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POPULATION AGEING AND FISCAL RESPONSIVENESS TO PUBLIC DEBT

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ABSTRACT

This paper examines whether population ageing weakens governments' fiscal responsiveness to public debt and whether this relationship differs across economic and political environments. A simple political-economy model with overlapping generations shows that, because older cohorts expect to bear a smaller share of future debt-servicing costs, a rising old-age dependency ratio lowers the equilibrium response of the primary balance to inherited debt. We test this prediction with a fiscal reaction function for 62 advanced and developing economies over 1962–2024. Governments respond positively to rising debt, mainly through primary expenditure, and the response is weaker in more aged societies. With a constant debt coefficient, the ageing effect is imprecisely estimated, but Bayesian panel time-varying-parameter estimates, which absorb common changes in fiscal responsiveness over time, show that ageing clearly dampens the response: moving from the 25th to the 75th percentile of the old-age dependency ratio lowers it by about one third. The evidence comes mainly from OECD economies, where ageing is most advanced: the effect is present within the OECD sample, whereas it cannot be identified among non-OECD economies. Time-varying estimates for the components of the primary balance show that ageing weakens the response mainly through the expenditure side: more aged societies cut primary spending by less in response to debt, whereas the response of revenue is unaffected. The dampening effect is also more apparent in democratic economies, consistent with the proposed electoral mechanism.

Keywords: Fiscal policy; Fiscal sustainability; Population ageing; Public debt; Time-varying parameters

JEL: C11; C23; E62; H62; H63; J11

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1. Introduction

Public debt sustainability has emerged as a key concern of fiscal policy challenges of the twenty-first century, as successive global shocks over the past decades have pushed debt ratios to historically elevated levels across both advanced and developing economies. At the same time, demographic dynamics are undergoing profound changes. Declining fertility rates and increasing life expectancy are leading to a steady rise in the share of the elderly population, placing additional pressure on public finances if no timely and well-designed measures are adopted (see e.g., Van Groezen et al., 2005; Rogoff, 2022; Koutsogeorgopoulou and Morgavi, 2025). These fiscal pressures, stemming from the need to reinforce pension and healthcare systems in ageing societies, are also expected to entail higher emergency expenditures as well as sustained public investment in resilience and adaptation capacity (European Commission, 2024). The coexistence of high public debt and rapid population ageing raises fundamental questions about the ability of governments to sustain fiscal discipline over time. In particular, it challenges the widely documented empirical regularity that fiscal authorities respond to increases in public debt by improving primary balances, a key condition for long-run fiscal sustainability. Importantly, demographic change may affect fiscal adjustment not only by increasing expenditure pressures but also by altering the political incentives underlying fiscal decisions. Whether these incentives translate into weaker fiscal responsiveness may depend on countries' demographic structures and political environments, making the relationship between ageing and fiscal policy an important question for comparative political economy.

[***Figure 1 goes here***]

Figure 1 reports the evolution of old-age dependency and debt-to-GDP ratio for our sample of 62 countries over time. Several patterns emerge. First, population ageing is a pervasive and sustained trend, with the level of the old-age dependency ratio rising steadily in advanced economies. Second, public debt exhibits a pronounced upward shift, particularly since the 1980s, with substantial increases observed across the full sample and notable volatility across country groups. While advanced economies tend to exhibit higher and more volatile debt levels, developing economies also experience

a marked upward trend over time. Taken together, these patterns point to the growing coexistence of rising demographic pressures and elevated public debt burdens, which impact primarily advanced economies. This joint evolution suggests that the fiscal challenges associated with ageing are unlikely to be transitory and reinforce the need to examine whether governments' fiscal responses to debt remain effective in the presence of shifting demographic structures. This concern has also been emphasized in recent policy discussions. In particular, a recent report by the ECB (Moshammer, 2024) notes that public debt levels and primary deficits have reached historical highs, while additional pressures are expected to arise from demographic ageing and other structural challenges. In this context, the report highlights population ageing as a key source of long-term fiscal strain across Eurozone countries, reinforcing the importance of reassessing fiscal sustainability in light of demographic trends.

A large body of literature evaluates fiscal sustainability through the estimation of fiscal reaction functions, typically modeling the primary balance as a function of lagged public debt. Building on the seminal work of Bohn (1998, 2007, 2008) and Canzoneri et al. (2001), a positive response of the primary balance to public debt often is interpreted as evidence consistent with the satisfaction of the government's intertemporal budget constraint. This framework has been widely applied across different country groups and time periods (e.g., Mendoza and Ostry, 2008; Lee et al., 2018), generally finding support for a stabilizing fiscal response, albeit with considerable heterogeneity across countries. Despite its empirical success, this literature has largely abstracted from demographic factors, even though population ageing is widely recognized as a key driver of fiscal imbalances. As the share of the elderly population increases, governments face rising expenditures on pensions and healthcare, while at the same time the tax base may shrink due to a declining working-age population. These dynamics are expected to deteriorate fiscal balances and complicate debt stabilization efforts. A growing strand of research highlights the adverse effects of ageing on fiscal sustainability and pension systems, emphasizing the need for policy reforms such as increasing retirement ages, adjusting benefits, or improving system efficiency (Barr and Diamond, 2006; Bloom et al., 2010; Börsch-Supan et al., 2014). At the firm level, Zhang and Zhao (2022) provide evidence from China showing that population ageing increases pension contribution burdens on firms

through the channel of local government fiscal pressure, with the effect varying according to the structure of pension administration systems.

More recently, empirical studies have begun to explore the interaction between demographic change and fiscal outcomes in a nonlinear framework. Cho and Lee (2022), for instance, show that the response of the primary surplus to public debt varies with demographic conditions, with countries experiencing fiscal crises exhibiting a declining and even negative response as ageing intensifies. Similarly, Cho and Lee (2025) document that the adverse effects of population ageing on pension sustainability become significantly stronger in environments characterized by weak government effectiveness, highlighting the role of institutional quality in shaping fiscal outcomes. These findings suggest that demographic structure is not merely an exogenous background condition but a key factor influencing fiscal behavior and sustainability.

