20.0			33.9	35.9	35.1	17.2	29.6	23.0	24.1	46.1	29.6		50.1	40.0
1999	19.0			35.5	33.7	27.5	16.6	31.4	20.0	25.9	47.7	32.5		52.0	39.3
2000	24.0			35.1	34.6	28.3	16.2	36.6	19.5	27.1	57.6	39.4		57.0	43.5
2001	22.7			36.7		41.1	15.7	33.5	14.1	26.6	55.3	42.2		58.4	41.0
2002	23.4			35.6			15.8			28.8	53.0			52.2	
2003															

Table B.7: Capital tax ratio (in percent) 2/2

	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	GRC	HUN	ISL	IRL	ITA	JPN
1970	23.1	14.8	24.4	22.6		15.9	18.8	39.8	18.9	3.2				11.7	30.1
1971	23.4	16.2	27.0	20.9		15.9	18.4	36.6	16.9	3.7				13.5	30.1
1972	22.2	15.8	28.0	23.1		13.7	19.1	38.0	18.8	7.2				14.8	31.8
1973	25.9	14.5	32.1	23.0		18.5	19.5	39.5	22.4	5.1				12.9	40.5
1974	30.1	17.7	34.6	26.0		22.3	18.8	59.1	22.4	7.8				10.4	47.9
1975	27.2	22.5	36.9	27.3		21.6	22.3	45.7	20.5	6.4				13.2	34.5
1976	23.1	16.8	34.2	23.7		25.5	37.7	56.6	21.1	6.4				14.2	35.1
1977	22.6	17.3	32.7	22.8		21.5	34.9	54.5	26.2	6.9				15.6	37.1
1978	19.1	19.1	32.5	21.5		23.2	21.5	39.3	27.1	6.5				19.6	41.5
1979	17.9	17.7	33.3	19.9		24.9	14.4	43.8	29.1	8.3				16.3	39.7
1980	21.7	18.5	29.5	20.8		29.1	16.1	59.9	30.0	8.4				16.6	44.7
1981	19.3	18.9	27.8	19.5		38.8	20.8	70.3	28.4	8.6				19.0	43.9
1982	18.4	14.8	32.0	16.3		25.1	19.6	89.7	28.2	10.0				22.0	43.9
1983	14.4	13.8	29.9	14.6		22.8	18.7	64.1	26.0	6.6				24.9	45.7
1984	15.4	16.2	29.4	15.9		35.6	17.4	48.1	26.6	7.1				23.9	47.5
1985	15.7	17.6	35.0	15.3		31.0	19.0	43.2	29.8	7.6				22.1	43.5
1986	15.9	17.2	33.4	17.5		44.6	19.5	34.0	27.7	11.5				24.9	42.4
1987	16.1	16.8	30.8	17.5		37.7	17.3	33.3	24.4	13.6				25.2	52.0
1988	16.2	16.7	25.8	17.7		42.3	18.1	29.4	24.5	10.9				22.6	52.6
1989	19.8	18.8	25.4	18.9		34.9	18.9	29.8	25.2	12.2				25.3	51.1
1990	21.1	16.5	22.7	17.8		22.6	31.5	31.2	20.8	16.7				27.8	45.2
1991	19.4	17.0	26.2	17.4		23.7	91.5	27.4	19.4	13.6				27.5	44.2
1992	18.7	20.1	23.6	16.1		20.1	50.5	28.1	21.7	14.5				32.2	42.9
1993	16.8	18.3	29.6	17.9	64.5	26.6	3.6	28.7	22.3	15.7				29.3	40.1
1994	19.8	15.5	31.3	18.2	49.3	21.7	4.7	27.8	15.5	18.3				24.9	42.1
1995	21.5	18.2	33.9	19.7	41.4	22.7	14.6	29.6	14.0	17.6	9.7			22.5	44.0
1996	22.0	22.7	36.8	21.8	34.5	26.6	22.2	35.6	19.0	18.2	9.0			24.4	44.2
1997	20.2	23.7	38.5	26.3	31.9	27.8	28.4	37.0	18.2	25.1	8.2			27.0	41.0
1998	21.7	23.1	42.6	26.9	28.8	35.4	27.0	34.4	17.5	36.5	8.7			19.4	42.3
1999	23.4	20.6	41.2	24.3	31.3	34.7	30.5	38.4	19.9	36.7	9.2			21.6	39.8
2000	31.2	21.0	39.9	23.7	32.3	22.8	33.9	39.8	21.3	46.6	8.8			20.3	40.1
2001	21.3	31.6	45.6	22.0		33.0	31.7	44.7	6.8	34.4				23.6	39.9
2002		22.5	50.5			30.7	27.4	38.8	7.7	31.8				20.4	35.8
2003															

Table B.8: Corporate income tax ratio (in percent) 1/2

	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	SVK	ESP	SWE	CHE	TUR	GBR	USA
1970				16.7	22.4	9.6				12.5	18.3	10.0		30.3	37.0
1971				19.7	18.6	10.1				13.1	19.0	9.9		22.8	26.0
1972	4.4			19.5	15.7	9.0				13.3	20.3	10.8		19.0	28.8
1973	3.1			20.3	17.1	7.8				13.9	19.8	11.8		21.5	30.4
1974	4.8			21.3	21.3	11.0				13.9	16.0	13.1		33.8	33.0
1975	4.5			27.5	19.1	10.3				13.9	21.6	14.5		25.2	28.4
1976	5.9			23.6	16.6	16.2				14.2	23.5	14.8		18.1	24.8
1977	6.7			24.2	17.5	22.0				13.2	26.0	13.6		19.8	28.8
1978	7.8			23.0	12.5	30.5				11.7	24.4	12.8		21.1	27.8
1979	8.6			22.8	16.4	25.4				11.9	20.5	11.6		24.3	28.2
1980	8.1			25.6	13.6	38.4				12.5	15.8	11.4		33.4	29.0
1981	8.1			25.2	12.0	48.0				13.9	20.6	12.0		38.4	24.1
1982	8.6			24.4	13.1	49.9				12.8	19.7	13.5		40.0	22.8
1983	8.3			20.8	8.8	40.2				15.1	19.5	14.1		37.7	13.5
1984	7.9			17.2	12.4	40.2				15.0	19.9	12.8		40.2	17.5
1985	8.6			20.4	13.0	45.1				15.2	20.1	13.2		41.8	18.4
1986	7.6			22.7	10.3	65.7				16.4	29.5	15.1		36.9	17.9
1987	9.6			27.5	16.4	40.2				20.8	28.2	15.9		32.4	22.3
1988	10.6			25.7	13.3	36.4				20.0	33.9	17.6		32.2	23.9
1989	14.5			22.2	16.7	22.0		11.7		28.2	25.8	16.9		37.9	22.7
1990	13.9			23.2	11.7	31.1		21.7		30.3	26.1	17.3		39.5	19.9
1991	11.7			24.2	12.5	32.1	37.5	27.1		27.6	24.8	18.0		36.7	20.4
1992	13.6			24.6	14.3	24.5	24.8	27.8		24.8	16.0	19.7		30.0	19.4
1993	11.9			27.1	15.7	25.0	23.0	22.4		21.1	24.2	17.6		23.0	20.1
1994	12.8			24.6	17.2	25.8	16.9	21.2		17.4	23.0	15.9		22.0	21.4
1995	14.1			23.0	17.5	26.6	16.5	27.4		18.5	20.9	17.2		26.2	23.0
1996	14.8			28.8	13.8	25.5	17.1	32.8		20.1	25.5	16.8		27.0	22.5
1997	12.8			30.9	15.0	29.1	16.5	38.4		27.5	29.7	16.3		30.5	22.3
1998	14.5			31.7	15.2	32.8	15.7	42.9	40.8	25.6	31.2	16.5		30.1	25.0
1999	11.2			32.9	14.2	21.0	14.0	48.0	34.4	30.1	35.2	21.9		30.5	24.2
2000	20.5			31.6	14.6	24.6	13.5	68.5	44.4	33.3	52.0	27.0		33.0	30.3
2001	17.2			33.3		40.4	11.2	62.0	29.9	31.0	56.7	36.7		34.3	24.7
2002	17.2			29.9			11.2			36.4	52.3			26.6	
2003															

