Negative rates, demographics and fiscal policy: Heterogeneous tilting taxation in the Euro Area

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Negative rates, demographics and fiscal policy: heterogeneous tilting taxation in the Euro Area

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Abstract

This paper estimates time-varying tax-tilting parameters for eleven EMU member states from 1970 to 2024 using a panel time-varying parameter state-space model that extends the traditional tax-smoothing framework to capture both common and country-specific dynamics. Core countries such as Austria, Belgium, Germany, the Netherlands, France, Ireland, and Finland display a more prudent fiscal stance, while peripheral countries, including Greece, Italy, Portugal, and Spain, shift taxation toward the future, generating current deficits. These patterns are driven by differences between government discounting of future revenues and market rates, and are further influenced by structural factors such as aging populations and unemployment. Periods of negative real interest rates relax fiscal constraints, encouraging governments to delay tax adjustments. The results underscore the need to reduce cross-country fiscal heterogeneity to strengthen long-term sustainability and advance fiscal integration in the Euro Area.

Keywords: Tax-smoothing, time-varying cointegration, multiple structural breaks, Kalman Filter, Time-varying parameters, EU fiscal policy

JEL Classification: H62; E62; C22.

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1 Introduction

The call for greater fiscal policy activism has recently regained momentum, as monetary policy alone has proven insufficient to address economic downturns. As highlighted by Arestis (2011) and Bergman (2011), the quality of fiscal policy is especially critical in times of turbulence. The Washington Consensus prescriptions, following Williamson (1990), promoted fiscal discipline alongside trade liberalization and capital account openness. However, these prescriptions were increasingly seen as inadequate in the aftermath of the 2007-2008 global financial crisis. This perception has since been reinforced in the context of a protracted *polycrisis*, marked by the cascading effects of global shocks such as the COVID-19 pandemic and Russia's invasion of Ukraine.

The controversial situation of fiscal policies is even more explicit in the context of a monetary union. The European Monetary Union (EMU) did not initially foresee a common fiscal policy. Simultaneously, strict constraints were imposed on member states' ability to incur budget deficits, limiting their capacity to stimulate aggregate demand and employment. From a Keynesian perspective, fiscal policy serves as a tool to stabilize output through countercyclical deficits. In contrast, the neoclassical approach emphasizes minimizing the distortions associated with government budgets and ensuring fiscal sustainability. In this vein, Barro (1979, 1981) introduces the well-known principle of intertemporal tax smoothing, proposing that governments minimize distortionary costs by stabilizing the average tax rate over time.

Under this framework, large fiscal deficits are justified in response to temporary spending needs, such as wartime expenditures, major infrastructure investments, or emergency support measures. During recessions, deficits can also compensate for shrinking revenues without exacerbating downturns through procyclical tax hikes. The tax-smoothing hypothesis implies that deficits or surpluses may be used to keep tax rates relatively stable over time. The availability and effective use of public debt instruments are thus central to the feasibility of such a policy.

Obviously, other elements critically challenge the fiscal sustainability of countries, such as demographic change. Over recent decades, European countries have experienced a steady rise in the share of elderly individuals in the population. For instance, in the EU, the old-age dependency ratio, defined as the ratio of people aged 65 or older to those aged 15-64, nearly doubled, increasing from 15.2% in 1960 to 29.9% in 2016. Projections suggest that this ratio will continue to rise substantially over the coming decades across most industrialized economies.

As the elderly population grows, governments face increasing pressures to expand social welfare expenditures while contending with reduced tax revenues due to a shrinking labor force. This dynamic exacerbates budgetary pressures and complicates efforts to maintain fiscal sustainability. While some research predicts a sharp decline in national saving rates and long-term economic growth, policy responses may partially mitigate these effects. Options include pension system reform and adjustments to income or consumption tax rates.

In addition to structural challenges, political economy considerations also play a central role in shaping fiscal outcomes. Strategic behavior by governments in the context of electoral uncertainty can lead to suboptimal debt accumulation. For example, Tabellini and Alesina (1990) and Alesina and Perotti (1995) argue that when incumbents face uncertain reelection prospects, they tend to favor higher debt levels. Along similar lines, Cashin et al. (1999) suggest that "tax tilting" may occur when incumbent governments deliberately increase debt to influence the fiscal choices of their successors. In this context, heterogeneous and time-varying fiscal reaction functions across EMU countries, as documented by Paniagua et al. (2017a), combined with country-specific demographic pressures on primary balances, may pose a significant obstacle to deeper fiscal integration.

In this paper, we employ annual AMECO data to test the tax-smoothing hypothesis across selected EMU countries. Special attention is paid to the possibility of idiosyncratic and time-varying degrees of tax tilting, which may act as a brake on progress toward a fully-fledged European fiscal union.

The remainder of the paper is organized as follows. Section 2 outlines the theoretical model. Section 3 presents the model specification. Section 4 presents the data and their statistical time properties. Section 5 discusses the results. Section 6 concludes.

2 Theoretical background

2.1 The tax smoothing hypothesis and the Government budget constraint

In a series of influential contributions beginning with Barro (1979) and later expanded in Barro (1980, 1981, 1986b,a), a positive theory of optimal government financing was developed, drawing a parallel with the life-cycle hypothesis of consumption (Hall, 1978). In the latter, the representative agent maximizes utility subject to an exogenous income stream by smoothing consumption over time, based on the concept of "permanent income." Analogously, in Barro's framework, the government selects a sequence of tax rates that minimizes the distortionary costs of taxation while financing an exogenous path of primary expenditure and servicing a given stock of public debt.

According to the tax-smoothing literature, in a deterministic economy with an initial debt stock and exogenously given government expenditure, optimal policy implies a constant tax rate. Under these assumptions, tax rates should exhibit persistence. Conversely, in a stochastic economy with incomplete financial markets, optimal taxation follows a random walk generated by a martingale process, such that expected changes in tax rates are zero. Consequently, governments can limit excess burdens by smoothing tax rates rather than adjusting them to meet short-term budgetary needs.

The rationale for tax smoothing is grounded in the convexity of distortionary costs: the welfare loss from taxation increases more than proportionally with the tax rate. Therefore, when a first-best system of lump-sum taxation is unavailable, the government seeks to minimize the welfare loss associated with distortionary taxation (Alesina and Perotti, 1995). Following Barro (1979), the government acts as a "benevolent social planner", choosing a sequence of taxes $\{\tau_t\}$ that minimizes V, the expected deadweight losses of taxation in Equation (1), subject to its intertemporal budget constraint.

$$V = -\frac{1}{2} \sum_{j=t}^{\infty} \beta^{j-t} E_t \left[\tau_j^2 \,\middle|\, \Omega_t \right], \tag{1}$$

where β is the government's subjective discount factor, E_t is the expectations operator conditional on the information set Ω_t at time t, and τ_j denotes the average tax rate in period j. It is plausible to assume that distortionary costs rise more than proportionally with tax rates. The subjective discount factor β can alternatively be expressed in terms of the implied subjective discount rate δ, such that $\beta = \frac{1}{1+\delta}$.

The government's optimization is limited by its intertemporal budget constraint, which requires the present value of tax revenues to be sufficient to cover the present value of government spending and the initial debt stock. The one-period budget constraint is given by:

$$B_{t+1} = (1 + i_t)B_t + G_t - \tau_t Y_t, \tag{2}$$

where B_t denotes public debt, G_t government spending, i_t the nominal interest rate, and Y_t output. Dividing through by Y_t, and letting ν_t denote the nominal GDP growth rate, yields:

$$(1 + \nu_t)b_{t+1} = (1 + i_t)b_t + g_t - \tau_t, \tag{3}$$

where lowercase variables represent ratios to output: $b_t = B_t/Y_t$ and $g_t = G_t/Y_t$.

We define the growth-adjusted interest rate ψ_t as:

$$\psi_t = \frac{1 + i_t}{1 + \nu_t} - 1 = \frac{i_t - \nu_t}{1 + \nu_t}, \tag{4}$$

which captures the effective interest rate on debt normalized by GDP growth. The corresponding market discount factor is:

$$\Psi_t = \frac{1}{1+\psi_t} = \frac{1+\nu_t}{1+i_t}. \tag{5}$$

Using forward iteration and imposing the intertemporal constraint, we obtain:

$$\sum_{j=t}^{\infty} \Psi^{j-t} E_t[\tau_j] = \sum_{j=t}^{\infty} \Psi^{j-t} E_t[g_j] + (1+i)b_t + \lim_{j\to\infty} \Psi^j E_t[(1+\nu)b_{t+j}]. \tag{6}$$

The transversality (or "no-Ponzi") condition requires the last term to converge to zero:

$$\lim_{j\to\infty} \Psi^j E_t[(1+\nu)b_{t+j}] = 0. \tag{7}$$

This condition ensures that deficits cannot be perpetually financed through new borrowing.

Solving the optimization problem in (1) subject to (6) and (7) yields the implied tax rate under the tax-smoothing hypothesis (TSH):

$$\tau_t = \theta \left[(1-\Psi) \sum_{i=0}^{\infty} \Psi^i E\{g_i \,|\, \Omega_t\} + (i-\nu)b_t \right], \tag{8}$$

where $\theta = \frac{1-(\Psi/\beta)\cdot\Psi}{1-\Psi}$ is the *tilting parameter*. If the subjective and market discount factors are coincident (i.e. $\beta = \Psi$), the Euler equation implies that $E_t[\tau_j] = \tau_t$ for all $j > t$, meaning tax rates follow a martingale process (see Ghosh, 1995).

The TSH predicts that tax rates should remain relatively stable, changing only in response to unanticipated shocks. Thus, predictable variations in tax rates are inconsistent with optimal fiscal policy. The optimal budget surpluses in the tax-smoothing framework, sur_t^{sm}, would absorb temporary expenditure shocks:

$$sur_t^{sm} = \sum_{j=1}^{\infty} \Psi^j E[\Delta g_{t+j} \mid \Omega_t], \qquad (9)$$

implying that the surplus equals the present discounted value of expected changes in government spending (Barro, 1981; Sahasakul, 1986).