Nevertheless, there is still no systematic assessment of how population ageing affects fiscal responses to public debt in a broad cross-country setting. The closest studies to this article are those of Cho and Lee (2022, 2025). Our paper departs from them in five main dimensions. First, we provide a simple political-economy framework with overlapping generations in which the dampening effect of ageing on fiscal responsiveness is derived rather than assumed: older cohorts weigh future debt-servicing costs less heavily because they expect to bear a smaller share of them, and their political weight rises with the old-age dependency ratio. Second, we test this prediction in a large panel of advanced and developing economies within a standard fiscal reaction function, allowing the response of the primary balance to lagged debt to vary with the old-age dependency ratio. Third, we decompose the primary balance into its revenue and expenditure components to identify the side of the budget through which governments adjust to debt. Fourth, we show that accounting for common changes in fiscal responsiveness over time is essential for identifying the effect of ageing, using Bayesian panel time-varying-parameter models in which the response to debt follows a random walk common to all countries. Fifth, we examine the comparative political-economy implications of the proposed mechanism by investigating differences between OECD and non-OECD economies and across political regimes. In particular, we assess whether the relationship between ageing and fiscal responsiveness is more pronounced in democratic settings, where electoral accountability provides a channel through which demographic composition may influence fiscal policy.

We find that governments exhibit a statistically significant positive response of the primary balance to lagged public debt, consistent with fiscal sustainability conditions in the tradition of Bohn (1998), and that this adjustment takes place mainly through primary expenditure. The response is weaker in more aged societies. When the debt coefficient is held constant over 1962–2024, the interaction between debt and ageing is negative but imprecisely estimated. The debt coefficient, however, has risen over time, as has population ageing, and a constant-coefficient specification partly confounds the two. Once common changes in fiscal responsiveness are absorbed, either by interacting debt with year dummies or by modelling the debt coefficient as a random walk, the dampening effect of ageing becomes clear: the posterior probability that ageing weakens the response exceeds 0.98 in all specifications, and moving from the 25th to the 75th percentile of the old-age dependency ratio lowers the debt coefficient by about one third. The evidence comes mainly from OECD economies. Within the OECD sample the interaction is negative in every specification, with posterior probabilities of a negative effect between 0.91 and 0.94, and it is confirmed in an independent panel of OECD economies, whereas among non-OECD economies, where ageing is less advanced, it is not identified. Because part of the full-sample estimate reflects differences between the two groups, the effect within the OECD is about half as large as in the full sample. Time-varying estimates of the spending and revenue equations show that this dampening effect operates almost entirely through the expenditure side: in more aged societies governments cut primary spending by less in response to higher debt, with posterior probabilities above 0.95 in all Bayesian specifications, whereas the interaction between debt and ageing in the revenue equation is close to zero. Finally, we examine whether political institutions condition the relationship between ageing and fiscal responsiveness. The dampening effect is concentrated in more democratic economies, whereas it is close to zero in less democratic settings. Although the estimated difference across political regimes is not sufficiently precise to establish institutional heterogeneity conclusively, the pattern is consistent with the electoral mechanism highlighted by the theoretical framework. Taken together, these findings suggest that demographic composition and political institutions may jointly shape fiscal adjustment incentives, with important implications for understanding differences in fiscal behaviour across countries.

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework. Section 3 describes the data and the empirical methodology. Section 4 presents the baseline results and some robustness checks. Section 5 reports the Bayesian time-varying estimates, a robustness analysis for OECD and non-OECD economies, time-varying estimates for primary spending and revenue, Section 6 examines the role of democracy and Section 7 the role of the interest–growth differential. Section 8 concludes.

2. Sketch of a Theoretical framework

This section develops a parsimonious political-economy framework that motivates the augmented fiscal reaction function estimated in Section 3. The aim is not a complete structural model of fiscal policy, but a simple mechanism through which population ageing affects how strongly the primary balance responds to inherited debt.

The framework combines the fiscal reaction function approach to debt sustainability (Bohn, 1998; Ghosh et al., 2013; Mauro et al., 2015) with the political economy of population ageing (Razin et al., 2002; Galasso and Profeta, 2002; Busemeyer et al., 2009). The mechanism is intergenerational. Younger and older households differ in the horizon over which they expect to bear the future cost of current public debt. As ageing raises the political weight of older cohorts, the equilibrium fiscal response to inherited debt weakens.

2.1 Demographics and fiscal preferences

Two cohorts coexist at each date t: young households (workers) and old households (retirees). The mass of the young is normalised to one and the mass of the old is $a_t > 0$, so that a_t is the old-age dependency ratio. Public debt relative to output evolves according to

$$b_t = R_t\, b_{t-1} - pb_t, \qquad R_t \equiv 1 + r_t - g_t \qquad (1)$$

where b_{t-1} is inherited debt, pb_t is the primary balance, and $r_t - g_t$ is the interest–growth differential, taken as given by policymakers.

Cohort $j \in \{Y, O\}$ evaluates fiscal policy according to

$$L^j(pb_t) = 1/2\left(pb_t - \bar{p}_j\right)^2 + 1/2\ \theta_j\, b_t^2 \qquad (2)$$

where $\bar{p}_j$ is the primary balance cohort j would prefer in the absence of debt considerations. Differences in $\bar{p}_j$ capture preferences over current taxation and spending. A stronger preference of older households for pensions, health care and other age-related spending implies $\bar{p}_O < \bar{p}_Y$ (Razin et al., 2002; Busemeyer et al., 2009). The second term is the expected cost of the future adjustment needed to service the debt carried into the next period, and $\theta_j \geq 0$ is the weight cohort j attaches to that burden. Young households bear the future adjustment with certainty, whereas old households bear it only with survival probability π (Yaari, 1965; Blanchard, 1985):

$$\theta_O = \pi\,\theta_Y, \qquad \theta_Y > 0, \qquad \pi \in [0,1) \qquad (3)$$

More broadly, π also captures the extent to which older households internalise burdens falling on their descendants (Barro, 1974). The mechanism therefore does not require the elderly to be myopic or indifferent to debt sustainability; it requires only that their effective horizon be shorter than that of the young. Minimizing (2) subject to (1) gives the preferred primary balance of cohort j (Appendix A.1):

$$pb_t^j = \frac{\bar{p}_j}{1+\theta_j} + \beta_j\, b_{t-1}, \qquad \beta_j = \frac{R_t\,\theta_j}{1+\theta_j} \qquad (4)$$

Since β_j is increasing in θ_j, conditions (3)–(4) imply, for $R_t > 0$,

$$\beta_Y > \beta_O \geq 0 \qquad (5)$$

Both cohorts may favour adjustment when debt rises, but the young prefer a stronger response. This ranking is derived from differences in effective horizons rather than imposed.