Table B.9: Corporate income tax ratio (in percent) 2/2

	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	GRC	HUN	ISL	IRL	ITA	JPN
1970	10.2	21.7	20.8	15.7				21.1	14.2	15.8		26.8	19.2	16.3	8.3
1971	10.1	21.9	20.1	16.1		24.2		20.8	13.9	15.6			19.6	15.7	7.8
1972	9.8	22.5	18.8	16.5		25.4		21.1	13.8	16.0			18.7	14.5	8.0
1973	10.1	21.6	18.2	17.3		23.9		20.3	13.4	16.0			19.1	13.4	7.6
1974	9.7	20.6	18.2	17.7		22.2		20.0	12.5	14.3			17.3	14.0	6.7
1975	10.3	19.5	17.3	16.1		21.5	19.9	18.8	11.9	15.2		29.8	17.1	12.2	6.1
1976	10.0	20.1	18.4	16.4		22.6	19.9	19.4	11.9	15.6			19.0	13.1	6.6
1977	9.7	19.5	18.3	16.3		23.9	21.1	18.1	11.9	15.4			17.9	13.6	6.5
1978	10.5	19.9	18.2	16.0		25.3	21.6	18.4	12.5	15.3			17.9	12.5	6.9
1979	11.2	20.2	17.9	16.2		26.2	21.8	19.2	12.8	16.5			16.6	12.3	7.0
1980	11.3	20.2	17.3	16.7		25.7	22.0	19.0	12.8	14.4		27.8	17.6	12.4	6.8
1981	11.1	20.5	17.0	18.7		25.4	22.2	18.3	12.6	14.2		28.8	18.6	12.2	6.8
1982	11.5	19.6	17.1	17.9		25.0	21.8	18.7	12.3	16.1		28.3	21.4	12.5	6.5
1983	12.1	19.5	17.2	17.3		25.9	21.7	18.6	12.6	15.1		25.4	22.5	13.6	6.5
1984	12.6	21.2	17.0	17.5		26.4	23.2	18.8	12.5	16.4		26.1	22.9	13.7	6.6
1985	12.4	21.2	16.6	16.7		26.5	22.9	19.2	12.1	16.8		24.7	21.7	13.1	6.3
1986	12.1	21.0	16.4	15.7		28.5	23.4	19.0	11.9	18.8		24.3	21.8	14.5	6.1
1987	12.0	21.0	16.9	16.2		28.2	23.7	19.1	12.1	19.2		24.8	21.4	14.4	6.2
1988	11.5	20.8	17.1	15.6		28.6	25.1	19.2	12.1	17.9		25.5	22.2	15.3	6.3
1989	11.5	20.6	17.2	15.5		27.5	25.8	18.8	12.5	16.1		25.7	21.8	14.9	6.3
1990	10.7	20.2	17.4	14.4		27.1	25.4	18.6	12.9	17.4		23.3	21.4	16.1	6.8
1991	9.7	20.0	17.1	14.3		26.5	23.8	17.8	14.7	18.1		23.1	20.7	16.0	6.7
1992	9.8	20.2	17.4	14.3		25.9	23.0	17.3	14.9	19.0		22.7	20.6	15.9	6.5
1993	10.6	19.5	17.6	14.3	22.2	25.5	22.8	17.1	15.3	18.2		22.8	20.1	16.3	6.5
1994	11.0	20.5	18.2	14.4	21.3	25.9	23.1	17.8	16.1	17.5		22.5	21.3	17.3	6.6
1995	11.2	17.8	17.7	14.2	21.0	26.4	22.7	18.2	15.6	17.2	26.4	22.5	21.7	16.6	6.6
1996	11.1	18.9	18.0	14.1	20.3	27.1	23.7	18.8	15.2	17.5	26.2	23.1	21.6	15.9	6.7
1997	10.8	18.8	18.4	14.1	19.2	27.3	24.2	18.9	15.0	17.9	24.9	22.9	22.0	16.0	7.2
1998	10.6	18.7	17.4	14.1	18.4	27.6	24.3	18.7	14.7	17.7	24.5	23.4	21.7	16.4	7.9
1999	10.3	18.8	17.7	13.9	19.3	28.0	24.7	18.7	15.2	18.0	25.0	24.3	21.1	16.7	8.0
2000	11.6	18.7	17.8	14.3	18.9	28.0	24.0	18.0	15.1	18.6	25.4	23.9	21.4	16.6	7.8
2001	11.8	18.3	17.1	13.7	18.0	28.0	23.2	17.4	14.9	19.1	23.9	22.5	20.5	15.4	7.7
2002		18.4	17.1		17.7	28.2	23.1	17.2	15.0	18.6	22.2	22.4		14.8	7.6
2003															

Table B.10: Carey and Rabesona Consumption tax ratio (in percent) 1/2

	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	SVK	ESP	SWE	CHE	TUR	GBR	USA
1970		9.5		15.8	11.1	24.3		12.6		9.3	19.3	9.8	8.3	15.3	7.5
1971		10.2		16.2	11.2	25.0		11.7		8.7	21.8	9.5	8.8	14.2	7.6
1972	8.9	11.4		17.0	11.0	25.3		11.9		8.9	21.1	9.8	8.9	13.4	7.5
1973	9.6	11.8		16.8	11.2	24.7		11.1		9.2	20.4	9.4	8.9	13.1	7.4
1974	10.4	11.2		15.8	10.7	23.5		10.2		7.5	18.3	8.8	7.8	12.8	7.3
1975	11.9	11.8		15.9	11.3	23.1		10.8		7.3	17.7	8.5	8.8	12.7	7.0
1976	13.5	11.3		16.4	11.2	24.2		12.9		7.3	18.7	8.4	9.4	12.8	7.0
1977	14.6	11.0		17.1	11.2	24.3		13.6		7.2	18.6	8.7	8.0	13.3	6.7
1978	15.7	11.3		16.9	11.4	24.8		13.5		7.4	18.5	9.0	7.0	12.8	6.7
1979	16.0	10.8		16.5	11.5	24.1		13.2		7.3	18.3	8.8	6.7	13.7	6.6
1980	15.3	12.7	13.1	16.5	10.9	25.1		15.5		7.2	18.4	8.8	5.5	15.1	6.6
1981	14.9	13.6	13.3	16.2	12.0	26.0		15.2		7.8	18.6	8.7	6.2	15.6	7.2
1982	15.1	15.5	15.3	15.9	12.3	25.5		15.8		8.0	18.1	8.6	6.4	16.0	6.9
1983	16.7	16.3	20.1	16.2	12.7	26.0		16.9		9.4	19.2	8.6	6.3	16.1	6.6
1984	16.3	16.3	18.2	16.7	13.4	26.4		16.4		10.6	20.0	8.6	5.1	16.6	6.8
1985	15.6	16.0	17.3	16.8	11.7	27.5		16.0		11.7	21.2	8.7	7.6	17.0	6.6
1986	16.2	16.1	14.5	17.2	13.3	27.3		20.9		14.6	20.9	9.0	7.8	16.5	6.4
1987	16.8	15.8	17.0	17.8	18.4	27.4		19.5		14.4	21.5	9.2	8.7	16.3	6.3
1988	15.9	15.7	13.9	18.1	17.3	25.4		20.4		14.8	21.5	9.3	8.8	16.2	6.4
1989	14.7	16.3	13.9	17.5	19.0	24.5		19.8		14.5	22.0	9.2	7.9	15.8	6.2
1990	15.8	16.6	13.6	17.5	18.3	24.6		19.1		14.3	22.6	8.9	7.9	15.5	6.2
1991	14.8	17.4	13.0	17.6	18.5	24.1	12.5	18.6		14.3	21.7	8.5	8.5	15.7	6.3
1992	14.9	18.8	12.2	17.7	18.9	24.6	14.8	20.3		14.4	19.7	8.1	9.3	16.2	6.4
1993	14.5	20.3	11.2	16.8	18.9	24.7	18.3	18.6		13.1	20.0	8.2	10.0	15.5	6.5
1994	14.6	20.7	10.9	17.5	18.7	26.0	18.9	20.1		13.9	19.7	8.3	11.3	15.7	6.6
1995	14.7	19.8	13.0	17.6	18.6	26.7	19.2	20.6		14.0	22.5	9.5	11.5	16.1	6.6
1996	15.3	19.2	13.9	18.5	17.9	26.7	18.9	20.2		14.1	21.6	9.3	13.7	15.8	6.4
1997	15.5	20.3	14.2	18.5	17.7	27.2	18.2	20.1		14.5	21.5	9.2	14.2	16.0	6.4
1998	14.4	20.3	11.8	18.3	17.5	26.9	17.4	20.5	17.4	15.1	21.4	9.6	13.7	15.6	6.3
1999	15.0	22.0	12.4	18.7	17.6	26.2	17.6	20.7	17.2	15.8	21.2	10.2	14.1	14.9	6.3
2000	15.1	23.3	14.1	18.9	17.3	26.3	16.7	20.3	18.0	16.0	21.5	10.6	17.5	15.3	6.2
2001	15.5	21.3	13.4	19.0	18.0	26.0	16.1	20.0	15.1	15.5	21.3	10.7	17.9	14.8	6.1
2002	15.2	21.5		18.7	18.3	24.5	16.6			15.4	21.5	10.5	19.8	14.5	
2003															