2.2 Tilting Taxes: Smoothing with Temporal Bias

As shown previously, tax-smoothing behavior inherently tends to generate fiscal deficits. This occurs because, in the absence of lump-sum taxes, an optimizing government aims to minimize the distortionary effects of taxation by maintaining relatively stable tax rates over time, rather than allowing them to fluctuate contemporaneously with government expenditures.

However, the tilting parameter $\theta = \frac{1-\frac{\Psi}{\beta}\cdot\Psi}{1-\Psi}$ in Equation (8) may differ from unity, implying that the government's subjective discount rate does not coincide with the market-driven effective interest rate on public debt. Consequently, the government's intertemporal allocation of taxation depends on whether it discounts future tax distortions at the same rate as financial markets discount future liabilities. When the government's discount factor β diverges from the effective market discount factor Ψ, tax tilting emerges. In this sense, tax tilting provides an additional rationale for running fiscal deficits beyond tax smoothing (see Ghosh, 1995; Cashin et al., 1998, 1999).

Thus, two main considerations can motivate a government to incur a deficit: tax smoothing and tax tilting. Even under the assumption of constant government expenditures over time, removing the need for tax smoothing, deficits may still arise as a result of tax-tilting behavior if the government discounts the future at a different rate than the market. This divergence creates incentives to shift the tax burden intertemporally. For example, if $\beta < \Psi$[1], the government reveals a preference for postponing taxation, running fiscal deficits in the present, and accumulating debt that will be serviced by higher taxes

[1]Note that $\beta < \Psi$ is equivalent to $\frac{1}{1+\delta} < \frac{1}{1+\psi}$, which implies $\delta > \psi$.

in the future. In this case, $\theta < 1$, and the government chooses to set relatively low tax rates today, deferring the necessary adjustments to cover the growing stock of liabilities.

The relationship can be formalized as:

$$sur_t^{sm} = \theta^{-1} \cdot \tau_t - (g_t + (i - \nu) \cdot b_t) = \theta^{-1} \cdot \tau_t - g_t^{tot} \tag{10}$$

Under the assumption that sur_t^{sm} is stationary, θ^{-1} becomes the cointegrating parameter in the regression of $(g_t + (i - \nu) \cdot b_t)$ on τ_t. Estimating θ from Equation (10), and assuming a value for the growth-adjusted market discount factor Ψ, allows one to derive the government's subjective discount factor β, and from it, the implied subjective discount rate δ. Cross-country heterogeneity in β (and therefore δ) could explain variations in the tilting factor across EMU member states, complicating the prospects for deeper fiscal integration. Furthermore, time-varying estimates of θ may shed light on the feasibility of debt mutualization within a fiscal union.

The divergence between subjective and market discount rates is well documented in the literature. Azar and Sterner (1996) distinguish between two approaches to discounting: one based on the opportunity cost of capital (the marginal rate of return on investment) and another reflecting the social rate of time preference (SRTP). While these should theoretically coincide in an idealized economy, empirical evidence suggests a persistent gap (see also Arrow, 1966).

Although the "no-Ponzi" condition introduced earlier requires a positive growth-adjusted interest rate, historical data show that long-term real interest rates have remained depressed during much of the second half of the 20th century (Schmelzing, 2020). This phenomenon is often attributed to "secular stagnation", a situation characterized by persistently low or negative real interest rates driven by structural factors such as excess savings or weak investment demand. The secular stagnation hypothesis, originally proposed by Hansen (1939), argued that the U.S. economy faced a structural shortfall in aggregate demand during the Great Depression. This notion was revived by Summers (2014), who claimed that the natural rate of interest, the real equilibrium rate consistent with full employment, had become permanently negative. Contributing forces include demographic trends (slowing population growth, increasing life expectancy), rising income inequality, declining relative prices of investment goods, and productivity slowdowns. Eggertsson et al. (2019) suggest that fiscal policy could be more effective than monetary policy in addressing secular stagnation; however, they warn that fiscal multipliers may eventually approach zero or become negative depending on the intergenerational tax distribution.

Recent studies examine how negative real interest rates influence government fiscal strategies, supporting the view that deferring taxation can be optimal under specific conditions. For instance, Ubide (2019) argues that traditional fiscal frameworks must adapt in a low- or negative-rate environment, as governments can finance expenditures more cheaply. Similarly, Azizi et al. (2012) question the universality of the no-Ponzi condition, showing that debt sustainability without immediate fiscal adjustment may be feasible under certain circumstances. Moreover, Aguiar and Amador (2016) demonstrate that when governments are more patient than private agents, deferring taxation can be optimal, potentially leading to future fiscal outcomes resembling negative taxes. Nevertheless, several contributions highlight the risks associated with negative real rates and caution against over-reliance on them for fiscal policy, given the possibility of rate normalization (Palley, 2018; Urbschat, 2018).

In Table 4, we simulate alternative values of θ for different combinations of Ψ (and its implied ψ) and β (and the corresponding δ). Results confirm that tax tilting to the future ($\theta < 1$) occurs when $\beta < \Psi$ and $\Psi < 1$, but also when $\beta > \Psi$ in scenarios with $\Psi > 1$ (negative growth-adjusted interest rates).

2.3 Time preference and the government subjective discount factor

As discussed above, tax-tilting behavior originates from the divergence between the government's subjective discount rate and the market-driven interest rate on public debt, potentially leading to current deficits and a postponement of taxation into the future. In the context of the modern welfare state, a high perceived social return justifies government spending, not only on public investment projects but also on other categories of expenditure. Additionally, when the government can finance debt at low borrowing rates, the gap between social return and the market cost of debt further reinforces the incentive to shift taxation forward, thereby increasing the public debt burden.

The Ramsey equation (Ramsey, 1928) provides a decomposition for the government's subjective discount factor β introduced above, and its implied subjective discount rate δ. In the standard representative-agent Ramsey model, the household Euler equation yields a steady-state relationship in which the real interest rate depends on the expected output growth rate of the economy and a residual component corresponding to the pure rate of time preference, denoted ρ:

$$(1+\delta) = (1+\eta)^{\alpha} \cdot (1+\rho) \tag{11}$$

In Equation (11), the subjective discount rate δ (and hence its implied discount factor β) can be decomposed into two components: the expected consumption growth rate η, raised to the power of α, the absolute value of the elasticity of marginal utility of consumption, and Ramsey's pure rate of time preference ρ. Rearranging Equation (11) in terms of ρ gives:

$$\rho = \frac{(1+\delta)}{(1+\eta)^{\alpha}} - 1 \approx \frac{\delta - \eta^{\alpha}}{(1+\eta)^{\alpha}} \tag{12}$$

For simplicity, assume $\alpha = 1$, which corresponds to a logarithmic instantaneous utility function. This specification is standard in macroeconomic models, given empirical evidence favoring a relatively strong intertemporal substitution elasticity and considerations of analytical tractability. Under this assumption, the expression for ρ becomes:

$$\frac{1}{(1+\rho)} = \frac{(1+\eta)}{(1+\delta)} \tag{13}$$

Or, equivalently:

$$\rho = \frac{(1+\delta)}{(1+\eta)} - 1 \approx \frac{\delta - \eta}{(1+\eta)} \tag{14}$$

Similarly, the government's subjective discount factor β in Equation (1) can be expressed as:

$$\beta = \frac{1}{(1+\delta)} = \frac{1}{(1+E[\gamma])(1+\rho)} \tag{15}$$

Equation (15) shows that the government discount factor β depends on the expected real GDP growth rate $E[\gamma]$ and the pure rate of time preference ρ. From this perspective, a high subjective discount rate δ can arise either from an impatient agent (high ρ) or from an optimistic agent, confident in a high future real GDP and consumption growth rate (high $E[\eta]$). In practice, it is impossible to disentangle these two components empirically.

There has been long-standing controversy regarding how the value of ρ should be determined. Ramsey (1928) argued that ρ should be zero on ethical grounds, asserting that it would be unfair for society to discount the welfare of future generations. However, other economists claim that ρ must be consistent with revealed intertemporal choices. Ramsey acknowledged that individuals might be myopic or impatient, but he maintained that social planning should not reflect these individual biases. In the same normative vein, Kantian ethics (Booth, 1994) emphasize a moral responsibility not to impair the ability of others to achieve happiness by degrading resources (e.g., environmental assets) essential to that goal.

From an empirical perspective, if the government's subjective discount rate δ can be estimated, it is possible to infer the pure rate of time preference ρ using the Ramsey rule, provided that expectations about real GDP growth are available. These expectations allow the de-normalization of the tax-to-GDP ratio τ into general government real tax revenue, which corresponds to real consumption in the Ramsey framework.

As highlighted by Azar and Sterner (1996), the subjective discount rate δ reflects two components: the expectation that society will be richer in the future and pure time preference. Consequently, differences in expected economic growth and productivity, whether realistic or overly optimistic, can increase δ (and lower β).

Regarding the pure rate of time preference ρ, the literature on the political economy of business cycles emphasizes that governments facing short election cycles or uncertain reelection prospects may heavily discount the future, leading to a higher ρ and favoring short-term policies such as spending increases and tax cuts. In the same vein, Pastén and Cover (2015) suggest that some governments use fiscal policy strategically to recruit and retain followers. Hence, a plausible candidate for country-specific tilting parameters would be political risk or instability.

Theories of government debt in the political economy also highlight demographic factors as key determinants of public debt dynamics. The demographic structure helps explain how one generation can extract resources from future, unborn generations (Tabellini, 1991; Cukierman and Meltzer, 1989). Similarly, Yared (2019) reviews theories suggesting that population aging increases present bias in government behavior. Some authors argue that aging exacerbates fiscal irresponsibility, as older generations prioritize short-term benefits over long-term sustainability (Wolter et al., 2013). Moreover, McCallum (1984) and O'Connell and Zeldes (1988), among others, identify a link between population growth rates and the time preference parameter, which in turn affects the trajectory of public debt.