2.2 Political equilibrium

Fiscal policy is determined through probabilistic voting (Lindbeck and Weibull, 1987; Persson and Tabellini, 2000). Electoral competition leads parties to minimize the politically weighted loss:

$$\Omega(pb_t) = [1-\mu(a_t)]L^Y(pb_t) + \mu(a_t)\,L^O(pb_t), \qquad \mu'(a_t) > 0 \qquad (6)$$

where $\mu(a_t)$ is the political weight of older households (Appendix A.2). This weight need not equal their population share: higher turnout or greater electoral

responsiveness can amplify their influence (Mulligan and Sala-i-Martin, 1999). The results require only that ageing raises it. Minimizing (6) subject to (1) gives the equilibrium fiscal reaction function (Appendix A.3)

$$pb_t^* = A(a_t) + B(a_t, R_t)\, b_{t-1} \qquad (7)$$

With:

$$A(a_t) = \frac{\bar{p}(a_t)}{1 + \bar{\theta}(a_t)}, \qquad B(a_t, R_t) = \frac{R_t\, \bar{\theta}(a_t)}{1 + \bar{\theta}(a_t)} \qquad (8)$$

where $\bar{\theta}(a_t) = [1 - \mu(a_t)]\theta_Y + \mu(a_t)\, \theta_O$ is the politically weighted concern with future debt and $\bar{p}(a_t) = [1 - \mu(a_t)]\bar{p}_Y + \mu(a_t)\, \bar{p}_O$ the politically weighted debt-free primary balance. Because the losses are quadratic, this aggregation is exact. Since $\theta_O < \theta_Y$ and $\mu'(a_t) > 0$,

$$\bar{\theta}'(a_t) = \mu'(a_t)(\theta_O - \theta_Y) < 0 \qquad (9)$$

2.3 Theoretical predictions

Proposition 1 (Positive fiscal responsiveness). For $R_t > 0$, the equilibrium primary balance responds positively to inherited debt:

$$\frac{\partial pb_t^*}{\partial b_{t-1}} = B(a_t, R_t) > 0 \qquad (10)$$

The model therefore delivers the positive response emphasized by Bohn (1998), which is sufficient for sustainability. The resulting debt dynamics also depend on the interest–growth differential and are not determined by the reaction coefficient alone.

Proposition 2 (Ageing weakens fiscal responsiveness). The response of the primary balance to inherited debt declines as the population ages:

$$\frac{\partial B(a_t, R_t)}{\partial a_t} = -\frac{R_t\, \mu'(a_t)\, (1 - \pi)\, \theta_Y}{[1 + \bar{\theta}(a_t)]^2} < 0 \qquad (11)$$

Ageing shifts political influence towards households with shorter effective horizons, lowering the weight placed on future debt-servicing costs. Policy may continue to respond positively to debt, but less strongly. The result does not require the

old to place zero weight on future burdens; it disappears only when the two horizons coincide ($\pi \to 1$). This is the central prediction taken to the data. Ageing can also shift the intercept $A(a_t)$. The sign of this level effect depends on the relative magnitudes of the cohorts' preferred debt-free balances and of their weights on future debt and is not determined by the model. The empirical analysis therefore focuses on the sharper prediction concerning the response to debt.

2.4 Empirical specification

Allowing for cross-country heterogeneity, common shocks and the standard determinants of fiscal policy, equation (7) becomes:

$$pb_{it} = \alpha_i + \lambda_t + A(a_{it}) + B(a_{it})\, b_{i,t-1} + X_{i,t-1}'\eta + \varepsilon_{it} \qquad (12)$$

where α_i and λ_t are country and time effects, $X_{i,t-1}$ contains the usual controls, and $B(\cdot)$ is evaluated at the sample-mean interest–growth differential. A first-order approximation around the sample-mean dependency ratio $\bar{a}$, with $\tilde{a}_{it} \equiv a_{it} - \bar{a}$, gives (Appendix A.5):

$$pb_{it} = \alpha_i + \lambda_t + \beta\, b_{i,t-1} + \gamma\, \tilde{a}_{it} + \delta\big(b_{i,t-1} \times \tilde{a}_{it}\big) + X_{i,t-1}'\eta + \varepsilon_{it} \qquad (13)$$

Where:

$$\beta = B(\bar{a}) > 0, \qquad \delta = B'(\bar{a}) < 0, \qquad \gamma = A'(\bar{a}) \gtrless 0 \qquad (14)$$

Centering the dependency ratio makes β the response to debt at average ageing rather than at the empirically irrelevant value $a_{it} = 0$. The interaction coefficient δ is the empirical counterpart of Proposition 2. Equation (8) also implies that the response to debt shifts over time with the interest–growth differential and, more generally, with common factors that affect the cost of carrying debt forward. Section 5 therefore relaxes the assumption of a constant β, allowing the debt coefficient to vary over time so that δ is identified from differences in ageing across countries observed in the same year. The framework is agnostic about which component of the primary balance adjusts. Demographic pressures may operate mainly through primary expenditure, since pensions and health spending are age-related and politically hard to adjust, but the model does not impose this. Expenditure and revenue responses are therefore examined separately as an empirical question.