Table B.11: Carey and Rabesona Consumption tax ratio (in percent) 2/2

	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	GRC	HUN	ISL	IRL	ITA	JPN
1970	13.6	29.6	28.6	19.6		26.6	24.4	27.8	25.4	23.3					14.9
1971	15.0	30.0	29.4	19.8		30.3	26.6	27.8	26.5	23.1					15.4
1972	14.4	30.6	29.8	20.4		29.7	27.6	28.2	27.7	22.8					16.1
1973	15.6	30.9	30.4	19.7		28.4	29.5	28.1	29.3	22.3				22.7	17.0
1974	17.9	31.6	31.7	20.9		31.6	29.5	29.0	29.8	22.6				24.9	16.9
1975	18.5	31.3	34.5	20.6		29.0	32.3	30.2	29.8	22.5				26.3	16.5
1976	19.3	30.9	34.2	21.3		28.0	35.4	31.6	30.8	24.9				25.3	17.1
1977	19.4	31.8	36.1	20.1		27.9	36.2	32.6	31.7	25.0				25.1	17.5
1978	18.4	34.2	37.2	20.2		28.7	32.6	32.5	31.2	25.4				25.5	18.2
1979	19.2	33.9	37.7	20.2		29.7	32.3	34.0	30.9	26.2				22.6	18.9
1980	19.5	34.7	37.6	20.8		31.4	32.2	35.2	31.4	27.6				28.5	20.1
1981	20.4	35.7	37.9	22.8		31.4	33.7	35.0	31.3	27.5				29.0	20.9
1982	20.2	35.5	39.6	23.0		31.3	32.5	35.8	31.5	29.9				30.8	21.3
1983	19.9	35.3	40.1	24.3		33.4	32.2	37.1	31.3	31.1				32.0	21.5
1984	21.4	36.4	41.7	23.6		33.6	33.7	38.3	31.5	32.0				31.4	21.4
1985	21.4	37.2	41.8	24.5		35.4	35.5	38.5	32.1	31.6				31.5	22.5
1986	22.3	37.2	41.9	25.7		35.1	37.5	38.7	31.9	32.1				33.5	23.2
1987	22.6	36.8	43.0	27.6		37.0	34.9	39.5	32.1	31.4				33.2	23.6
1988	22.5	37.1	42.4	26.6		36.3	38.7	39.2	32.0	29.5				33.7	23.5
1989	21.1	35.9	41.2	27.1		36.7	38.5	39.6	32.3	29.0				34.6	24.4
1990	21.1	36.6	41.2	28.2		35.9	40.5	40.2	31.0	29.8				34.8	25.8
1991	20.6	37.1	40.7	29.0		36.5	40.5	40.8	35.0	31.0				35.1	25.3
1992	20.5	38.3	41.0	28.9		37.5	41.4	40.1	35.7	31.3				35.9	24.5
1993	21.3	39.4	40.5	28.5	37.8	38.6	44.4	40.3	35.7	34.5				37.2	24.9
1994	21.8	39.6	41.5	29.3	38.7	41.7	49.9	40.8	36.5	35.3				35.9	23.7
1995	22.4	40.2	41.4	29.4	37.9	41.0	47.9	40.5	36.9	32.5	40.1			37.0	24.5
1996	23.3	41.0	41.5	30.0	38.5	41.4	49.0	40.8	35.9	33.8	38.8			40.8	24.5
1997	23.9	41.8	41.8	30.3	38.7	41.7	46.6	40.6	36.3	33.6	38.9			42.2	24.9
1998	23.8	41.5	42.0	30.4	39.3	41.1	46.8	40.2	36.5	34.0	38.7			39.3	23.3
1999	24.8	41.5	41.7	30.9	39.0	43.0	46.6	40.6	36.2	34.5	38.3			39.7	23.0
2000	22.0	40.9	41.8	30.5	39.4	43.6	45.8	40.5	35.8	33.3				37.6	24.2
2001	23.5	42.0	41.5			43.2	44.8	39.8	35.9	35.3					24.6
2002		41.7	41.9			42.9	45.6	39.6	35.6	34.5					
2003															

Table B.12: Carey and Rabesona Labor income tax ratio (in percent) 1/2

	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	SVK	ESP	SWE	CHE	TUR	GBR	USA
1970				32.1	16.5	28.9				15.5	36.2	16.3		24.2	18.6
1971				33.7	18.0	31.2				16.4	36.3	16.3		23.2	17.4
1972	2.3			34.6	18.3	34.0				17.4	38.1	16.4		21.8	17.7
1973	2.1			36.2	19.5	36.5				17.9	37.8	19.6		20.5	17.9
1974	1.9			37.1	22.4	36.2				18.2	40.5	20.7		23.4	18.9
1975	2.1			37.2	21.9	35.8				20.4	41.5	22.5		25.7	19.0
1976	3.8			37.2	22.5	36.2				19.7	45.5	23.9		26.3	18.5
1977	3.5			37.0	25.4	35.7				23.2	48.0	24.3		25.7	19.6
1978	3.5			37.5	24.5	35.5				25.0	48.6	24.3		24.5	19.8
1979	3.7			38.4	24.9	36.9				26.0	47.5	24.0		24.0	20.6
1980	3.4			38.9	26.4	36.3				27.0	48.0	23.7		24.2	20.9
1981	3.5			38.8	26.7	36.5				28.2	49.4	23.8		25.2	21.7
1982	3.7			39.7	27.1	35.3				28.7	48.3	24.3		26.1	21.8
1983	3.6			41.8	25.6	35.4				29.1	49.0	24.9		25.2	20.7
1984	3.5			40.6	24.8	34.2				30.1	48.8	25.4		24.4	20.4
1985	3.8			40.7	27.8	33.9				29.5	48.2	20.6		23.5	21.0
1986	4.0			40.5	29.0	34.3				28.5	50.3	21.2		25.1	20.9
1987	4.3			40.9	26.4	35.1				30.4	51.7	20.9		24.3	21.6
1988	5.2			41.6	27.7	36.4				30.0	52.4	21.3		24.1	21.2
1989	5.8			39.7	28.7	37.4		25.2		31.4	53.6	20.9		22.4	21.8
1990	7.0			38.4	28.8	36.6		24.2		30.5	53.8	21.2		22.1	21.6
1991	6.4			40.9	26.9	36.6		24.8		30.9	50.5	20.9		22.1	21.5
1992	7.2			40.2	27.4	35.7	35.1	26.1		32.3	48.8	21.2		21.8	21.3
1993	8.5			40.7	28.0	34.5	39.5	25.5		32.0	45.2	22.2		21.4	21.7
1994	8.4			38.3	28.0	35.7	39.2	25.9		31.9	46.5	22.9		22.5	22.0
1995	8.2			37.3	27.9	35.4	38.8	24.8		30.3	47.7	22.8		22.7	22.3
1996	8.6			35.3	25.9	36.0	37.8	24.3		29.8	49.5	23.5		22.3	22.8
1997	11.4			35.5	25.8	36.4	37.2	24.1		30.0	50.9	23.0		21.8	23.3
1998	13.5			31.9	23.9	36.2	36.3	24.3	35.9	29.4	51.8	23.5		24.0	23.5
1999	13.5			32.6	24.2	36.6	31.5	24.8	34.8	29.5	52.0	22.8		23.8	23.7
2000	14.1			32.6	24.8	36.1	32.0	25.0	34.1	29.6	52.2	23.5		24.1	24.2
2001	15.0			30.4		36.6	31.4	25.1	35.0	30.3	49.4	22.3		24.5	24.2
2002	15.3			30.6			32.1			30.7	48.4			23.9	
2003															

Table B.13: Carey and Rabesona Labor income tax ratio (in percent) 2/2

	AUS	AUT	BEL	CAN	CZE	DNK	FIN	FRA	DEU	GRC	HUN	ISL	IRL	ITA	JPN
1970	35.2	30.6	30.9	53.2		50.3	27.3	27.3	28.3	8.9					24.9
1971	36.9	33.1	32.9	51.9		56.0	28.6	26.1	29.0	9.3					26.7
1972	35.6	33.6	34.2	53.0		52.9	29.5	26.9	31.2	9.5					29.0
1973	38.5	35.2	36.6	48.7		54.5	30.9	29.6	34.4	8.1				14.8	34.3
1974	47.7	37.7	39.6	50.3		62.0	30.8	30.5	35.9	9.7				15.1	37.7
1975	47.4	43.5	45.0	51.3		58.8	34.8	36.6	34.2	9.3				16.1	32.2
1976	43.5	40.2	44.4	49.9		57.1	46.7	41.4	35.0	11.2				19.9	32.8
1977	43.0	41.9	47.1	48.5		57.5	44.7	41.2	38.3	10.9				22.1	34.5
1978	36.5	48.6	49.1	46.5		60.7	35.2	40.0	36.9	10.5				24.3	37.1
1979	35.5	43.5	50.2	43.1		63.3	28.8	43.5	37.2	10.3				25.4	37.5
1980	39.9	44.8	49.8	44.1		67.4	31.1	49.6	38.7	10.2				25.7	40.1
1981	40.0	47.1	49.8	45.8		66.9	37.1	54.1	37.5	9.9				28.6	41.4
1982	43.4	41.1	52.2	47.3		59.6	35.5	56.7	37.2	11.6				32.3	43.0
1983	36.8	38.2	50.7	42.1		63.2	35.4	55.4	35.9	10.7				34.6	45.6
1984	38.8	41.2	51.1	41.0		68.2	37.5	56.3	36.3	10.9				33.3	47.1
1985	40.5	42.0	52.7	40.7		71.7	41.7	54.6	38.0	10.8				32.0	45.5
1986	45.3	41.7	51.5	45.6		81.7	44.7	50.7	36.9	11.5				34.9	47.1
1987	43.9	41.2	51.1	46.0		88.9	41.2	50.5	36.8	11.5				34.0	53.3
1988	44.4	41.4	46.0	47.7		97.4	43.9	48.2	36.1	9.6				33.5	53.8
1989	46.2	39.6	43.2	52.3		87.8	46.5	47.3	36.8	9.4				34.9	53.3
1990	47.4	38.9	43.9	58.7		75.9	55.1	47.3	33.1	12.4				36.9	52.0
1991	43.0	40.2	45.7	64.1		73.8	78.7	49.8	36.0	11.9				38.2	51.2
1992	40.2	43.1	46.5	64.6		69.9	68.4	51.9	38.7	12.2				43.9	49.0
1993	39.3	44.2	50.0	62.2	52.8	77.3	43.7	52.6	39.3	11.9				48.7	48.5
1994	43.3	39.4	52.5	56.7	45.4	68.4	39.2	52.9	36.2	13.2				42.4	47.2
1995	44.7	40.7	52.9	56.2	37.7	67.9	36.6	54.7	35.9	17.8	15.5			41.7	49.6
1996	45.7	43.7	54.6	57.8	34.6	68.9	42.3	59.0	35.5	33.2	15.1			41.7	49.1
1997	43.3	47.4	55.8	60.7	33.7	68.7	43.0	60.6	34.2	19.8	13.6			43.5	47.0
1998	44.9	46.8	58.2	61.3	32.3	76.9	41.0	60.4	34.1	23.7	14.1			43.8	46.3
1999	48.0	46.3	57.1	56.7	33.9	77.1	44.4	62.9	36.4	26.5	14.9			45.8	44.3
2000	53.4	44.1	57.7	52.2	34.4	61.6	48.7	63.1	38.1	28.4				43.9	46.0
2001	42.6	51.3	61.3			68.1	46.5	64.4	32.7	24.5					46.5
2002		45.1	64.3			66.0	43.0	60.9	31.0	22.0					
2003															