The political and demographic biases described above, which push toward a higher subjective discount rate (a lower β), are amplified in a context of secular stagnation and the persistent decline of real interest rates on public debt. This decline reduces the real effective market discount factor (Ψ), thereby widening the gap between Ψ and β and intensifying incentives for tax tilting.

The coexistence of declining real interest rates and persistently high government discount rates creates a structural bias toward deficit accumulation and intergenerational inequity. Policy frameworks that ignore the subjective nature of government discounting may underestimate fiscal risks. Incorporating explicit assumptions about ρ and β into debt sustainability analyses, alongside political and demographic risk factors, can improve the design of fiscal rules and ensure a fairer intertemporal allocation of resources.

3 Empirical Specification

In this section, we present the empirical specification used to obtain the (inverse) tax-tilting parameter within a panel time-varying parameters (TVP) framework. The starting point is a (potentially) cointegrating measurement (or observation) equation in which the total (primary) fiscal surplus to GDP ratio is explained by the tax ratio and a set of control variables, allowing for a time-varying component in the coefficient of taxation. The measurement equation is specified as:

$$g_{it}^{tot} = \alpha_{0,i} + (\theta_i^{-1} + \xi_{i,t}) \cdot \tau_{it} + \alpha_{1,i} \cdot yvar_{i,t} + \alpha_{2,i} \cdot gvar_{i,t}^{tot} + \omega_{i,t} \tag{16}$$

where $i = 1, \ldots, N$ indexes countries, $t = 1, \ldots, T$ time, g_{it}^{tot} denotes the (total) primary surplus (or fiscal balance) ratio, τ_{it} the tax revenue ratio, $yvar_{i,t}$ the (scaled) cyclical output component, $gvar_{i,t}^{tot}$ the temporary (idiosyncratic) component of government expenditure, and $\omega_{i,t}$ is an idiosyncratic disturbance term. The coefficient on $\tau_{i,t}$ is decomposed into a country-specific mean (the inverse tilting parameter θ_i^{-1}) plus a stochastic deviation $\xi_{i,t}$.

Following the tax-smoothing framework in Barro (1979), additional non-debt determinants of the (primary) surplus enter as controls. Selecting appropriate controls is non-trivial: consistent with Mendoza and Ostry (2008) (advanced vs. emerging economies), and Paniagua et al. (2017a) (EMU countries), we include (i) a business cycle variable

$yvar_{i,t}$ and (ii) a measure of temporary government spending $gvar_{i,t}$[2]. The second variable isolates discretionary or shock-driven expenditure components not directly tied to the contemporaneous cycle.

To construct these variables, we adopt the approach in Bohn (1998), who operationalizes the closed-form tax-smoothing solution in Barro (1979) through measures of temporary fluctuations in output and government purchases. In particular (see also Barro (1986b)), the cyclical/output gap-scaled measures are:

$$yvar_t = \frac{(y_t^* - y_t)}{y_t^*} \cdot \frac{g_t^*}{y_t} = \left(1 - \frac{y_t}{y_t^*}\right) \cdot \frac{g_t^*}{y_t}, \tag{17}$$

$$gvar_t = \frac{(g_t - g_t^*)}{g_t^*} \cdot \frac{g_t^*}{y_t} = \frac{(g_t - g_t^*)}{y_t}, \tag{18}$$

where y_t and g_t denote, respectively, actual GDP and government expenditure, and y_t^* and g_t^* their trend (or long-run) components.

Trend components y_t^* and g_t^* are obtained by applying the Hamilton (2018) filter to the observed series, which provides an alternative cyclical extraction method with preferable statistical properties than the Hodrick-Prescott filter for potentially nonstationary data. According to Barro's tax-smoothing model, positive realizations of $yvar_t$ and $gvar_t$ (temporary output shortfalls and temporary spending increases) are expected to reduce the primary surplus (i.e., their coefficients should be negative), reflecting countercyclical fiscal behavior.

In Equation (16), the (inverse) tax-tilting coefficient on τ_{it} comprises a fixed country component and a time-varying stochastic deviation:

$$\theta_{i,t}^{-1} = \theta_i^{-1} + \xi_{1,i,t}. \tag{19}$$

The TVP structure is completed by specifying the law of motion for the unobserved com-

[2]Other controls, such as interest rates or inflation, are often added to capture financial market stress or valuation effects; their inclusion does not materially alter the core results and is omitted here for parsimony.

ponent(s). Each element of the state vector $\xi_{i,t}$ follows a stochastic transition equation:

$$\xi_{i,t+1} = \phi \cdot \xi_{i,t} + \mu_{1,i} \cdot odr_{i,t-1} + \mu_{2,i} \cdot uwapr_{i,t-1} + \mu_{3,i} \cdot odrg_{i,t} + \mu_{4,i} \cdot \Delta uwapr_{i,t} + \upsilon_{i,t}, \quad (20)$$

with $\upsilon_{i,t} \sim N(0, Q)$. The autoregressive parameter ϕ_i governs persistence, while demographic and labor-market indicators, lagged old-age dependency ratio $odr_{i,t-1} = \frac{pop_{i,t}^{+65}}{pop_{i,t}^{15-54}}$ and lagged unemployment ratio to working-age population $uwapr_{i,t-1} = \frac{pop_{i,t}^{u}}{pop_{i,t}^{15-54}}$, enter through parameters μ_{i1}, μ_{i2} that we will test whether they are common to all countries (i.e. $\mu_{i1} = \mu_1$ for all i and $\mu_{i2} = \mu_2$ for all i). Two additional (possibly country-specific) drivers, the growth rate of the old-age dependency ratio $odrg_{i,t}$ and the change in the unemployment ratio $\Delta uwapr_{i,t}$, are captured by $\mu_{3,i}$ and $\mu_{4,i}$ respectively.

The general state-space model (measurement equation (16) plus transition equation) is estimated by (quasi) maximum likelihood using the Kalman filter. In the empirical results section, we consider restricted variants (e.g., common vs. country-specific ϕ_i; exclusion of demographic drivers) nested within this general specification.

The estimated (inverse) tax-tilting parameter $\theta_{i,t}^{-1}$ is related to structural discount factors through:

$$\theta = \frac{1 - \frac{\Psi}{\beta} \cdot \Psi}{1 - \Psi}, \qquad \Psi = \frac{1 + \nu}{1 + i} = \frac{1}{1 + \psi},$$

where Ψ is the (observed) market discount factor implied by nominal GDP growth ν and the nominal interest rate i (with ψ the growth-adjusted interest rate). Given an estimate of θ and observed Ψ, the implied subjective discount factor β is recovered as:

$$\beta = \frac{\Psi^2}{1 - \theta \cdot (1 - \Psi)} = \frac{\Psi^2}{1 - \theta + \theta \cdot \Psi}, \quad (21)$$

which corresponds to a subjective discount rate δ defined by:

$$\beta = \frac{1}{1 + \delta}. \quad (22)$$

This mapping permits the interpretation of estimated tilting behavior in terms of underlying intertemporal preferences.

4 Data and Time-Series Properties Analysis

This section documents the data, sources, procedures used to construct the variables, and the univariate time-series properties of the fiscal and demographic variables employed in the empirical analysis. We begin by performing unit root tests for the fiscal variables: primary (non-interest) government expenditure (g_t), nominal interest service on lagged debt ($i_t b_{t-1}$), total government expenditure (g_t^{tot}), and tax revenue (τ_t), all expressed as ratios to GDP. After establishing the order of integration of these series, we proceed (in subsequent sections) to estimate a potential cointegration relationship and the associated time-varying tilting parameter for a panel of EMU countries, paying particular attention to its evolution and possible convergence patterns relevant for deepening fiscal integration.

4.1 The Data

Fiscal data were extracted from the European Commission AMECO (Annual Macro-Economic) database for the period 1970–2024. The sample comprises a group of "peripheral" EMU economies (Portugal, Ireland, Italy, Greece, Spain, and Finland) together with core Euro Area members (Germany, France, Belgium, the Netherlands, and Austria). Eastern Euro Area economies are excluded due to shorter and less homogeneous data availability.

Constructing homogeneous long-run fiscal series requires addressing two main sources of discontinuity: (i) changes in the European System of Accounts (ESA79 for roughly 1970–1995, ESA95 for 1995–2010, and ESA 2010 thereafter) and (ii) the German reunification break. Following Paredes et al. (2009), we eliminate level discontinuities by iteratively "back-casting" earlier vintages using growth rates from the subsequent accounting standard. Specifically, to obtain a consistent ESA95* level compatible with ESA2010, and analogously for earlier breaks, we apply:

$$Y_{t-1}^{\text{ESA95}^*} = \frac{Y_t^{\text{ESA95}}}{\left(\frac{Y_t^{\text{ESA79}}}{Y_{t-1}^{\text{ESA79}}}\right)}. \tag{23}$$

This recursive adjustment is applied successively so that historical segments are expressed on a common latest-standard methodological basis.

The panel thus constructed possesses both adequate time depth and cross-sectional variation to support robust estimation of the time-varying specification.

The effective government interest rate is computed directly as the ratio of net interest payments during fiscal year t to the average stock of government debt held by the public over that year. Because this is a simple (period) rate, we convert it to an equivalent compound annual rate for consistency. Whenever expressions such as $i_t - \nu_t$ appear, i_t denotes this compound interest rate and ν_t nominal GDP growth.

In line with Cho and Lee (2022), we use the old-age dependency ratio, $odr_{i,t}$, as a demographic indicator, defined as the population aged 65 and over divided by the working-age population (15–64). This ratio is constructed from AMECO demographic series.

Additionally, from the OECD database we retrieve a set of variables related to the fiscal impact of ageing: (i) the social security contributions ratio to GDP, $ssc_{i,t}$; (ii) total social security expenditure, $ss_{i,t}^{tot}$; and (iii) public pension expenditure, $ss_{i,t}^{pen}$; all expressed as shares of GDP. The social expenditure series are available from 1980 onward.