The framework is deliberately parsimonious and partial equilibrium. The interest–growth differential is exogenous, and the model abstracts from strategic debt accumulation and endogenous risk premia. Richer politico-economic models incorporate these mechanisms and share the insight that fiscal discipline originates with the cohorts that bear future costs (Cukierman and Meltzer, 1989; Alesina and Tabellini, 1990; Tabellini, 1991; Song et al., 2012). The simpler structure suffices here: it provides a transparent foundation for the debt–ageing interaction and maps directly into the fiscal reaction function estimated below.

3. Data and empirical strategy

3.1 Description of data

We use a yearly unbalanced panel data set from 1960 to 2024 of 62 countries[1]; 31 advanced and 31 developing economies. The macroeconomic variables are taken from the IMF World Economic Outlook, while data for old-age dependency ratio are taken from the World Bank. Table 1 shows the descriptive statistics of the variables used in our analysis.

[***Table 1 goes here***]

3.2 Empirical strategy

3.2.1 Baseline specification

To empirically assess fiscal responsiveness and following the seminal work of Bohn (1998), Canzoneri et al. (2001) and Mauro et al. (2015), we estimate a standard fiscal reaction function in which the primary balance responds to lagged public debt:

$$pb_{it} = \alpha_i + \lambda_t + \beta\, b_{it-1} + \rho\, pb_{it-1} + \eta X_{it-1} + \varepsilon_{it} \quad (15)$$

[1] Argentina, Australia, Austria, Belgium, Bosnia and Herzegovina, Brazil, Canada, Chile, China, Croatia, Cyprus, Czech Republic, Denmark, Ethiopia, Fiji, Finland, France, Germany, Ghana, Greece, Hong Kong SAR, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Kyrgyz Republic, Luxembourg, Malaysia, Maldives, Mexico, Moldova, Morocco, Namibia, Netherlands, New Zealand, Norway, Pakistan, Panama, Philippines, Poland, Portugal, Romania, Russia, Seychelles, Slovak Republic, Slovenia, Solomon Islands, South Africa, Spain, Sweden, Switzerland, Tanzania, Thailand, Türkiye, United Kingdom, United States and Vanuatu.

where pb_{it} denotes the primary balance (as a share of GDP) in country $i$and year t, and $b_{it-1}$is the lagged public debt-to-GDP ratio. Lagged public debt is used to mitigate simultaneity concerns, as fiscal policy decisions in period t are unlikely to affect debt contemporaneously. Country fixed effects α_i control for time-invariant heterogeneity across countries, time fixed effects λ_t capture global shocks common to all countries, while lagged dependent variable pb_{it-1} is included to capture persistence in the primary balance, reflecting fiscal inertia and the gradual adjustment of fiscal policy over time. X_{it-1} is a vector of control variables, which includes the lagged values of real GDP growth rate, inflation rate (based on GDP deflator) and real long-term interest rates to ensure that the estimated relationship between debt, ageing, and primary balance is not driven by macroeconomic conditions. The control variables are included with one lag to mitigate endogeneity and reverse causality, ensuring that economic conditions temporally precede fiscal policy decisions.

A positive coefficient β indicates that governments improve their primary balance in response to higher public debt, consistent with fiscal sustainability. However, we have to acknowledge that a positive coefficient β is sufficient but not a necessary condition for satisfying the intertemporal budget constraint (see Bohn, 2008; Mendoza and Ostry, 2008).[2] This framework implicitly assumes that fiscal responsiveness is stable across time and countries. However, structural factors, such as demographic change, may systematically affect governments' ability and incentives to adjust fiscal policy.

To this end, to examine whether population ageing affects fiscal responsiveness, we augment equation (15) by interacting debt with a measure of demographic structure, i.e. the old-age dependency ratio:

$$pb_{it} = \alpha_i + \lambda_t + \beta\, b_{it-1} + \gamma\, a_{it} + \delta(b_{it-1} * a_{it}) + \rho\, pb_{it-1} + \eta X_{it-1} + \varepsilon_{it} \quad (16)$$

where a_{it} denotes the degree of population ageing, as proxied by the old-age dependency ratio. The coefficient δ captures how ageing modifies the response of the primary balance to debt. Consistent with the theoretical framework, we expect:

[2] For instance, within a finite sample, a government may postpone its response to increasing debt levels for a number of years and still ultimately satisfy the transversality condition by adjusting its primary balance at a later stage. Conversely, the existence of a positive and statistically significant coefficient βdoes not ensure that the government will honor its intertemporal budget constraint over an infinite horizon.

$$\delta < 0$$

implying that higher levels of population ageing weaken the fiscal response of the primary balance to public debt. From equation (16), the marginal effect of public debt on the primary balance is given by:

$$\frac{\partial pb_{it}}{\partial b_{it-1}} = \beta + \delta a_{it}$$

This expression shows that fiscal responsiveness varies systematically with demographic structure. Hence, if $\delta < 0$, population ageing reduces fiscal responsiveness.

Equation (16) is the empirical counterpart of equation (13) in Section 2. Centering the old-age dependency ratio at its sample mean leaves the interaction coefficient unchanged and only shifts the coefficient on debt, which in equation (16) measures the response at a zero old-age dependency ratio; the marginal effects reported below evaluate it at empirically relevant values.