Table B.14: Carey and Rabesona Capital tax ratio (in percent) 1/2

	KOR	LUX	MEX	NLD	NZL	NOR	POL	PRT	SVK	ESP	SWE	CHE	TUR	GBR	USA
1970				33.6	44.2	30.5				10.1	38.6	26.1		72.3	47.5
1971				37.1	40.4	35.4				10.5	40.5	26.3		62.2	41.1
1972	6.2			38.4	38.0	36.4				11.2	41.6	27.2		58.1	42.9
1973	5.6			39.3	39.6	33.5				11.7	41.1	29.5		53.1	42.1
1974	6.5			41.3	48.3	35.4				11.9	40.9	31.6		68.6	45.0
1975	6.7			46.4	47.7	36.1				12.7	46.2	34.9		71.2	41.9
1976	8.9			44.0	44.0	39.1				13.0	53.2	36.3		62.3	39.8
1977	9.0			46.3	47.7	43.8				13.1	66.6	36.5		60.0	42.9
1978	9.6			47.9	43.3	42.8				13.5	55.2	36.0		58.9	41.0
1979	10.3			49.7	46.4	39.4				13.8	47.5	34.9		62.9	40.7
1980	10.1			50.4	46.2	45.8				14.6	44.4	34.6		76.2	42.9
1981	10.3			49.1	44.9	51.1				16.5	48.5	35.5		85.7	41.3
1982	11.3			49.7	45.9	51.1				16.2	45.2	37.8		82.5	43.5
1983	11.6			47.4	39.6	46.1				20.9	48.7	40.2		70.9	35.3
1984	10.8			42.9	41.5	45.0				22.6	47.9	38.7		69.4	35.1
1985	11.2			41.9	45.2	49.2				19.5	50.6	35.1		66.9	36.2
1986	10.4			44.2	42.5	63.3				20.0	61.1	38.1		67.9	36.1
1987	12.1			51.8	49.9	55.4				25.1	74.3	39.2		62.3	39.4
1988	13.5			52.0	45.0	55.6				25.0	64.3	40.8		62.0	39.3
1989	17.2			47.1	50.4	42.3		17.6		29.2	62.4	40.4		64.7	39.3
1990	19.0			49.3	46.3	43.3		20.8		30.2	69.0	39.3		62.9	38.9
1991	17.8			53.4	44.4	43.2		24.0		29.9	62.9	40.2		57.3	39.9
1992	19.3			54.7	43.0	39.0	20.6	25.7		30.3	48.0	42.3		50.1	38.3
1993	19.5			59.9	40.8	37.6	21.5	22.7		29.1	48.6	41.0		46.9	38.0
1994	20.4			53.1	41.7	38.0	18.7	22.0		28.2	44.7	39.1		45.1	38.6
1995	21.9			50.1	42.9	38.5	18.3	27.4		28.6	40.9	39.5		48.0	39.8
1996	22.4			50.7	39.6	37.3	17.9	30.1		28.5	49.4	39.9		47.6	39.4
1997	20.8			51.6	39.6	39.5	17.8	31.4		31.4	54.1	38.4		49.3	40.0
1998	21.0			50.5	38.9	45.1	17.4	32.7	29.5	32.5	58.6	41.4		53.0	43.3
1999	20.3			54.6	36.1	36.5	16.8	34.4	26.4	34.8	67.8	45.5		54.8	42.6
2000	25.1			54.3	37.4	33.8	16.3	40.2	26.7	36.2	73.6	52.4		59.9	47.0
2001	23.5			53.0		46.9	15.8	37.0	21.8	35.7	72.4	57.5		61.5	44.5
2002	24.0			52.2			15.9			37.5	69.5			55.4	
2003															

Table B.15: Carey and Rabesona Capital tax ratio (in percent) 2/2

B.4 Empirical results

B.4.1 Static panel estimation using fixed-windows (five-years)

	QGR.OLS	AGR.OLS	APC.OLS	CYC.OLS
TimeDummies	:	:	:	:
CountryDummies	:	:	:	:
TaxesLaborIncome	-1.635079	-2.53505 .	-8.280836 ***	-3.998332 **
TaxesCapitalIncome	2.453743 *	4.142319 ***	6.237451 ***	5.32912 ***
TaxesConsumption	2.076692	4.514353 *	5.886598 *	4.283451 *
TaxesCorporateIncome	-1.816133 **	-2.64655 ***	-3.826827 ***	-3.19638 ***
OtherRGDPpC.GrowthMean	-3.044921	-6.689553	-8.183902	-3.811896
OtherPRIVYMean	-0.440946 .	-0.264693	-0.304132	-0.446355
OtherInflMean	-0.715909	-3.473633 *	-5.696499 **	-2.434931
OtherInflSD	1.036377	8.842174 *	10.240105 **	4.275154
OtherOpenMean	0.044851	1.5083 *	2.609042 ***	1.786787 **
OtherXRSD	1.464054	1.603561	1.295101	1.568794
OtherGGDPMean	3.212187	-1.260615	-2.459536	0.951662
OtherGGDPSD	-4.483156	21.739731	48.837395 **	10.832152
Degrees of freedom	78	78	85	78
Adjusted R-Squared	0.66	0.44	0.43	0.49
F-statistic	7.13	3.49	3.53	3.97

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	QGR.LAD (boot)	AGR.LAD (boot)	APC.LAD (boot)	CYC.LAD (boot)
TimeDummies	:	:	:	:
CountryDummies	:	:	:	:
TaxesLaborIncome	-2.532126 .	-3.633514 *	-8.209809 ***	-2.938336 *
TaxesCapitalIncome	1.945286 .	4.266292 **	4.835716 **	5.225375 ***
TaxesConsumption	1.07612	3.067093	2.232416	2.303637
TaxesCorporateIncome	-1.712603 *	-2.894986 **	-3.085629 **	-2.788352 ***
OtherRGDPpC.GrowthMean	-2.040284	-10.733091 **	-6.010972	-4.789768
OtherPRIVYMean	-0.231068	-0.347701	-0.628746 .	-0.580805 .
OtherInflMean	-1.107622	-6.525236 ***	-7.84334 ***	-3.645483 *
OtherInflSD	-0.077683	14.881784 ***	13.673779 ***	3.625562
OtherOpenMean	0.719551	2.277198 **	2.35164 ***	2.424219 ***
OtherXRSD	0.593864	1.744245	4.699192 *	2.912515 *
OtherGGDPMean	4.723613	-1.431899	-2.590243	2.497684
OtherGGDPSD	-12.651339	24.363748 .	39.965649 **	1.195136

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	QGR.huber (boot)	AGR.huber (boot)	APC.huber (boot)	CYC.huber (boot)
TimeDummies	:	:	:	:
CountryDummies	:	:	:	:
TaxesLaborIncome	-1.998026	-2.820754 .	-7.825227 ***	-2.921701 *
TaxesCapitalIncome	2.241739 *	3.805002 **	5.009185 **	4.627562 ***
TaxesConsumption	1.81095	4.113338 .	4.794089 .	3.083402
TaxesCorporateIncome	-1.716754 **	-2.443709 ***	-3.15205 **	-2.722874 **
OtherRGDPpC.GrowthMean	-3.326972	-8.021536 *	-7.361805	-0.765575
OtherPRIVYMean	-0.401541	-0.267257	-0.312495	-0.34086
OtherInflMean	-0.730339	-4.646784 **	-6.838717 ***	-1.79023
OtherInflSD	0.980374	9.368065 **	10.720221 **	3.26595
OtherOpenMean	0.257705	1.885843 **	2.434917 **	1.846916 **
OtherXRSD	1.455886	2.067098	3.134567	2.084699
OtherGGDPMean	3.580968	-1.23025	-1.446025	2.727921
OtherGGDPSD	-8.365876	17.134826	39.326171 *	6.532811