4.2 Univariate Properties of the Data

We next analyse the order of integration of the fiscal variables (all as GDP ratios), allowing for the presence of structural breaks and cross-sectional dependence. As emphasized by Perron (1989), failing to model structural breaks can lead to spurious evidence of unit roots.[3] Distinguishing between stochastic and deterministic sources of non-stationarity

[3] As noted by Perron (1997), introducing even a single break is often sufficient to weaken apparent unit root evidence in the classic macroeconomic series of Nelson and Plosser (1982).

carries substantive policy implications: if trends are stochastic, shocks have permanent fiscal effects with potential solvency risks; if breaks are deterministic (level or trend shifts), deviations may be transitory and correctable through policy interventions (Nguyen et al., 2017).

To accommodate multiple structural breaks and cross-section dependence, we employ the panel unit root procedures of Bai and Carrion-i Silvestre (2009), which pool modified Sargan-Bhargava (MSB) statistics.[4] Their framework allows for (i) multiple break dates in each series[5] and (ii) a general common factor structure capturing cross-section dependence.[6] Common factors may themselves be stationary, non-stationary, or a mixture. The number of factors is selected using the panel Bayesian Information Criterion of Bai and Ng (2002).

In implementation, we allow up to four structural breaks per series, with break dates selected via the Bai and Perron (1998) procedure.[7] Applied to our 11-country panel, the tests yield strong evidence of multiple structural breaks across most fiscal variables, with substantial heterogeneity in both number and timing (see Table B.1).

Table B.2 reports the panel unit root test statistics for (i) the general government (GG) tax revenue ratio τ_t, (ii) the GG total expenditure ratio g_t^{tot}, and (iii) the GG non-interest expenditure ratio g_t. After controlling for common factors and allowing for structural breaks, the null of a unit root cannot be rejected for these variables across both the "conventional" and "simplified" test variants.[8]

The joint presence of (i) non-rejection of unit roots in the core fiscal ratios and (ii) multiple breaks of heterogeneous timing across countries is consistent with the existence of a cointegrating relationship among revenue, expenditure, and interest service variables.

[4]Sargan and Bhargava (1983).

[5]Break detection adapts the methodology of Bai and Perron (2003) to the panel context.

[6]Following Bai and Ng (2004) and Moon and Perron (2004).

[7]GAUSS routines provided by the original authors were adapted for our dataset; see Bai and Carrion-i Silvestre (2009) for algorithmic details.

[8]Bai and Carrion-i Silvestre (2009) note that the simplified set of statistics is especially suited to level-and-trend break specifications; they also report that the Z and P statistics exhibit favorable small-sample properties.

This finding motivates the subsequent estimation of a (possibly time-varying) long-run fiscal equilibrium vector and the extraction of the tax-tilting parameter dynamics reported later in the paper.

5 Results and Discussion

5.1 State-space model estimation

This subsection reports the estimation of the empirical state-space specification introduced in Section 3. As shown in Hamilton (1994), among others, state-space methods provide a flexible framework for modeling time-varying parameters. We implement our estimation using `sspaneltvp`, a GAUSS toolbox developed by Camarero et al. (2025) to estimate fully fledged panel time-varying parameter (TVP) models via the Kalman filter.

The `sspaneltvp` environment extends the univariate setup in Hamilton (1994) to a panel context with both fixed (common or country-specific) and stochastic time-varying components. Under suitable parameter restrictions, the system nests mean-reverting specifications, and the fixed (mean) component may include a deterministic trend. The transition equation admits autoregressive alternatives and exogenous "drivers" (control instruments) whose coefficients can be imposed as common across countries or allowed to vary idiosyncratically for uncovering asymmetric responses to common shocks. In addition, the GAUSS code supports user-defined restrictions on the variance-covariance matrices of both the transition and measurement equations.[9]

To select our baseline model, we compare a general unrestricted model with alternative specifications nested within the general state-space model presented in Section 3 and equations (16) and (20). The most general model is Model 1 in Table 1, where all the variables in the measurement and the transition equations are idiosyncratic, except for the autoregressive parameter ϕ. We compare the unrestricted model with several alternative specifications, where we reduce the heterogeneity of the different parameters in the two

[9] Applications using earlier versions of this code include Camarero et al. (2021), Camarero et al. (2020), Paniagua et al. (2017a), and Paniagua et al. (2017b).

equations. For example, in Model 2, we test if parameter $\alpha_{2,i} = \alpha_2$, so that all the countries share the same parameter for variable $gvar_i^{tot}, t$. This hypothesis is rejected. We also tested if for the variable $yvar_{i,t}$, that we omit for the sake of simplicity[10]. Next, in Model 3 where we test whether all the countries share the parameters μ_1 and μ_2 in the transition equation, that is, whether all the countries have a similar reaction to lagged old-dependence ratio and lagged unemployment rate. The LR test $\lambda_{L.R.}$ is asymptotically χ^2-distributed if the null hypothesis is true. In Table 1, we have marked in grey the second row, where we accept this hypothesis. Nested in Model 3, Model 4 tests whether in addition to the accepted hypothesis about μ_1 and μ_2 all the countries share the same variance. This is also rejected. Therefore, this is the model we estimate and consider our baseline specification. From Model 5 to Model 9 we test some additional hypotheses related to model characteristics (which we will discuss later).

[10]We have also tested whether both α_1 and α_2 have both the same parameter for all the countries in the sample, also rejected.

Table 1: Likelihood ratio test results for model specification and hypotheses testing.

Model	Restrictions	Parameters	Hypothesis	LogLikel	LR	df	p-value	Result
1	Initial Specification	101		-718.524	–	–	–	–
2	$\alpha_{2,i} = \alpha_2$ $sig_{v,i} = sig_v$	91	H_0: Model 3 H_1: Model 1	-735.639	61.43	10	0.001	Reject
3	$\mu_{1,i} = \mu_1$ $\mu_{2,i} = \mu_2$	91	H_0: Model 3 H_1: Model 1	-704.924	27.20	10	1.000	Accept
4	$\mu_{1,i} = \mu_1$ $\mu_{2,i} = \mu_2$ $sig_{v,i} = sig_v$	81	H_0: Model 4 H_1: Model 3	-741.731	73.61	10	0.000	Reject
5	$\mu_{k,i} = 0,\ i = 1,2,3,4$ $sig_{v,i} = sig_v$	57	H_0: Model 5 H_1: Model 3	-829.240	248.63	34	0.000	Reject
6	$\alpha_{1,i} = \alpha_1$ $\alpha_{2,i} = \alpha_2$ $\mu_{1,i} = \mu_1$ $\mu_{2,i} = \mu_2$ $sig_{v,i} = sig_v$	61	H_0: Model 6 H_1: Model 3	-784.071	158.29	30	0.000	Reject
7	$\theta_i^{-1} = \theta^{-1}$ $\mu_{1,i} = \mu_1$ $\mu_{2,i} = \mu_2$ $sig_{v,i} = sig_v$	51	H_0: Model 7 H_1: Model 3	-834.066	258.28	40	0.000	Reject
8	$\alpha_{1,i} = \alpha_1$ $\alpha_{2,i} = \alpha_2$ $\mu_{k,i} = 0$	37	H_0: Model 8 H_1: Model 3	-859.976	310.10	54	0.000	Reject
9	$\phi = 1$ $\mu_{1,i} = \mu_1$ $\mu_{2,i} = \mu_2$	90	H_0: Model 9 H_1: Model 3	–	–	1	0.000	Reject

Table 2: State-Space Tax Tilting 1970-2024. Selected EMU Countries.

	BEL	DEU	GRC	ESP	FRA	IRE	ITA	NED	AUT	PRT	FIN
Measurement Equation: $g^{tot}_{it} = \alpha_{0,i} + (\theta_i^{-1} + \xi_{i,t}) \cdot \tau_{it} + \alpha_{1,i} \cdot yvar_{i,t} + \alpha_{2,i} \cdot gvar^{tot}_{i,t} \omega_{it}$											
$\alpha_{0,i}$	36.876***	35.851***	0.366	1.925	17.716***	23.810***	1.236	35.894***	30.344***	8.592**	27.558***
	(9.582)	(9.279)	(0.850)	(1.679)	(4.921)	(4.733)	(2.013)	(8.474)	(6.064)	(3.989)	(5.557)
$\theta^{-1}_{1,i,t}$	0.177	0.056	1.120***	0.862***	0.541***	0.179	1.188***	0.206	0.365***	0.463*	0.175
	(0.223)	(0.221)	(0.169)	(0.149)	(0.123)	(0.185)	(0.127)	(0.197)	(0.121)	(0.260)	(0.147)
α_{1i}	2.465***	2.425***	0.795**	1.256***	2.746***	1.255***	1.420***	2.325***	1.758***	0.771**	2.394***
	(0.555)	(0.473)	(0.345)	(0.375)	(0.294)	(0.381)	(0.455)	(0.474)	(0.326)	(0.352)	(0.254)
α_{2i}	1.363***	1.888***	0.311**	0.095	1.590***	1.068***	1.361***	1.119***	1.207***	0.504***	0.896***
	(0.343)	(0.263)	(0.158)	(0.129)	(0.309)	(0.141)	(0.394)	(0.280)	(0.233)	(0.160)	(0.190)
$sigw$	0.681***	0.347	0.347	0.000***	0.305**	1.238***	0.775***	0.461**	0.594***	0.580**	0.460**
	(0.167)	(0.232)	(0.235)	(0.000)	(0.122)	(0.333)	(0.190)	(0.233)	(0.148)	(0.267)	(0.238)
State Transition equation: $\xi_{i,t+1} = \phi_i \cdot \xi_{i,t} + \mu_1 \cdot odr_{i,t-1} + \mu_2 \cdot uwapr_{i,t-1} + \mu_{3,i} \cdot odrg_{i,t} + \mu_{4,i} \cdot \Delta uwapr_{i,t} + \upsilon_{it}$											
ϕ	0.922***										
	(0.013)										
μ_1	0.062***										
	(0.012)										
μ_2	0.035**										
	(0.013)										
$\mu_{3,i}$	-1.230**	0.186	-2.971	-0.967	-0.491**	-3.512**	-2.658***	-1.093	-0.556	3.034*	1.502***
	(0.558)	(0.500)	(1.932)	(1.370)	(0.280)	(1.252)	(0.893)	(0.677)	(0.396)	(1.721)	(0.576)
$\mu_{4,i}$	1.974	1.359**	-0.373	0.483	0.651	6.721***	-0.371	0.967**	0.270	1.858**	2.305***
	(0.793)	(0.648)	(0.814)	(0.473)	(0.491)	(0.964)	(0.855)	(0.434)	(0.838)	(0.835)	(0.332)
$sigv$	0.022***	0.023***	0.063***	0.046***	0.011***	0.057***	0.022***	0.023***	0.015***	0.049***	0.019***
	(0.004)	(0.004)	(0.009)	(0.004)	(0.002)	(0.010)	(0.006)	(0.004)	(0.003)	(0.007)	(0.004)
Log likelihood	-704.925										
Number of Observations: 55											