3.2.2 Primary balance decomposition

The baseline specification, i.e. equation (16), focuses on the primary balance as the dependent variable, thereby capturing the overall fiscal response to public debt. However, the primary balance is a composite measure, reflecting the joint evolution of total public revenues and government primary expenditures, which may respond differently to both debt dynamics and demographic pressures. To better identify the underlying fiscal adjustment mechanisms, we decompose the primary balance into its main components and re-estimate equation (16) using primary spending (equation 17) and total revenues (equation 18) as alternative dependent variables. This approach allows us to assess whether the impact of population ageing on fiscal responsiveness operates predominantly through the expenditure side, the revenue side, or a combination of both, thus providing a more nuanced understanding of how governments adjust their fiscal policy in the presence of rising debt and demographic change. To this end, we estimate:

$$ps_{it} = \alpha_i + \lambda_t + \beta\, b_{it-1} + \gamma\, a_{it} + \delta(b_{it-1} * a_{it}) + \rho\, ps_{it-1} + \eta X_{it-1} + \varepsilon_{it} \quad (17)$$

$$rev_{it} = \alpha_i + \lambda_t + \beta\, b_{it-1} + \gamma\, a_{it} + \delta(b_{it-1} * a_{it}) + \rho\, rev_{it-1} + \eta X_{it-1} + \varepsilon_{it} \quad (18)$$

In all regression specifications, we retain the same set of control variables as in equation (16), ensuring consistency in the empirical framework and comparability of results. However, in equation (17), where the dependent variable is primary spending, we additionally include total revenues as a control variable. This is done to account for contemporaneous revenue conditions, which may mechanically constrain or enable expenditure decisions and thus help isolate the discretionary component of government spending. In addition, in equation (18), where the dependent variable is total revenues, we include total government spending as an additional control variable. This allows us to account for the scale of government activity, thereby capturing the fiscal environment in which revenue mobilization takes place and improving the identification of revenue-side adjustments independently of overall government size.

Equations (16) – (18) are estimated using OLS estimator with country and time fixed effects with Driscoll–Kraay standard errors to account for potential heterogeneity, cross-sectional dependence and serial correlation. In Section 5.4 we also estimate equations (17) and (18) with the time-varying-parameter models of Section 5.1.

4. Empirical findings

4.1 Baseline findings

Table 2 reports the results of equations (16) – (18), which examine the impact of public debt and population ageing on fiscal policy outcomes, distinguishing between the primary balance, primary spending, and total revenues. Across all specifications, the estimated model includes a standard set of macroeconomic controls widely used in the fiscal reaction literature, ensuring consistency with existing empirical work (e.g., Bohn, 1998; Bohn, 2008; Mauro et al., 2015). The inclusion of lagged dependent variables accounts for persistence in fiscal outcomes, reflecting gradual adjustment processes and institutional inertia commonly documented in the literature. As shown in Table 2, this persistence is strongly supported by the data, as the lagged dependent variables are positive and highly statistically significant across all three specifications, indicating a robust degree of inertia in fiscal behaviour regardless of the outcome variable considered.

As regards the control variables, real GDP growth is positive and statistically significant in columns (1) and (3), indicating that higher economic activity is associated with increases in primary surpluses and total revenues. This result is consistent with countercyclical fiscal behaviour, whereby improved macroeconomic conditions strengthen the fiscal position through both automatic stabilizers and higher tax bases, which is consistent with Barro (1979). In addition, higher inflation is associated with an improvement in the primary balance (see column 1), while increased total revenues are associated with higher primary spending (see column 2) and a larger government size, as proxied by total expenditure, is associated with higher total revenues (see column 3). This positive co-movement between revenues and expenditures is consistent with the fiscal synchronization hypothesis (e.g., Musgrave, 1966; Meltzer and Richard, 1981), whereby changes in one side of the budget are accompanied by adjustments in the other.

Turning to the variables of interest, the results indicate a positive and statistically significant response of the primary balance to lagged debt, consistent with the existence of fiscal adjustment behaviour (see column 1). This adjustment appears to be primarily driven by primary expenditure reductions, as reported in column (2), where higher lagged debt is associated with a statistically significant decline in primary spending, while the response of revenues is small and statistically insignificant (column 3). The old-age dependency ratio itself is negative and statistically significantly associated with the primary balance, whereas it is positively and significantly associated with primary spending, suggesting that population ageing is linked to lower primary balances or higher primary expenditure. The interaction between debt and ageing in column (1) is negative and statistically significant, implying that the response of the primary balance to debt weakens as societies age. The marginal effects evaluated at the 25th, 50th and 75th percentiles of the old-age dependency distribution declined from 0.022 to 0.018 and remain statistically significant, although the differences between them are not. Section 5.2 shows that this imprecision largely reflects the restriction that the debt coefficient is constant over time.

Columns (2) and (3) provide further insight into the adjustment mechanisms. In the primary spending equation, the interaction between debt and ageing is positive, consistent with a smaller expenditure cut in response to debt in more aged societies, while in the revenue equation it is close to zero; neither coefficient is statistically

significant. The evidence therefore indicates that fiscal adjustment to debt operates mainly through the expenditure side, but it does not allow us to attribute the weaker response in ageing societies to a specific side of the budget with precision. Section 5.4 shows that, once common changes in fiscal responsiveness over time are absorbed, the weaker response in more aged societies can be attributed to the expenditure side.

[***Table 2 goes here***]

4.1.1 Robustness checks

4.1.1.1 Addressing endogeneity concerns

A potential concern with the baseline specification is the presence of endogeneity, which may stem from reverse causality between fiscal policy and debt dynamics, omitted variables that simultaneously affect both, as well as measurement error in key variables, particularly debt and its interaction with population ageing. To further strengthen the identification strategy and assess the robustness of the estimated relationship, we complement the baseline analysis with an IV approach.[3] In line with the seminal work of Fatás and Mihov (2003), we instrument lagged debt and its interaction with the old-age dependency ratio using their second and third lags. The identification strategy rests on the assumption that deeper lags of debt are strongly correlated with current debt dynamics, satisfying the relevance condition, while being plausibly exogenous to contemporaneous fiscal shocks affecting the primary balance. By exploiting predetermined variation in public debt, this approach seeks to mitigate potential endogeneity biases.

The validity of this strategy is supported by the diagnostic tests reported in Table 3. The Kleibergen–Paap rk LM statistics strongly reject the null of underidentification across all specifications, indicating that the instruments are sufficiently correlated with the endogenous regressors. Moreover, the Kleibergen–Paap rk Wald F statistics exceed conventional thresholds, alleviating concerns about weak instruments. The Hansen J test fails to reject the null hypothesis of instrument validity in most specifications,

[3] The use of System GMM is not pursued in this context, as the Nickell bias becomes negligible when T is large. With N = 62 and T = 64, our panel satisfies T > N, rendering the small-T asymptotic bias that motivates System GMM estimation inconsequential.

providing further support for the empirical adequacy of the instrument set, conditional on the identifying assumptions.