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

B.4.2 Static panel estimation using fixed-windows (ten-years)

	QGR.OLS	AGR.OLS	APC.OLS	CYC.OLS
TimeDummies	:	:	:	:
CountryDummies	:	:	:	:
TaxesLaborIncome	-2.48235 *	-2.740947 *	-5.720252 **	-4.448425 ***
TaxesCapitalIncome	2.720623 ***	4.281391 ***	5.535741 ***	4.981295 ***
TaxesConsumption	-1.895412	-0.140325	-0.414841	1.054209
TaxesCorporateIncome	-1.86975 **	-2.530595 ***	-2.891929 **	-3.242023 ***
OtherRGDPpC.GrowthMean	-11.620816 *	-24.937207 ***	-29.773322 ***	-18.201171 ***
OtherPRIVYMean	-0.719345 **	-0.626113 *	-0.473591	-0.725863 **
OtherInflMean	-3.916933 *	-7.293641 ***	-4.859475 *	-3.030939 *
OtherInflSD	1.500774	6.589927 **	6.450703 *	-0.010896
OtherOpenMean	0.058814	1.17439 *	1.731556 **	1.810576 ***
OtherXRSD	3.21002 *	3.821865 *	2.903014	4.119299 **
OtherGGDPMean	1.011289	-5.084571 *	-5.092788	-0.748191
OtherGGDPSD	-10.782176	-7.10741	-4.010563	-16.463533
Degrees of freedom	35	35	38	35
Adjusted R-Squared	0.81	0.55	0.42	0.63
F-statistic	9.42	3.47	2.54	4.4

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	QGR.LAD (boot)	AGR.LAD (boot)	APC.LAD (boot)	CYC.LAD (boot)
TimeDummies	:	:	:	:
CountryDummies	:	:	:	:
TaxesLaborIncome	-4.373374 **	-5.676654 **	-4.920487 *	-2.528106 .
TaxesCapitalIncome	3.505605 ***	4.631273 **	3.590421 *	3.376298 **
TaxesConsumption	-1.330149	-3.932937 .	-2.960539	2.415043
TaxesCorporateIncome	-2.582379 **	-3.001314 **	-1.675597	-2.157064 **
OtherRGDPpC.GrowthMean	-15.73762 **	-31.028936 ***	-20.027505 *	-16.573156 **
OtherPRIVYMean	-1.141576 **	-0.949108 **	-0.327843	-0.641815 *
OtherInflMean	-4.23953 *	-11.622758 ***	-5.001146 .	-1.235523
OtherInflSD	1.126379	3.560922	4.10454	-1.96345
OtherOpenMean	0.58838	1.750078 *	0.901039	1.612946 **
OtherXRSD	3.110237	2.86011	2.464836	2.864015
OtherGGDPMean	1.656477	-3.9132	-0.041494	-0.797523
OtherGGDPSD	-24.650384 *	-29.09953 **	-17.710614	-9.795785

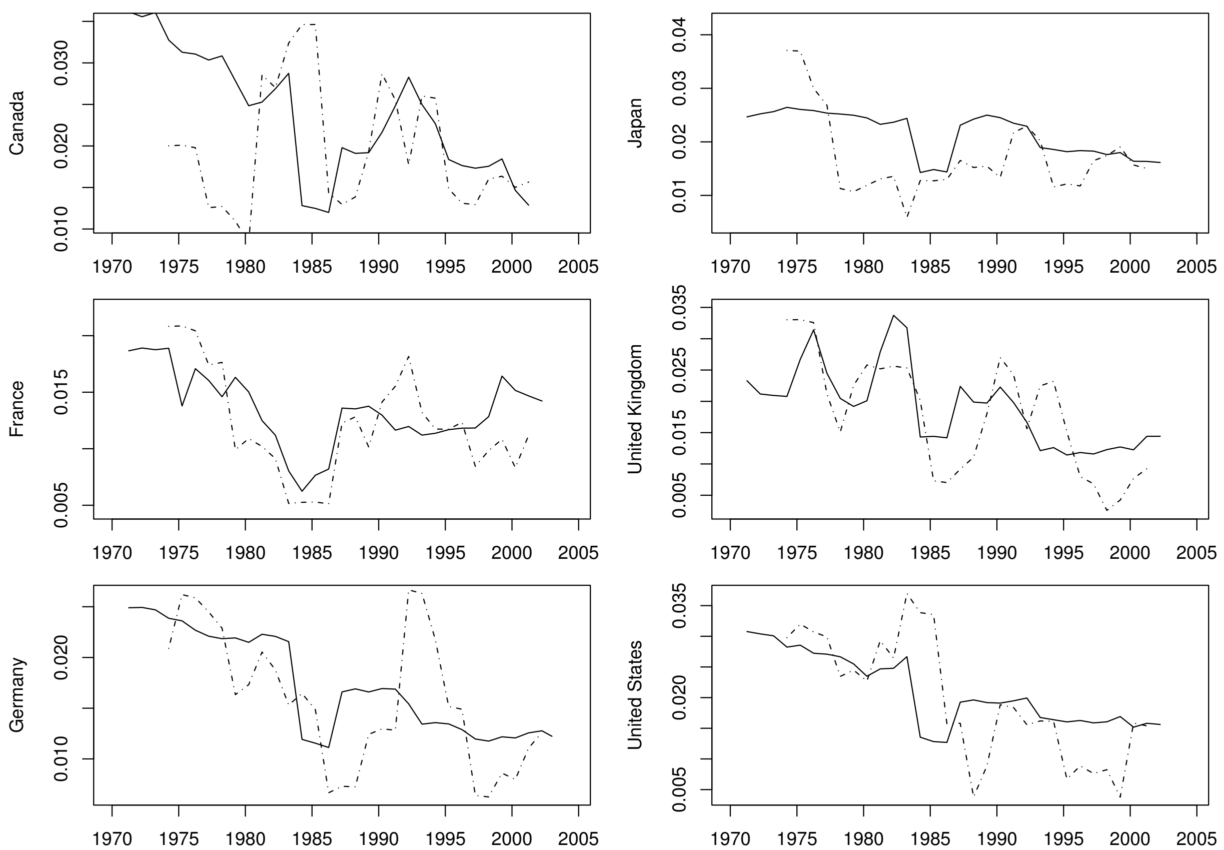
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	QGR.huber (boot)	AGR.huber (boot)	APC.huber (boot)	CYC.huber (boot)
TimeDummies	:	:	:	:
CountryDummies	:	:	:	:
TaxesLaborIncome	-2.859199 *	-3.428622 *	-5.430617 **	-3.685176 **
TaxesCapitalIncome	2.783384 **	4.644285 ***	4.549469 **	4.625156 ***
TaxesConsumption	-1.49373	-0.450893	-0.47825	0.936186
TaxesCorporateIncome	-2.00641 **	-2.50709 ***	-2.279002 *	-2.701099 ***
OtherRGDPpC.GrowthMean	-13.283917 **	-27.190227 ***	-21.298105 **	-16.600827 **
OtherPRIVYMean	-0.798727 **	-0.604403 *	-0.362545	-0.673233 *
OtherInflMean	-4.241737 **	-8.064626 ***	-3.709367	-2.394807
OtherInflSD	1.330244	5.738344 *	5.930446	-0.281981
OtherOpenMean	0.232357	1.062947 *	1.214057 .	1.760296 ***
OtherXRSD	3.307308 .	3.321421 .	3.613627	3.595741 *
OtherGGDPMean	1.59175	-5.600712 *	-2.586475	-1.095756
OtherGGDPSD	-12.624446 .	-13.336183	-7.820244	-18.157781 *