Notes: standard deviations in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The maximum-likelihood estimates of the hyperparameter vector are reported in Table 2. The mean (inverse) tax-tilting parameter, $\bar{\theta}_i^{-1}$, is statistically significant for Greece, Spain, France, Italy, Austria and Portugal. Point estimates cluster into two broad groups. For core EMU countries is only significant in the case of Austria and France, with values $\bar{\theta}^{-1} = 0.365$ and 0.541, respectively. Portugal could also be included in this group, as its parameter is around 0.5. This implies tilting *toward the present* (i.e., proportionally more current taxation). In Greece and Italy, we obtain $\bar{\theta}_i^{-1} > 1$, consistent with *tilting toward the future* and thus with a structural tendency to run current budget deficits as a share of GDP. Finally, in Spain, the parameter is large but below one (0.862).

Turning to the lower half of the table and state (transition) dynamics of $\theta_{i,t}^{-1}$, the panel-common coefficients on the lagged old-age dependency ratio (μ_1) and on the unemployment-to-working-age-population ratio (μ_2) are both positive and statistically significant. This suggests that demographic aging and labour market slack each contribute to widening the gap between government expenditure needs and contemporaneous taxation, interpretable as a decrease in θ_i and therefore increased tax tilting toward the future. As for the second group of parameters, which are μ_{3i} and μ_{4i}, the country-specific responses to the *growth* of these demographic and labour market variables, several patterns emerge. First, some countries react strongly to aging pressures and others to changes in unemployment. Second, for most countries with a significant μ_3 coefficient, the response to growth in old-dependency is negative (Belgium, France, Ireland and Italy), but for Portugal and Finland it is positive. Third, μ_4 is only positive and significant for Germany, Ireland, the Netherlands, Portugal and Finland.

Figure 1: Time-Varying tax-tilting parameters. Core EMU Countries

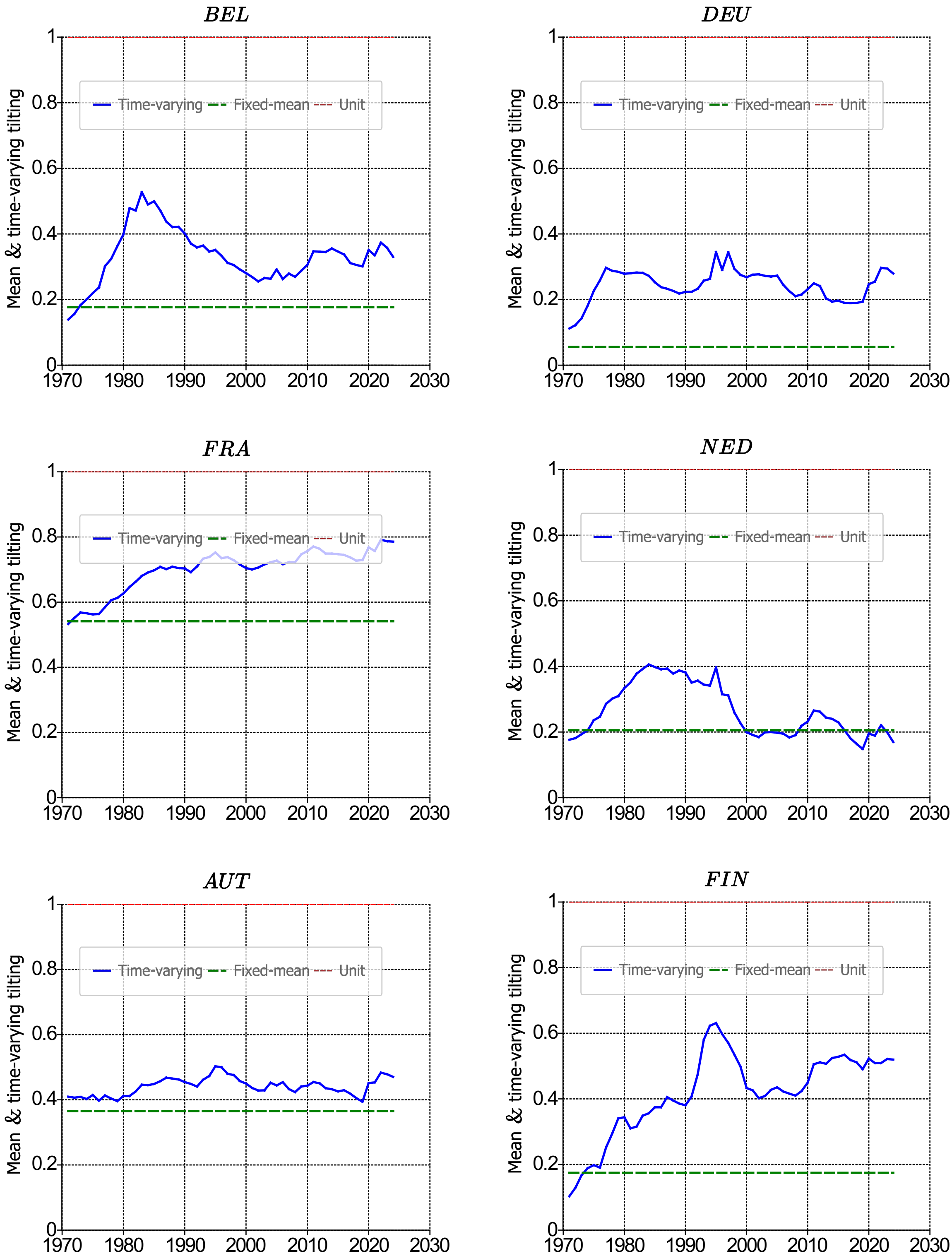

Figure 1: (continued)