Importantly, the IV estimates corroborate the baseline findings. The response of the primary balance to debt remains positive and statistically significant, while the interaction term continues to indicate a weakening of fiscal responsiveness in more aged societies. The marginal effects confirm a declining response of the primary balance to debt as the old-age dependency ratio increases. Consistent with the baseline results, this effect appears to operate primarily through the expenditure side, as higher debt is associated with reductions in primary spending, whereas the revenue response remains muted. Overall, these findings reinforce the robustness of the baseline results and provide additional evidence consistent with an adverse effect of population ageing on governments' fiscal responsiveness to public debt.

[***Table 3 goes here***]

4.1.1.2 Excluding high debt countries

As an additional robustness check, we assess whether the baseline results are driven by countries with very high levels of public debt. This concern is particularly relevant given the extensive literature suggesting that fiscal behaviour and macroeconomic dynamics may differ in the upper tail of the debt distribution, with potential non-linearities or threshold effects at high debt levels (e.g., Reinhart and Rogoff, 2010). Even though the existence and exact location of such thresholds remain debated, there is broad agreement that high-debt episodes may be associated with distinct fiscal responses and stronger market discipline, raising the possibility that they disproportionately influence estimated fiscal reaction functions (Égert, 2015). To address this issue, we trim our sample by excluding observations in the top 5 percent of the debt distribution, that is, country-year observations with a debt-to-GDP ratio above 114.6 percent. This approach allows us to abstract from extreme debt episodes and examine whether our findings are representative of the bulk of the sample rather than being driven by high-debt outliers.

The results are reported in Table 4. Notably, the main findings remain qualitatively unchanged. The response of the primary balance to debt remains positive and statistically significant, while the interaction between debt and population ageing

continues to indicate a weakening of fiscal responsiveness in more aged societies. The marginal effects confirm a declining response of the primary balance to debt as the old-age dependency ratio increases, consistent with the baseline estimates. At the same time, the decomposition analysis indicates that it is both the expenditure and the revenue sides that are impacted by ageing. Overall, these results suggest that our findings are not driven by extreme high-debt observations but instead reflect a more general empirical pattern across countries.

[***Table 4 goes here***]

5. Bayesian time varying estimates

5.1 Time-varying fiscal responsiveness: framework

The specifications in Section 3 impose a debt coefficient β that is constant over 1962–2024. Two considerations suggest that this restriction matters for the estimate of the ageing interaction. First, the theoretical framework implies that the response to debt depends not only on ageing but also on the interest–growth differential, $B(a_t, R_t)$ in equation (8), and more generally on common factors that have shifted fiscal behaviour over time, such as the adoption of fiscal rules, changes in monetary regimes and financial crises (Mauro et al., 2015). Second, the old-age dependency ratio trends upwards in almost every country of the sample. If the common component of fiscal responsiveness has also changed over time, a specification with a constant β partly attributes this common drift to the interaction between debt and ageing. We therefore allow the debt coefficient to vary over time and estimate two Bayesian panel time-varying-parameter models.

In the first model (Model A), the coefficient on lagged debt follows a random walk that is common to all countries, while the ageing interaction is constant:

$$pb_{it} = \alpha_i + \lambda_t + \beta_t\, b_{i,t-1} + \delta\left(b_{i,t-1} \times \tilde{a}_{it}\right) + \gamma\, \tilde{a}_{it} + \rho\, pb_{i,t-1} + X_{i,t-1}'\eta + \varepsilon_{it}, \qquad \varepsilon_{it} \sim N(0, \sigma^2) \tag{19}$$

$$\beta_t = \beta_{t-1} + u_t, \qquad u_t \sim N\left(0, q_\beta\right) \tag{20}$$

where $\tilde{a}_{it}$ is the old-age dependency ratio centred at its sample mean and the remaining notation follows equation (16). Random-walk coefficients are the standard way of modelling gradual changes in macroeconomic behaviour (Cogley and Sargent, 2005; Primiceri, 2005). Because the year effects λ_t absorb common shifts in the level of the primary balance and β_t absorbs common shifts in its response to debt, δ is identified solely from differences in ageing across countries observed in the same year. Model A therefore provides a direct test of Proposition 2 that is robust to any common time variation in fiscal responsiveness. In the second model (Model B), the ageing interaction is also allowed to drift:

$$\delta_t = \delta_{t-1} + v_t, \qquad v_t \sim N(0, q_\delta) \qquad (21)$$

with v_t independent of u_t, and δ in equation (19) replaced by δ_t. Model B asks whether the dampening effect of ageing has itself changed over time. Since δ_t is identified from the cross-section of at most 62 countries for each year, year-specific estimates are necessarily imprecise. We therefore summarise them by their time average, $\bar{\delta} = T^{-1}\sum_t \delta_t$, computed draw by draw over the years in which at least 20 countries are observed.

Both models are estimated with a Gibbs sampler. Conditional on the path of the time-varying coefficients, the country and year effects and the remaining coefficients have a Gaussian full conditional distribution. Conditional on these, the path of β_t (and δ_t) is drawn by forward filtering and backward sampling (Carter and Kohn, 1994; Frühwirth-Schnatter, 1994), with all countries observed in a given year entering the measurement update jointly. The variances σ^2, q_β and q_δ have inverse-gamma full conditionals. To improve mixing, the regressors with time-varying coefficients are demeaned by year and standardised before sampling; given the year effects this leaves the model unchanged, and all results are reported in the original units. Priors are weakly informative: $N(0, 10^4)$ for the static coefficients and fixed effects, $N(0{,}100)$ for the initial states (in standardised units) and $IG(2{,}1)$ for σ^2. The innovation variances follow $IG(3, b_q)$, with b_q chosen so that the prior mean of q equals $(\kappa s)^2$, where s is the absolute value of the corresponding pooled coefficient, or twice its standard error if larger. Because the variance of random-walk innovations is weakly identified and tends to pile up at zero (Stock and Watson, 1998), we set $\kappa = 0.10$ in the baseline and report results for $\kappa = 0.05$ and $\kappa = 0.20$. We run three independent chains of 15,000

iterations, discard the first 3,000 and keep every second draw, which leaves 18,000 posterior draws. The Gelman and Rubin (1992) statistic is below 1.002 for every parameter and year, and the effective sample size (Geyer, 1992) exceeds 1,600 throughout.