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

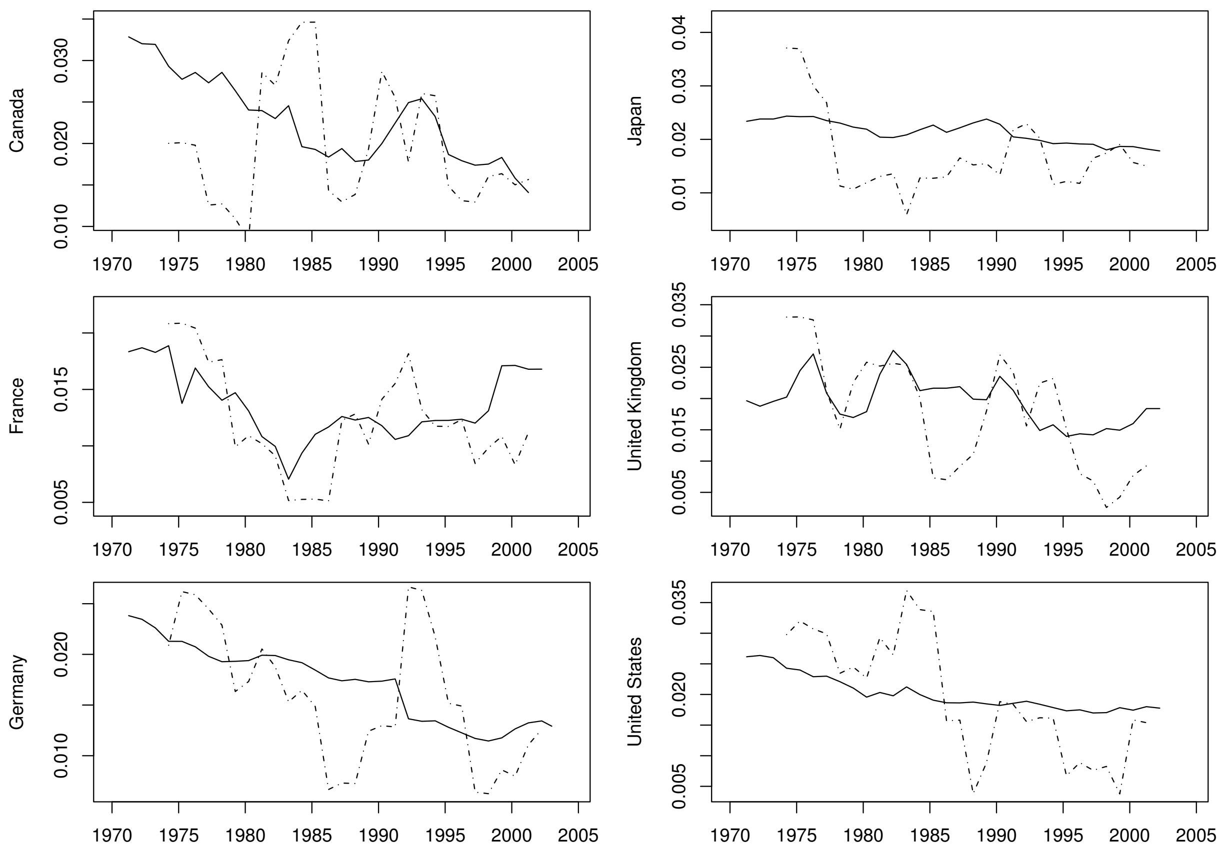
B.4.3 Static panel estimation

Figure B.1: Static panel, observed and estimated volatility for key countries, model (i)



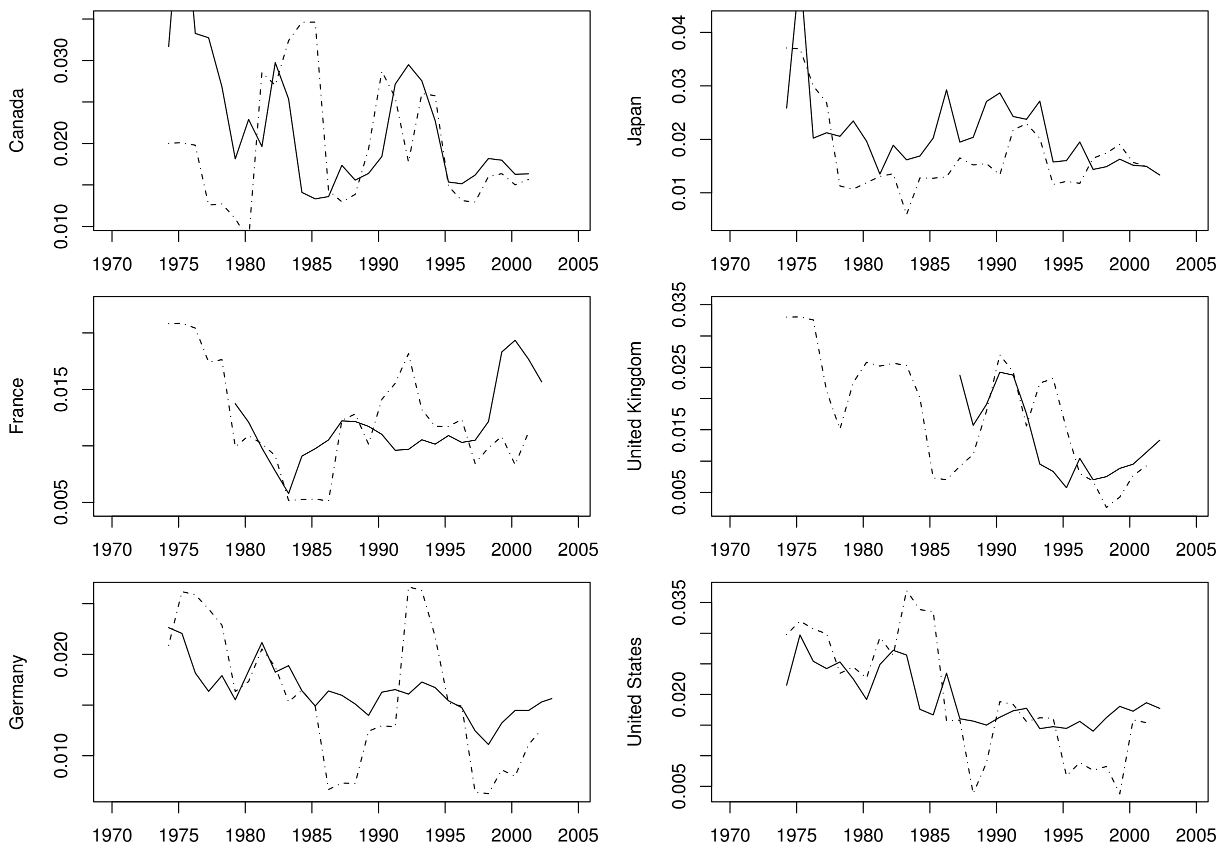
Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) both of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 5, model (i)).

Figure B.2: Static panel, observed and estimated volatility for key countries, model (iii)



Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) both of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 5, model (iii)).

Figure B.3: Static panel, observed and estimated volatility for key countries, model (iv)



Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) both of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 5, model (iv)).

Table B.16: Static panel estimation, contemporaneous results

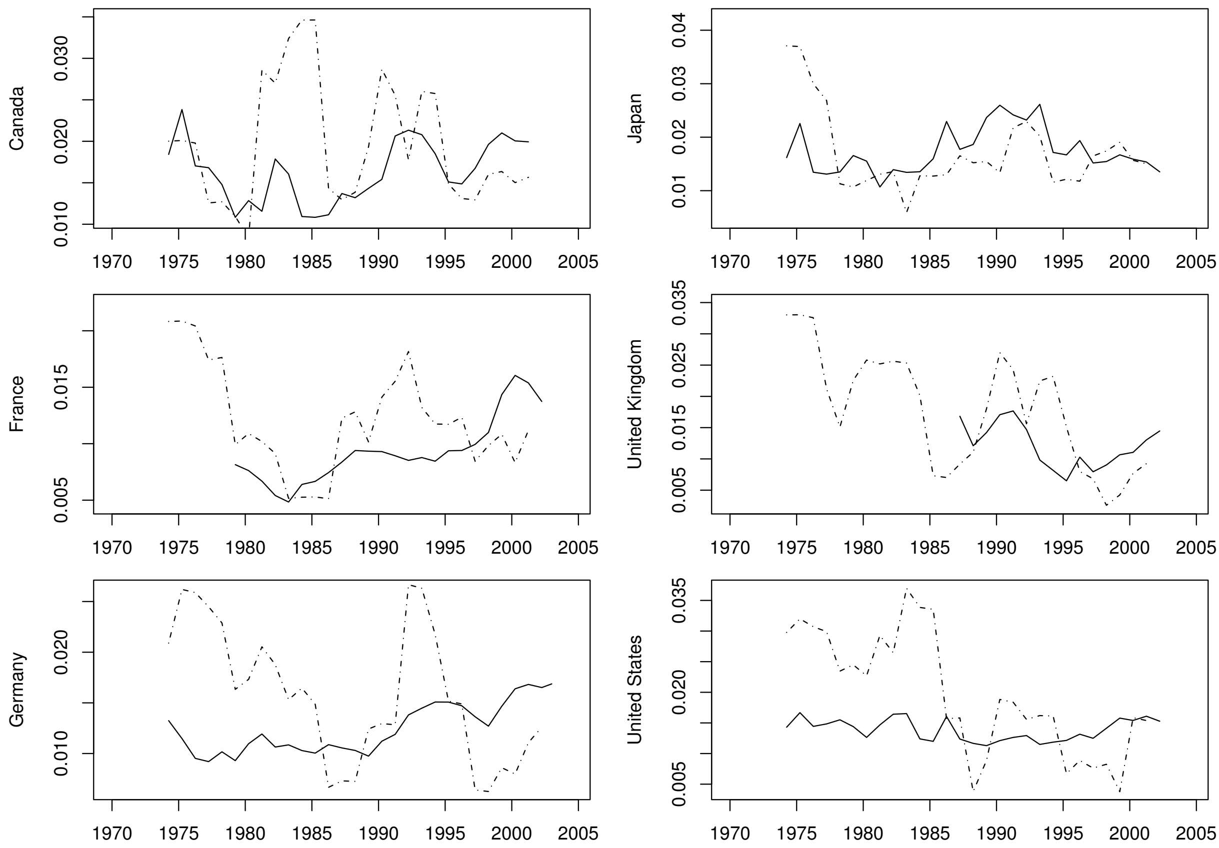
OECD		MLE (i)		MLE (ii)		MLE (iii)		MLE (iv)	
$LABOR_{it}$	β_1	−4.32 (1.39)	**	−5.42 (1.96)	**	−5.40 (1.14)	***	−4.85 (1.55)	**
$CAPITAL_{it}$	β_2	3.80 (1.20)	**	4.82 (1.82)	**	3.80 (1.16)	**	4.83 (1.66)	**
$CONS_{it}$	β_3	−0.33 (2.15)		−0.16 (3.41)		−2.04 (1.90)		−1.41 (2.99)	
$CORP_{it}$	β_4	−1.03 (0.65)		−1.68 (0.93)	·	−1.00 (0.62)		−1.68 (0.84)	*
$PRIVY_{it}$	γ_1			0.15 (0.54)				0.30 (0.45)	
$INFL_{it}$	γ_2			4.97 (1.81)	**			4.16 (1.58)	**
$INFLFI_{it}$	γ_3			−4.72 (3.51)				−2.64 (3.23)	
$GGDP_{it}$	γ_4			11.56 (3.88)	**			8.58 (3.59)	*
$DGFI_{it}$	γ_5			−1.87 (1.99)				−1.44 (1.94)	
$XRFI_{it}$	γ_6			2.11 (1.37)				2.05 (1.36)	
Degrees of freedom		573		455		578		460	
Log-likelihood		1575.6		1322.9		1563.8		1310.8	
Country fixed effects	α_i	yes		yes		yes		yes	
Time fixed effects	λ_t	yes		yes		no		no	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the joint estimation of (24a) and (24b) using maximum likelihood, explaining the conditional *sd* of annual growth rates of real GDP per capita. Asymptotic standard errors are in parentheses.