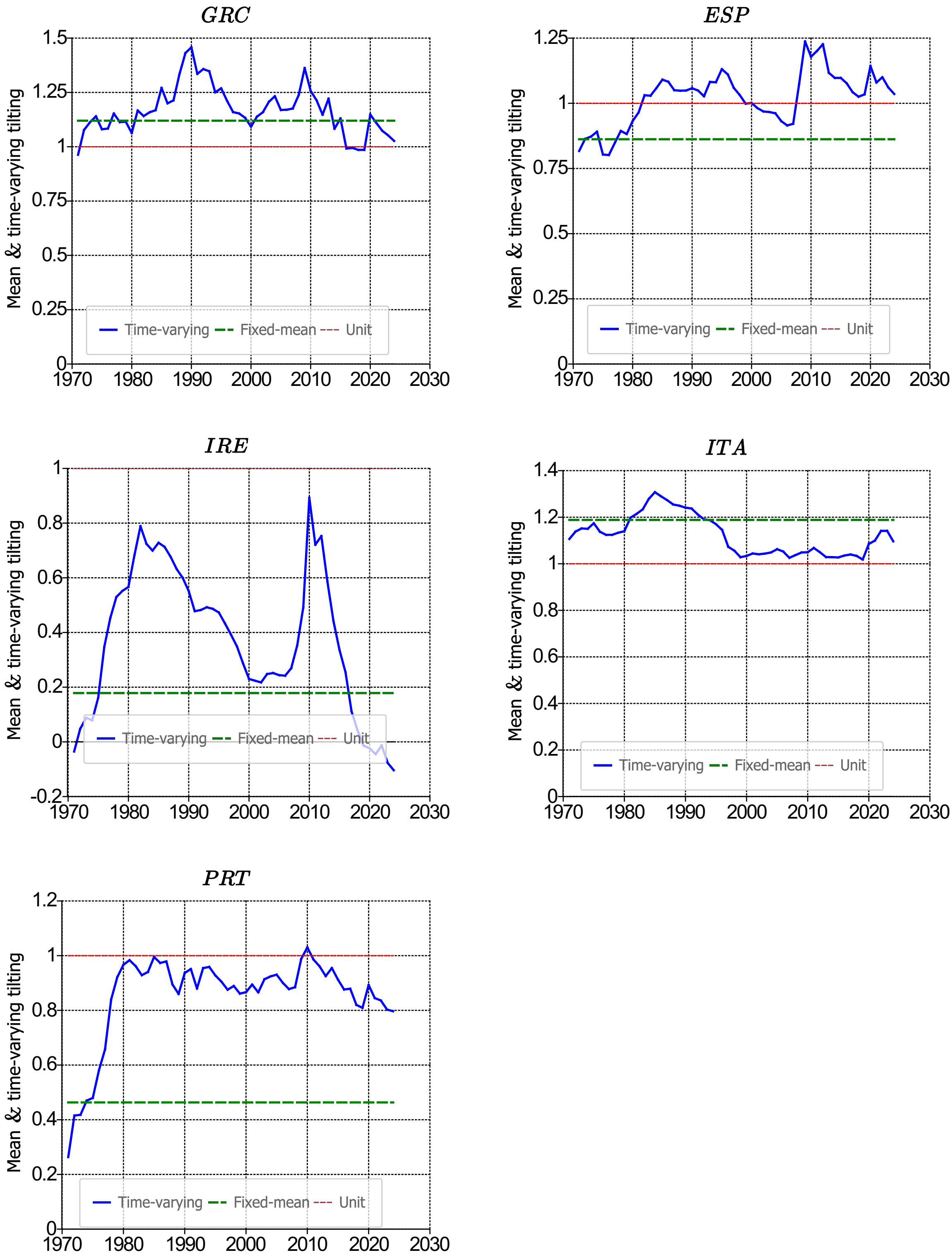

Figure 2 plots the estimated time-varying deviations of the country-specific coefficient around its mean implied by the mean-reverting transition equation. Core countries have a fixed-mean (green line) around 0.4 or below (Belgium, Germany, the Netherlands, Austria, and Ireland). France's mean is close to 0.6, but the trend of the time-varying parameter is worsening in the latter. Italy's mean is around 1.2 and Greece's is close to 1.2, but the trend of its time-varying parameter is decreasing in both. In the case of Spain, the fixed-mean is below 1 but has deteriorated steadily since the 1980s, when it crossed the value 1. After 2000, its value returned below 1, only to worsen again with the financial crisis. Portugal's mean is around 0.5, but the time-varying parameter has approached 1 since 1980. Following the financial crisis and subsequent bailout, the rate has been decreasing.

5.2 Additional hypotheses testing

As mentioned above, the choice of the model specification has been made using a sequential procedure relying on likelihood ratio tests, which led to the preferred specification (Model 3), where two control inputs in the transition equation (*odr* and *uwapr*) entered with common parameters.

We tested for additional restrictions on this preferred model to verify whether specific model components, such as time-varying dynamics or country-specific parameters, are essential to capture the tax-tilting behavior.

In the second part of Table 1, after the double horizontal line, we present the results.

The first hypothesis we test in Model 5 is whether all the control inputs in the transition equation, that is the lagged old dependence ratio and unemployment rate and the rate of growth for the former and the first difference of the latter, can be excluded from the model; jointly we also test that all the countries in the panel share the same variance. This would imply that only the autoregressive parameter *phi* explains the unobserved component $xi_{i,t+1}$. These restrictions are clearly rejected.

Next, we have tested (Model 6) for common parameters on the *yvar* and *gvar*, maintaining common parameters for the control inputs in the transition equation in our baseline model. The LR test rejects this hypothesis as well, which also includes a common variance.

In Model 7 of Table 1, we test whether we can impose a homogeneous tax-tilting parameter, i.e. that all countries share the same constant component for the tax-tilting parameter:

$$\theta_{i,t}^{-1} = \theta^{-1}, \tag{24}$$

and potentially homogeneous responses to business-cycle and government-spending fluctuations, as in our baseline model. If this hypothesis was fullfilled, the :

$$g_{it}^{tot} = \alpha_0 + \theta^{-1} \cdot \tau_{it} + \alpha_1 \cdot yvar_{i,t}^{tot} + \alpha_2 \cdot gvar_{i,t}^{tot} + \omega_{it}. \tag{25}$$

This restriction reduces parameter proliferation and tests the hypothesis that demographic and labor-market drivers of fiscal tilting are common structural features across the panel. According to the LR test, this hypothesis is rejected.

In Model 8, we consider a specification excluding the demographic and unemployment variables from the state equation but homogeneous responses to business-cycle and government-spending fluctuations:

$$\xi_{i,t+1} = \phi_i \cdot \xi_{i,t} + \upsilon_{it}, \tag{26}$$

which tests whether the inclusion of these control variables significantly improves the explanatory power of the model. This hypothesis is, again, clearly rejected.

A final hypothesis we test (Model 9), as an alternative to the autoregressive state process, consists of allowing the unobserved component to follow a random walk:

$$\xi_{i,t+1} = \xi_{i,t} + \upsilon_{it}, \tag{27}$$

which corresponds to setting $\phi_i = 1$ and excluding all control inputs from the transition equation. This specification tests whether the time variation in $\theta_{i,t}^{-1}$ is better captured by a driftless random component, as opposed to being systematically driven by demographic and labor-market factors.

The results of the implemented tests favor the chosen specification against these alternatives. In particular, they support idiosyncratic tax-tilting behavior among countries; the relevance of considering demographic factors and unemployment dynamics, as well as a highly persistent autoregressive parameter against a random walk.

5.3 Tilting, taxes and subjective time preferences

Given the estimated mean values of the tilting parameter θ_i and the observed values of the market discount factor Ψ_i, we can recover the implied subjective discount factor β_i for each country using the following relationship. Starting from the expression:

$$\theta = \frac{1 - \frac{\Psi}{\beta} \cdot \Psi}{1 - \Psi}, \tag{28}$$

we solve for β to obtain:

$$\beta = \frac{\Psi^2}{1 - \theta \cdot (1 - \Psi)} = \frac{\Psi^2}{1 - \theta + \theta \cdot \Psi}. \tag{29}$$

This formula links the government's subjective discount factor β to the estimated tilting parameter θ-which governs the intertemporal trade-off between taxes and expenditure-and the effective market discount factor Ψ, which incorporates observed interest and growth rates.

To illustrate, Table 3 presents country-level results for the year 2024. Based on the values in the first five columns (from i_t to γ_i), we compute the growth-adjusted interest rate ψ_i and the corresponding discount factor Ψ_i. These, together with country-specific estimates of the inverse tilting parameter θ^{-1}, allow us to derive both θ and the implied β for each country.

The tilting parameter θ captures the deviation from the benchmark of perfect tax smoothing. When $\theta = 1$, the government discounts the future at the same rate as the market, implying neutral intertemporal preferences and a flat tax path over time. If $\theta > 1$, the

Table 3: 2024 values for interest rate, GDP growth, effective interest rate, Ψ and θ .

	i_i	ν_i	π_i	r_i	γ_i	ψ_i	Ψ_i	θ_i^{-1}	θ_i
BEL	2.20%	3.84%	2.67%	-0.46%	1.14%	-1.59%	1.016	0.330	3.031
GER	1.70%	2.83%	2.95%	-1.21%	-0.11%	-1.10%	1.011	0.279	3.578
GRC	2.26%	5.68%	3.49%	-1.19%	2.12%	-3.24%	1.033	1.027	0.974
ESP	2.53%	6.11%	3.05%	-0.51%	2.97%	-3.37%	1.035	1.036	0.966
FRA	2.04%	3.38%	2.22%	-0.17%	1.14%	-1.29%	1.013	0.786	1.273
IRE	1.53%	2.73%	3.29%	-1.70%	-0.54%	-1.16%	1.012	-0.104	-9.636
ITA	2.96%	2.28%	1.60%	1.34%	0.67%	0.67%	0.993	1.096	0.912
NED	1.78%	5.92%	5.03%	-3.10%	0.84%	-3.91%	1.041	0.169	5.900
AUT	1.95%	3.58%	4.23%	-2.19%	-0.62%	-1.58%	1.016	0.470	2.126
PRT	2.22%	5.53%	3.82%	-1.54%	1.65%	-3.14%	1.032	0.797	1.255
FIN	1.66%	1.12%	1.40%	0.26%	-0.28%	0.54%	0.995	0.520	1.924

government is relatively more impatient than the market (i.e., $\beta < \Psi$): it places greater weight on present fiscal costs, leading to more front-loaded taxation and quicker adjustment. Conversely, when $\theta < 1$, the government is more patient than the market (i.e., $\beta > \Psi$), leading to a preference for delayed fiscal effort and greater reliance on future adjustments. These differences affect not only the timing of fiscal consolidation but also the intertemporal allocation of welfare and potential trade-offs between short-run economic stability and long-run sustainability.

We observe that for Greece, Spain, Italy, and Portugal, the estimated tilting parameter lies below unity ($\theta < 1$), indicating a preference for delaying tax adjustments relative to the tax-smoothing benchmark. This suggests a higher effective government discount factor compared to the market ($\beta > \Psi$), consistent with a more patient intertemporal fiscal stance. In contrast, although both Italy and Finland display market discount factors Ψ below one-indicating that real interest rates exceed output growth-their resulting tilting parameters diverge: in Italy, $\theta < 1$, reinforcing the tendency to back-load fiscal effort, whereas in Finland, $\theta > 1$, reflecting a more front-loaded approach and closer alignment with tax-smoothing principles.

To further interpret the implied government discount factor β, we decompose it to isolate the contributions of pure time preference and expected consumption growth. Adapting the Ramsey framework, we express the relationship as:

$$\frac{1}{1+\rho} = \frac{1+E[\eta]^{\alpha}}{1+\delta}, \tag{30}$$

which implies:

$$\frac{1}{1+\rho} = \beta \cdot (1+E[\eta]^{\alpha}). \tag{31}$$

This formulation links the pure rate of time preference ρ to the subjective discount factor β and the expected growth rate of consumption $E[\eta]$, raised to the elasticity of marginal utility α.

To implement this expression empirically, we adopt two standard assumptions applied uniformly across countries. First, we approximate $E[\eta]^{\alpha}$ using the geometric mean of real GDP growth, denoted γ, over the sample period. Second, we set $\alpha = 1$, corresponding to logarithmic utility-a conventional assumption in intertemporal macroeconomic modelling.[11]

Table 4 reports, for 2024, the estimated pure rates of time preference ρ_i, obtained by adjusting the subjective discount factors β_i for expected real GDP growth (γ_i) in line with the Ramsey framework. The results reveal marked cross-country heterogeneity in intertemporal fiscal preferences.