As a simple frequentist counterpart, we also re-estimate equation (16) allowing the debt coefficient to differ by decade and by year, by interacting lagged debt with decade and year dummies.

5.2 Results

Table 5 compares the interaction of ageing across specifications. Column (1) reproduces the baseline estimate of Table 2, in which δ is negative and significant only at the 10% level (-0.000290, Driscoll–Kraay standard error 0.000174). Allowing the debt coefficient to differ by decade raises the estimate in absolute value to -0.000432, significant at the 10% level (column 2). Allowing it to differ freely by year raises it further to -0.000615, significant at the 5% level (column 3). The Bayesian model with a random-walk debt coefficient (column 4) yields a posterior mean of -0.000540, with a 95% credible interval of $[-0.000915, -0.000169]$ and a posterior probability $P(\delta < 0) = 0.998$. The persistence of the primary balance and the level effect of ageing are essentially unchanged relative to the baseline.

[***Table 5 goes here***]

Figure 2 shows why the treatment of time variation matters. The common debt coefficient β_t was around 0.012–0.014 in the late 1960s and 1970s, with a 95% credible interval that includes zero between 1971 and 1981 (1975–1979 for the 90% interval), rose to about 0.021 in the early 1990s, declined to about 0.015 around 2000 and increased steadily thereafter, to 0.025–0.027 in the 2010s and 2020s. Because population ageing advanced over the same period, a specification with a constant β partly confounds the common rise in fiscal responsiveness with the interaction between debt and ageing, which attenuates the estimate of δ. Once the common time variation is absorbed, the cross-country evidence that more aged societies respond less to debt becomes clear. This pattern is consistent with the theoretical framework: equation (8) implies that the response to debt shifts with common factors such as the interest–growth differential, whereas Proposition 2 concerns the effect of ageing in a given environment.

The rise in β_t therefore does not contradict Proposition 2: it reflects common changes in fiscal behaviour, whereas δ captures the fact that, in any given year, more aged societies respond less to debt. In 2020, for instance, the implied response is about 0.025 for a country at the 25th percentile of the old-age dependency ratio and about 0.015 for a country at the 75th percentile. Section 5.3 shows that the rise in the common debt coefficient after 2000 reflects mainly the non-OECD economies of the sample.

[***Figure 2 goes here***]

The effect is economically meaningful. Moving from the 25th (12.2) to the 75th percentile (23.5) of the old-age dependency ratio lowers the debt coefficient by about 0.006 (-0.000540×11.3), roughly one third of its average value over the sample (0.018). Under the constant-coefficient baseline the implied reduction is about half as large (0.003).

Column (5) of Table 5 and Figure 3 report Model B. The posterior mean of δ_t is remarkably stable, ranging between -0.00065 and -0.00047 over 1967–2024, and its time average, $\bar{\delta} = -0.000536$ (95% credible interval $[-0.000971, -0.000099]$, $P(\bar{\delta} < 0) = 0.991$), is virtually identical to the estimate of Model A. Year-specific credible intervals are wide in the early decades, when fewer countries are observed, but the 95% intervals exclude zero in every year from 1990 onwards and the 90% intervals from 1980 onwards. The dampening effect of ageing therefore appears to be a persistent feature of fiscal behaviour rather than a phenomenon confined to a particular period.

[***Figure 3 goes here***]

Table 6 shows that these conclusions do not depend on the prior for the innovation variances. Across $\kappa = 0.05$, 0.10 and 0.20, the posterior mean of δ in Model A ranges between -0.000438 and -0.000598, and that of $\bar{\delta}$ in Model B between -0.000442 and -0.000537, with posterior probabilities of a negative effect above 0.98 in all cases. Tighter priors produce a smoother path for β_t and move δ slightly towards the constant-coefficient estimate, as expected. Overall, the time-varying estimates strengthen the baseline conclusion: once common changes in fiscal responsiveness over time are accounted for, population ageing clearly weakens the response of the primary balance to public debt, as predicted by Proposition 2. Section 5.3 shows that this evidence comes mainly from OECD economies.

[***Table 6 goes here***]

5.3 Robustness: OECD and non-OECD economies

Our sample combines economies at very different stages of the demographic transition. The 33 current OECD members in the sample account for 1,634 of the 2,357 observations, and population ageing is far more advanced among them: the old-age dependency ratio averages 21.6 in the OECD estimation sample, against 11.3 among the 29 non-OECD economies, whose observations are also concentrated in the period after the mid-1990s. To assess where the evidence comes from, we re-estimate all the specifications of Table 5 separately for the two groups, keeping equation (16), the controls and the priors unchanged.

Table 7 reports the results. Among OECD economies (Panel A), the interaction between debt and ageing is negative in every specification. Its magnitude is stable across estimators, from -0.000237 to -0.000346 in the fixed-effects regressions and -0.000290 in Model A, with $P(\delta < 0) = 0.918$, and $\bar{\delta} = -0.000374$ in Model B, with $P(\bar{\delta} < 0) = 0.936$. Across $\kappa = 0.05$, 0.10 and 0.20, the posterior probability of a negative effect lies between 0.91 and 0.94. Among non-OECD economies (Panel B), by contrast, the interaction is not identified: point estimates change sign across specifications, standard errors and posterior standard deviations are two to four times larger than in the OECD sample and the posterior probability of a negative effect lies between 0.39 and 0.67. This is not surprising, since ageing is less advanced and varies less across countries in this group, and the time dimension is shorter. The evidence that ageing weakens the response to debt therefore comes mainly from OECD economies.