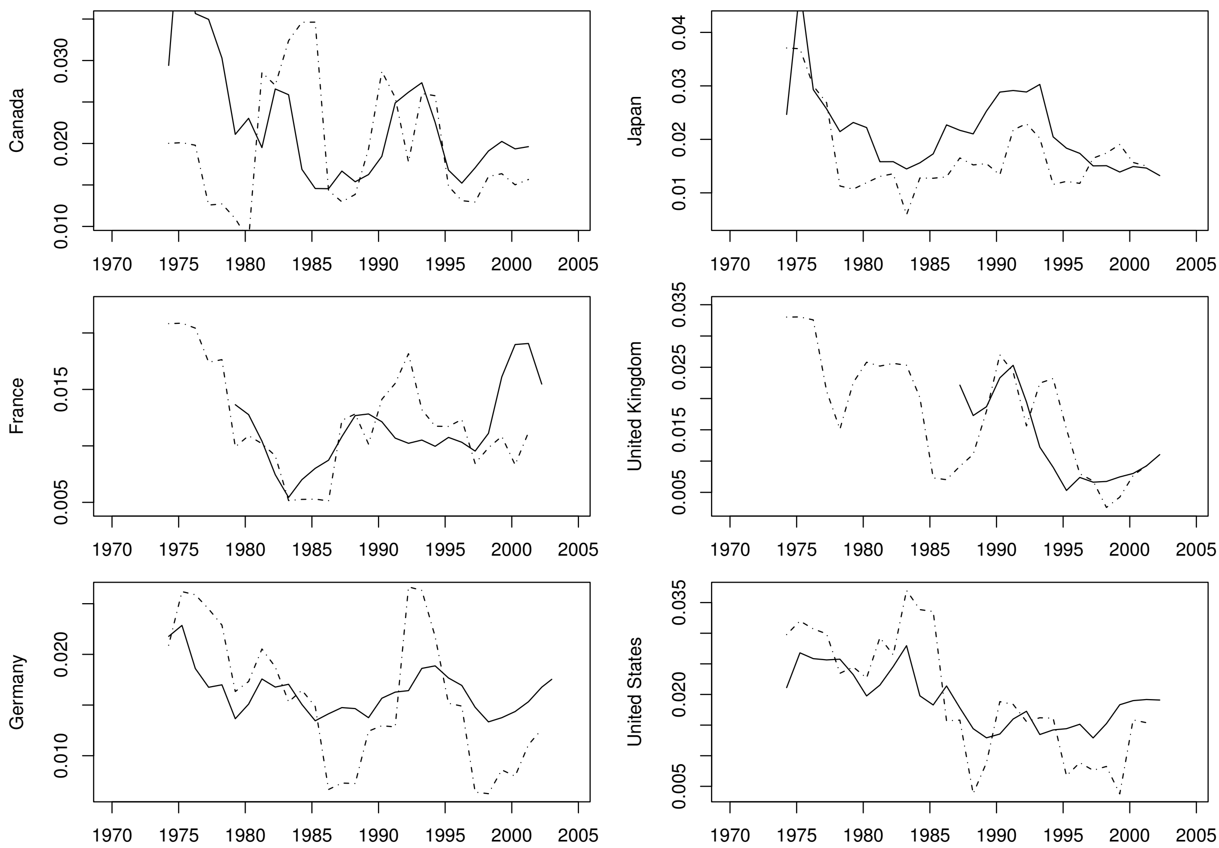
B.4.4 Dynamic panel estimation

Figure B.4: Dynamic panel, observed and estimated volatility for key countries, model (i)



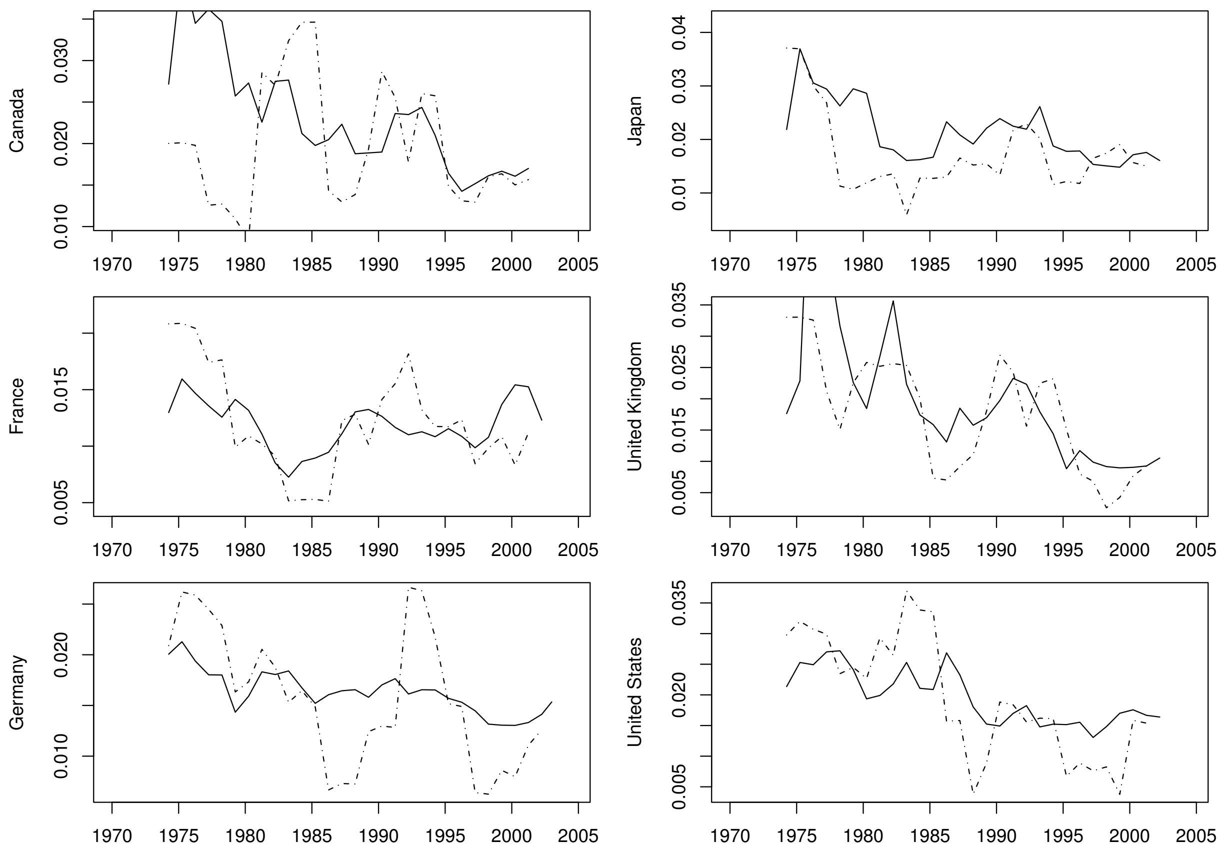
Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) both of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 6, model (i)).