In **Belgium**, **Italy**, **Austria**, and **Finland**, ρ_i is close to zero (between 0.06% and 0.80%), indicating broadly neutral intertemporal preferences once growth expectations are incorporated. Governments in these countries neither strongly front-load nor postpone taxation relative to the tax-smoothing benchmark. **Germany** exhibits a moderately positive ρ (1.82%), suggesting a slight preference for present fiscal benefits, whereas **the Netherlands** stands out with a very high ρ (13.54%), consistent with a pronounced front-loading bias. Such elevated values may partly reflect optimistic long-run growth or productivity assumptions, given that the decomposition corrects β using γ_i.

[11] Liu (2012) extends the Ramsey (1928) framework to incorporate uncertainty in the pure rate of time preference.

By contrast, several economies show *negative* ρ_i values, indicating greater patience than implied by market interest rates. The most extreme cases are **Ireland** (-12.94%) and the southern EMU countries—**Greece**, **Spain**, and **Portugal**—with ρ_i between -3.95% and -6.27%. In these cases, governments place relatively more weight on the future than the market does, which—combined with low or negative effective interest rates—creates incentives to postpone tax increases. **France** also registers a moderately negative ρ (-2.06%), pointing in the same direction.

The magnitude of θ in these countries reinforces this interpretation. For **Greece** and **Spain**, $\theta < 1$ but close to unity, signalling a systematic delay in fiscal adjustment. In **Portugal**, by contrast, $\theta > 1$ despite a negative ρ, suggesting that other constraints or policy choices may drive a modest front-loading tendency. The extreme negative ρ in **Ireland** corresponds to a negative θ, which in practice signals a breakdown of the simple tilting logic—likely reflecting exceptional macroeconomic factors, such as volatile GDP data driven by multinational activity.

An interesting finding of the research is the different patterns observed when facing a negative effective interest rate on public debt (e.g., -2%). For some governments, the estimated value of $\theta^{-1} > 1$ (or $\theta < 1$) implies a government's subjective discount rate, which is also negative but higher (e.g., -2.5%). This implies that the government places more value on future outcomes than the market does and optimally chooses to postpone heavily tax increases. Expectations of stronger future fiscal capacity can justify such behavior, the desire to smooth tax distortions during periods of high current costs, or the low cost of debt rollover in a negative-rate environment. It may also reflect features of secular stagnation or dynamic inefficiency, where delaying taxes improves welfare. However, while such stances may be optimal in the short run, their persistence raises questions about the *credibility and sustainability* of long-term fiscal adjustment—particularly if underlying assumptions about growth or interest rates prove overly optimistic.

Table 5 summarises the combinations of market discount rates (ψ), government subjective discount factors (β), and the resulting tilting parameters (θ), along with the associated

Table 4: Values in 2024 of tilting, subjective discount factors and idiosyncratic rate of pure time preference, ρ.

	Ψ_i	θ_i^{-1}	θ_i	β_i	δ_i	γ_i	ρ_i
BEL	1.016	0.330	3.031	0.984	1.59%	1.14%	0.44%
GER	1.011	0.279	3.578	0.983	1.71%	-0.11%	1.82%
GRC	1.033	1.027	0.974	1.034	-3.32%	2.12%	-5.33%
ESP	1.035	1.036	0.966	1.036	-3.49%	2.97%	-6.27%
FRA	1.013	0.786	1.273	1.010	-0.95%	1.14%	-2.06%
IRE	1.012	-0.104	-9.636	1.155	-13.41%	-0.54%	-12.94%
ITA	0.993	1.096	0.912	0.993	0.73%	0.67%	0.06%
NED	1.041	0.169	5.900	0.873	14.49%	0.84%	13.54%
AUT	1.016	0.470	2.126	0.998	0.17%	-0.62%	0.80%
PRT	1.032	0.797	1.255	1.024	-2.36%	1.65%	-3.95%
FIN	0.995	0.520	1.924	1.000	0.04%	-0.28%	0.32%

Table 5: Values of ψ and β and implied values of β for θ.

Market rate ψ	β vs. $\frac{1}{1+\psi}$	θ	Interpretation	Cases
$\psi = \frac{1+r}{1+g} - 1$	$\beta = \frac{1}{1+\delta}$	$\theta = \frac{1-\frac{\Psi}{\beta}\cdot\Psi}{1-\Psi}$		
$\psi > 0$	$\beta < \frac{1}{1+\psi}$	$\theta < 1$	Postpone taxes to the future	ITA
$\psi > 0$	$\beta > \frac{1}{1+\psi}$	$\theta > 1$	Front-load taxes to the present	FIN
$\psi < 0$	$\beta < \frac{1}{1+\psi}$	$\theta > 1$	Front-load taxes to the present	IRE, BEL, DEU FRA, NED, AUT, PRT
$\psi < 0$	$\beta > \frac{1}{1+\psi}$	$\theta \ll 1$	Postpone taxes **heavily** very optimistic(?) government	– GRC, ESP,

fiscal behaviour across EMU countries.

Italy (ITA) is the only country in the sample where both the market rate ψ is positive and the implied government discount factor β is relatively low, leading to a tilting parameter $\theta < 1$. This configuration suggests a preference for deferring tax increases to the future, which may reflect either expectations of future fiscal capacity or an attempt to smooth tax distortions over time under persistently high debt ratios.

Finland (FIN), by contrast, also exhibits a positive ψ but with a high value of β, implying $\theta > 1$. This corresponds to front-loading of taxes, consistent with a more conservative fiscal stance and a stronger emphasis on intertemporal budgetary discipline. In this case, the government places relatively more weight on current consolidation efforts than on future adjustments.

The majority of the sample—including Ireland (IRE), Belgium (BEL), Germany (DEU), France (FRA), the Netherlands (NED), Portugal (POT) and Austria (AUT)—falls into the third category, where $\psi < 0$ and $\beta < \frac{1}{1+\psi}$, resulting in $\theta > 1$. Despite the presence of negative growth-adjusted interest rates, these governments exhibit a relatively impatient stance, opting to front-load taxes. This behaviour may reflect concerns about fiscal sustainability, institutional constraints, or a conservative interpretation of the non-Ponzi condition, even under favourable borrowing conditions.

The final group consists of Greece (GRC), and Spain (ESP), which combine negative ψ with relatively high β, yielding values of $\theta \ll 1$. These countries exhibit strong tax tilting toward the future, consistent with either optimistic expectations about future fiscal conditions or strategic delay in adjustment facilitated by negative effective interest rates. This behaviour results in an intertemporal profile where present taxation is low relative to future requirements, raising concerns about the long-term credibility of fiscal consolidation paths—especially in the event of a reversal in interest rate conditions or growth prospects.

Overall, the dispersion in θ across countries reflects meaningful differences in fiscal preferences and constraints. While some of the heterogeneity can be explained by differences in borrowing costs and growth expectations, the resulting fiscal paths highlight the challenges of achieving coordination and convergence in a monetary union with decentralised fiscal policies.

To complement the cross-sectional evidence, Figure 2 depicts the time-varying evolution of the key parameters $\beta_{i,t}$ and $\psi_{i,t}$ for all countries in our sample. The upper panel corresponds to the *core* EMU economies, while the lower panel focuses on the *peripheral* group. In the latter, both series almost coincide for most of the sample, suggesting that governments' intertemporal discounting behaviour is closely aligned with prevailing financial market conditions. This alignment points to a fiscal stance largely shaped by market constraints and incentives, potentially leaving limited room for autonomous, forward-looking policy decisions-an indication of possible political bias in tax-smoothing behaviour. By contrast, core economies display a more stable trajectory for $\beta_{i,t}$, less sensitive to short-term fluctuations in $\psi_{i,t}$. Sometimes, they even display a mirroring behaviour. These countries tend to leverage favourable market conditions not to increase indebtedness, but to accelerate debt repayment and strengthen fiscal positions, consistent with a more proactive and countercyclical approach to debt management.

Figure 2: Time-Varying tax-tilting parameters and effective interest rates. Core EMU Countries