Figure B.5: Dynamic panel, observed and estimated volatility for key countries, model (ii)



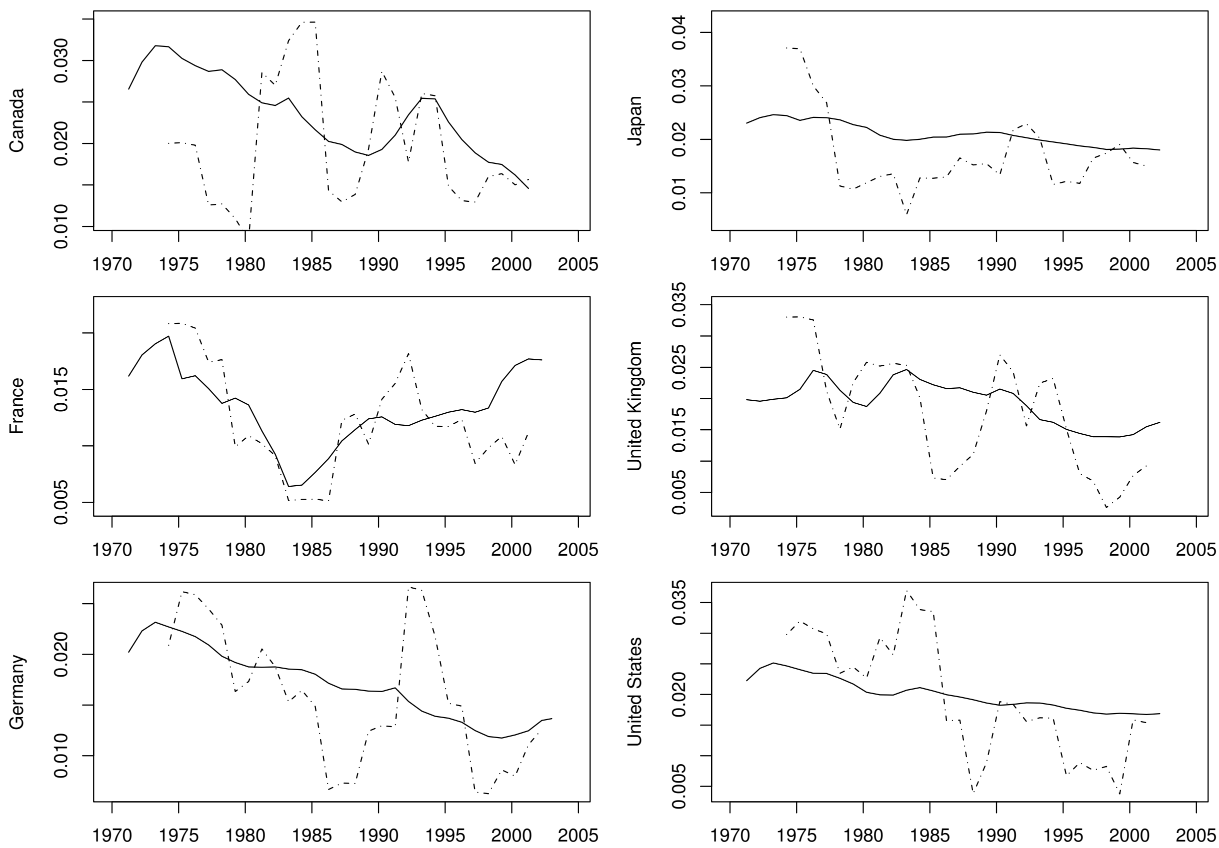
Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) both of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 6, model (ii)).

Figure B.6: Dynamic panel, observed and estimated volatility for key countries, model (iii)



Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) both of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 6, model (iii)).

Figure B.7: Dynamic panel, observed and estimated volatility for key countries, model (iv)



Notes: These figures plot estimated conditional *sd* (solid) and observed five-year rolling *sd* (dot-dashed) both of annual growth rates of real GDP per capita for key countries starting in 1970 (cf. Table 6, model (iv)).

Table B.17: Dynamic panel estimation, non-contemporaneous cointegrating relationship

OECD		MLE (i)		MLE (ii)		MLE (iii)		MLE (iv)	
$LABOR_{i,t-2}$	β_1	−2.79 (2.32)		−3.3600 (1.52)	*	−4.53 (2.15)	*	−5.02 (1.71)	**
$CAPITAL_{i,t-2}$	β_2	5.54 (2.07)	**	3.0500 (1.32)	*	8.30 (2.33)	***	3.19 (1.27)	*
$CONS_{i,t-2}$	β_3	4.08 (3.42)		3.4100 (2.16)		2.58 (2.85)		1.71 (1.36)	
$CORP_{i,t-2}$	β_4	−2.21 (1.02)	*	−1.6400 (0.76)	*	−3.35 (0.99)	***	−1.97 (0.70)	**
$PRIVY_{i,t-2}$	γ_1	0.41 (0.57)				−0.06 (0.47)			
$INFL_{i,t-2}$	γ_2	1.91 (1.90)				3.90 (1.65)	*		
$INFLFI_{i,t-2}$	γ_3	1.70 (3.95)				3.02 (3.87)			
$GGDP_{i,t-2}$	γ_4	−5.77 (4.46)				−3.65 (3.98)			
$DGFI_{i,t-2}$	γ_5	0.06 (0.04)				0.07 (0.04)	·		
$XRFI_{i,t-2}$	γ_6	−0.92 (1.59)				−1.12 (1.48)			
$\sigma_{i,t-1}$	$1+\rho$	−0.02 (0.11)		0.03 (0.10)		−0.016 (0.13)		0.14 (0.13)	
Country fixed effects	α_i	yes		yes		yes		yes	
Time fixed effects	λ_{t-1}	yes		yes		no		no	
Degrees of freedom		438		567		443		572	
Log-likelihood		1310.6		1582.6		1297.2		1558.8	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the joint estimation of (24a) and (24b) using maximum likelihood, explaining the conditional *sd* of annual growth rates of real GDP per capita. Asymptotic standard errors are in parentheses.

B.4.5 The link between volatility and growth

To avoid a spurious association in the conditional variance equation, we extend our analysis of the link between volatility and growth to a *dynamic* approach, jointly estimating the following system using maximum likelihood,

$$\Delta y_{it} = \theta_i + \nu\sigma_{it} + \varepsilon_{it}, \quad \text{where} \quad \varepsilon_{it} \sim \mathcal{N}(0, \sigma_{it}^2), \tag{47a}$$

$$\Delta \log(\sigma_{it}) = \alpha_i + \lambda_{t-1} + \beta' x_{i,t-1} + \gamma' z_{i,t-1} + \rho \log(\sigma_{i,t-1}) \tag{47b}$$

where Δy_{it} is the growth rate of output per capita for country i in year t, expressed as log difference; σ_{it} is the *sd* of the residuals ε_{it}; θ_i allows for country-specific effects in the growth equation (47a); whereas α_i and λ_t allow for fixed effects in the variance equation (47b). Observe that compared to the system (24a) to (24b), only the conditional variance appears as an additional control in the growth equation (for the results see Table B.18).

Table B.18: Dynamic panel estimation, the link between volatility and growth

OECD		MLE (i)		MLE (ii)		MLE (iii)		MLE (iv)	
$LABOR_{i,t-1}$	β_1	−0.97 (1.25)		−2.38 (0.80)	**	−3.82 (1.13)	***		
$CAPITAL_{i,t-1}$	β_2	2.72 (1.08)	*	2.51 (0.74)	***	3.12 (0.94)	**		
$CONS_{i,t-1}$	β_3	2.52 (1.56)		1.08 (0.99)		0.90 (1.01)			
$CORP_{i,t-1}$	β_4	−1.29 (0.53)	*	−1.21 (0.42)	**	−1.49 (0.49)	**		
$PRIVY_{i,t-1}$	γ_1								
$INFL_{i,t-1}$	γ_2	3.17 (1.00)	**						
$INFLFI_{i,t-1}$	γ_3	5.40 (2.37)	*	10.52 (2.61)	***				
$GGDP_{i,t-1}$	γ_4								
$DGFI_{i,t-1}$	γ_5	0.04 (0.03)		0.07 (0.03)	*	0.07 (0.03)	*	0.10 (0.03)	**
$XRFI_{i,t-1}$	γ_6	2.41 (0.74)	**	1.46 (0.78)	·				
$\sigma_{i,t}$	ν	−1.15 (0.21)	***	−0.84 (0.25)	***	−0.42 (0.21)	*	−0.70 (0.40)	·
$\sigma_{i,t-1}$	$1+\rho$	0.06 (0.07)		0.24 (0.06)	***	0.23 (0.08)	**	0.15 (0.12)	
Country fixed effects	α_i	yes		yes		yes		yes	
Time fixed effects	λ_{t-1}	yes		no		no		no	
Degrees of freedom		527		533		553		565	
Log-likelihood		1544.0		1507.3		1521.9		1515.6	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '·' 0.1

Notes: This table reports the semi-elasticities of the joint estimation of (47a) and (47b) explaining the conditional *sd* of annual growth rates of real GDP per capita. For the estimation we use a two-step procedure. First, the model was estimated by maximum likelihood with ν set to zero. The estimated conditional variances and parameters were then included as starting values, and the model was re-estimated by maximum likelihood. Asymptotic standard errors are in parentheses.