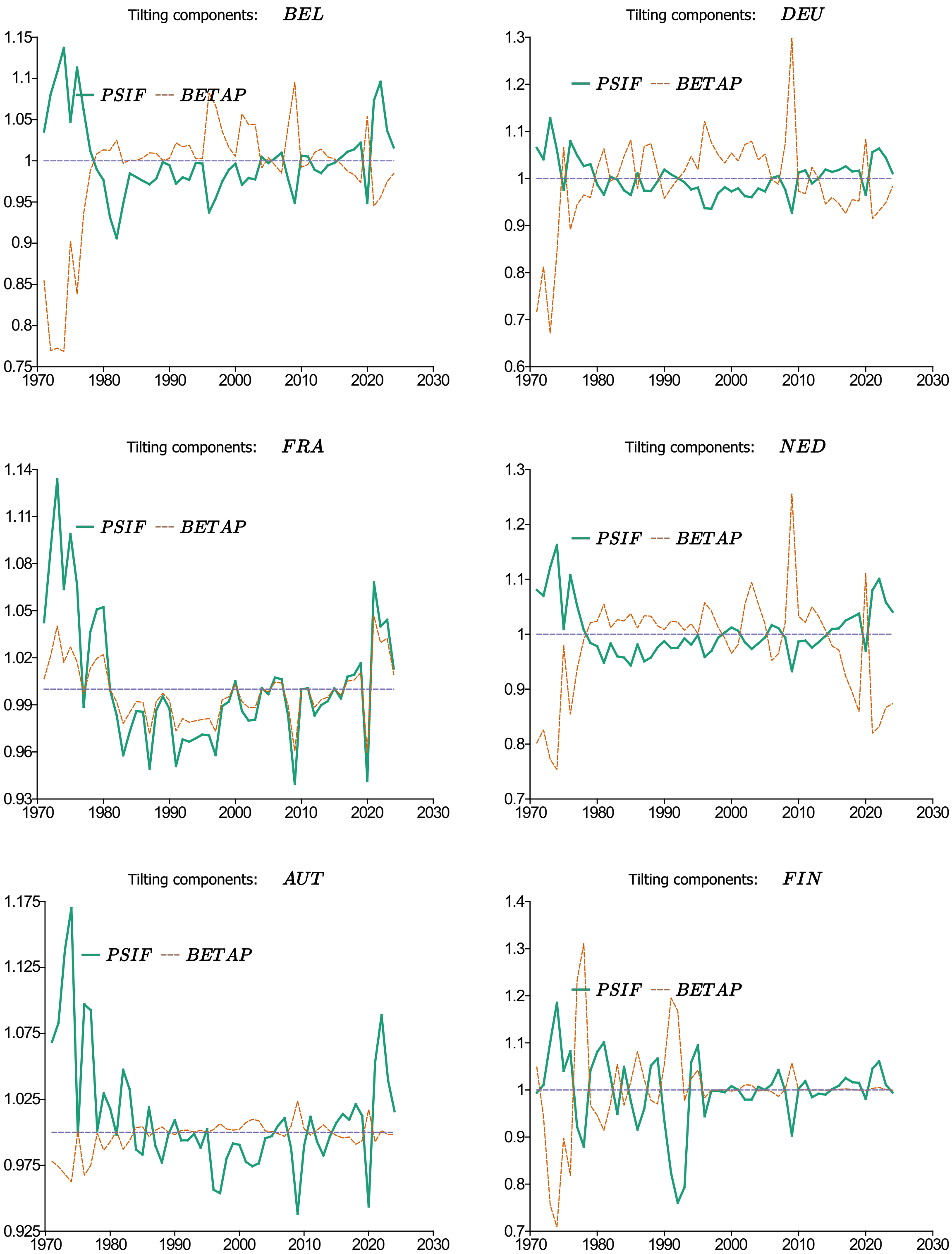

Figure 2: (continued). Peripheral EMU Countries

Overall, reducing the social, political, and demographic sources of heterogeneity documented here would facilitate debt mutualization and strengthen the institutional foundations for a future fiscal union in the Euro Area.

6 Conclusions

This paper employs a panel Time-Varying Parameter (TVP) state-space framework to estimate tax-tilting behavior across 11 European Monetary Union (EMU) member states. Our findings reveal substantial heterogeneity in intertemporal fiscal behavior, allowing countries to be grouped into two broad categories.

Several core EMU members, such as Austria, Belgium, Germany, the Netherlands, France, Ireland, and Finland, exhibit a relatively prudent fiscal stance, with tax tilting that supports intertemporal budget discipline. In contrast, peripheral countries, namely Greece, Italy, Portugal, and Spain, tend to tilt taxation toward the future ($\theta_{i,t}^{-1} > 1$), thereby incurring present fiscal deficits. This behavior reflects a preference for financing current expenditures by deferring tax efforts to future periods.

A central insight of our analysis is that such tax-tilting patterns are driven by a divergence between the government's subjective discount factor and the effective market discount factor used to value future tax revenues. Using a Ramsey framework, we estimate country-specific rates of pure time preference that shed light on the intertemporal decision-making behind observed fiscal trajectories.

We also identify important asymmetries in the impact of structural variables. The old-age dependency ratio, in particular, tends to exacerbate fiscal tilting in some countries, suggesting that demographic pressure undermines efforts to maintain intertemporal balance. Similarly, higher unemployment relative to the working-age population is associated with more pronounced deferral of tax obligations.

A particularly relevant macroeconomic context is the presence of persistently negative effective real interest rates $\left(\psi_t = \frac{1-i_t}{1+\nu_t} - 1\right)$, or equivalently an effective market factor $\left(\Psi_t = \frac{1}{1+\psi_t}\right)$ greater than one. In such a setting, the intertemporal government budget constraint (GIBC) relaxes, as the real value of public debt declines over time. This dynamic may allow governments to roll over debt and generate a net fiscal surplus without raising taxes, effectively acting as a "negative" tax burden.

Under these conditions, some governments appear to operate with a subjective discount factor $\beta > 1$, exceeding both unity and the market factor. This leads them to "anticipate this negative tax burden to the present", expanding current expenditure and worsening present deficits. When the "required taxes to meet the GIBC are negative", such behavior can be interpreted as the intertemporal valuation of future fiscal payoffs in a context where the marginal cost of postponing taxation is also negative.

These findings raise important considerations regarding long-term fiscal sustainability and the credibility of future policy adjustments. More broadly, they suggest that addressing the deep-rooted heterogeneities (be they social, political, or demographic) is essential for facilitating debt mutualization and advancing toward a more integrated fiscal union within the Euro Area. Convergence in fiscal behavior and preferences appears to be a necessary precondition for deeper economic integration among EMU member states.

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A Notation for variables employed

Table A.1: Key Variables, Parameters, and Data Sources

Symbol-Name	**Definition / Construction (ratios to nominal GDP unless otherwise stated)**	**Source**
A. Market Discount Parameters		
i_t	Nominal interest rate.	AMECO / ECB
ν_t	Nominal GDP growth rate.	AMECO
π_t	Inflation rate.	AMECO
r_t	Real interest rate.	Constructed
γ_t	Real GDP growth rate.	AMECO
ψ_t	Effective interest rate: $\psi_t = \frac{i_t - \nu_t}{1+\nu_t}$.	Constructed
Ψ_t	Growth-adjusted discount factor: $\Psi_t = \frac{1}{1+\psi_t}$.	Constructed
n_t	Population growth.	AMECO
B. Subjective Discount Parameters		
δ	Government subjective discount rate.	Assumed / Calibrated
β	Government discount factor: $\beta = \frac{1}{1+\delta} = \frac{1}{(1+\rho)(1+\eta)^{\alpha}}$.	Constructed
ρ	Government pure rate of time preference.	Calibrated
η	Consumption growth rate.	AMECO / Authors
α	Elasticity of marginal utility of consumption (absolute value).	Calibrated
θ	Tilting parameter: $\theta = \frac{1-\frac{\Psi_t}{\beta}\cdot\Psi_t}{1-\Psi_t}$.	Constructed
C. Fiscal Variables		
τ_t	Tax revenue to GDP ratio.	AMECO
g_t	Government expenditure (excluding interest) to GDP.	AMECO
g_t^{tot}	Total government expenditure including interest: $g_t + i_t b_{t-1}$.	Constructed
b_t	Gross public debt stock.	AMECO
bal_t	Primary balance (surplus) to GDP.	Constructed
def_t	Primary deficit to GDP. $def_t = -bal_t$.	Constructed
bal_t^{tot}	Total balance (surplus) to GDP.	Constructed

Continued on next page

Table A.1 – continued from previous page

Symbol-Name	Definition / Construction	Source
def_t^{tot}	Total deficit to GDP. $def_t^{tot} = -bal_t^{tot}$.	Constructed
D. Ageing and Social Variables		
odr_t	Old-age dependency ratio: $odr_t = \frac{pop^{65+}}{pop^{15-64}}$.	AMECO
u_t^{wap}	Unemployed to working-age population: $u_t^{wap} = \frac{pop^{u}}{pop^{15-64}}$.	OECD
ssc_t	Social security contributions to GDP.	OECD
ssc_t^{τ}	Social security contributions to total revenue.	OECD
ssg_t^{tot}	Total government social expenditure to GDP.	OECD
ssg_t^{pen}	Government pension expenditure to GDP.	OECD
ssg_t^{hth}	Government health expenditure to GDP.	OECD
ssg_t^{une}	Government unemployment expenditure to GDP.	OECD

B Tables and Additional Figures

Table B.1: Bai and Carrion-i-Silvestre (2009) structural Breaks, (1970 - 2024).

	$g_{i,t}^{tot}$	$\tau_{i,t}$	$g_{i,t}$	observations
BEL	1979	1981 1994		54
GER				54
GRC				54
ESP				54
FRA				54
IRE	1984	2010	2010	54
ITA	1982	1982	1981	54
NED	1983			54
AUT			1981	54
PRT		1980		54
FIN		1983 1992	1981 1992	54

Note: Bai and Carrion-i-Silvestre 2009 estimations, allowing for up to 3 breaks.

Table B.2: Bai and Carrion-i-Silvestre (2009) Panel Unit Root Test with common factors and structural breaks (1970-2024).

	Model 2. Trend Break Model									
	Test Statistics			**Simplif. tests Statics**						
	Z	P_m	P	Z	P_m	P	T	N	m	fr
$\tau_{i,t}$	-0.311	-0.594	18.061	0.342	-0.374	19.518	54	11	3	22
$g_{i,t}^{tot}$	1.766	-1.339	13.121	1.620	-1.879	9.538	54	11	3	22
$g_{i,t}$	0.334	-0.229	20.483	0.232	0.267	23.768	54	9	3	22

Notes: Z, P and Pm denote the test statistics proposed by Bai and Carrion-i-Silvestre (2009). Z and P_m follow a standard normal distribution and their 1%, 5% and 10% critical values are, -2.326, -1.645, -1.282, and 2.326, 1.645 1.282, respectively. P follows a Chi-squared distribution with 2N degrees of freedom with critical values *40.289, 33.924 and 30.813*, at 1%, 5% and 10% respectively). The number of common factors are estimated using the panel Bayesian information criterion proposed by Bai and Ng (2002). Z^*, P^* and P_m^* refer to the corresponding statistics obtained using the p-values of the simplified MSB statistics. The null hypothesis of a unit root is rejected at * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ significance level, respectively, if the statistic is greater than the upper level.

Figure B.1: Gen. Government. Tot Expenditure and revenue, ratios to GDP. Selected EMU Countries. 1970-2024.

Figure B.2: Old-age and Unemployed to Population 15-64 Ratio. Selected EMU Countries. 1970-2024.

Figure B.3: Public Social Expenditure: Total (% GDP). Selected EMU Countries. 1970-2024.

Figure B.4: YVAR and GVAR cycle measures. 1970-2024.

Figure B.5: GDP, interest rates and inflation. Selected EMU Countries. 1970-2024.