[***Table 7 goes here***]

Figure 4 compares the time-varying coefficients of the two groups. In OECD economies the common debt coefficient rises from about 0.013 in the 1960s and 1970s to about 0.020 in the early 1990s and then fluctuates between 0.015 and 0.017, without a trend. The ageing interaction δ_t is negative throughout, at about -0.0004 until the mid-2000s and about -0.0003 in the last decade, with fully overlapping credible intervals. In non-OECD economies, by contrast, the response to debt more than triples after 2000, from about 0.012 to 0.045. The rise in the common coefficient of the full sample after 2000 (Figure 2) therefore reflects mainly the non-OECD economies. Since

these economies are also the youngest in the sample, a single debt coefficient common to all countries can attribute part of their increasing responsiveness to the interaction between debt and ageing.

[***Figure 4 goes here***]

We examine this possibility by estimating a version of Model A in which the debt coefficient follows separate random walks for OECD and non-OECD economies, while the ageing interaction is common to both groups. Figure 5 shows the two coefficients: the OECD coefficient evolves smoothly between 0.013 and 0.023, whereas the non-OECD coefficient, estimated from 1997 onwards, is more volatile and lies above the OECD coefficient in most years after 2008. This specification yields $\delta = -0.000425$, with $P(\delta < 0) = 0.974$. When we also allow for separate year effects for the two groups, so that δ is identified only from differences in ageing within each group in a given year, the estimate falls to -0.000271, with $P(\delta < 0) = 0.897$, close to the estimate for the OECD sample. Part of the full-sample estimate in Section 5.2 thus reflects differences between the two groups, and the within-group effect is about half as large. Moving from the 25th (17.7) to the 75th percentile (24.9) of the old-age dependency ratio in the OECD sample lowers the debt coefficient by about 0.002, roughly one eighth of its average value in this group.

[***Figure 5 goes here***]

5.4 Time-varying estimates for primary spending and revenue

Section 4.1 showed that governments adjust to debt mainly through primary expenditure, but the constant-coefficient estimates of equations (17) and (18) did not allow us to attribute the weaker response in more aged societies to a specific side of the budget. Since the same restriction attenuates the ageing interaction in the primary balance equation, we re-estimate equations (17) and (18) with the specifications of Table 5: fixed-effects regressions in which the debt coefficient differs by decade and by year, and Models A and B of Section 5.1, with the dependent variable replaced by primary spending and total revenue, respectively. Controls, priors and sampler settings are the same as for the primary balance. Proposition 2 implies a positive interaction in both equations: in more aged societies, governments should cut primary spending by less and raise revenue by less in response to higher debt.

Table 8 reports the results. In the primary spending equation (Panel A), the interaction between debt and ageing is positive in every specification. It rises from 0.000180 with a constant debt coefficient to 0.000426 when the debt coefficient differs by decade, significant at the 5% level, and to 0.000656, significant at the 1% level, when it differs by year. The Bayesian estimates are $\delta = 0.000471$ in Model A and $\bar{\delta} = 0.000521$ in Model B, with posterior probabilities of a positive effect of 0.987 and 0.988, respectively, and between 0.95 and 0.99 across $\kappa = 0.05$, 0.10 and 0.20. Moving from the 25th (12.2) to the 75th percentile (23.5) of the old-age dependency ratio raises the debt coefficient of primary spending by about 0.005, roughly half of its average value over the sample (-0.010 in Model A). In the revenue equation (Panel B), by contrast, the interaction is close to zero in every specification, with posterior probabilities of a positive effect between 0.39 and 0.62, and the response of revenue to debt is itself small.

[***Table 8 goes here***]

Figure 6 shows the time-varying coefficients. The debt coefficient of primary spending is close to zero until the mid-1980s, is significantly negative from 1988 onwards (from 1986 at the 90% level) and becomes increasingly negative over time, from about -0.012 in the early 1990s to about -0.019 in the second half of the 2010s, while the debt coefficient of revenue declines gradually from about 0.008 in the 1960s to about 0.003 and its 95% credible interval includes zero from the mid-1970s onwards (the 90% interval from the late 1980s). The rise in the response of the primary balance to debt documented in Figure 2 therefore reflects mainly stronger expenditure adjustment. The ageing interaction in the spending equation is remarkably stable, at about 0.0005 throughout, and its 95% credible interval excludes zero in every year between 1987 and 2022, and its 90% interval in every year of the sample, whereas the corresponding interaction in the revenue equation is essentially zero in every year.

[***Figure 6 goes here***]

These results locate the dampening effect of ageing on the expenditure side. Since the primary balance is the difference between revenue and primary spending, the two interactions imply an effect on the primary balance of about $-0.000013 - 0.000471 = -0.000484$, close to the estimate of -0.000540 in Table 5, so that smaller expenditure cuts account for nearly all of the weaker response of the primary

balance to debt in more aged societies. This is consistent with the theoretical framework, in which older cohorts attach less weight to future debt-servicing costs, and with the evidence in Table 2 that ageing raises primary spending but not revenue.

6. Ageing, democracy and fiscal responsiveness

In the theoretical framework, ageing weakens fiscal responsiveness because the political weight of older cohorts rises with their share in the electorate. This mechanism should operate mainly where governments are electorally accountable. We therefore examine whether the dampening effect of ageing is stronger in more democratic countries by extending equation (16) with a triple interaction:

$$pb_{it} = \alpha_i + \lambda_t + \beta b_{i,t-1} + \delta\left(b_{i,t-1} \times a_{it}\right) + \gamma a_{it} + \rho\, pb_{i,t-1} + \theta_1 D_{it} + \theta_2\left(b_{i,t-1} \times D_{it}\right) + \theta_3(a_{it} \times D_{it}) + \theta_4\left(b_{i,t-1} \times a_{it} \times D_{it}\right) + X_{i,t-1}'\eta + \varepsilon_{it} \qquad (22)$$

where D_{it} is the electoral democracy index of the Varieties of Democracy project (V-Dem, Coppedge et al., 2026), which ranges from 0 to 1, centered at its sample mean of 0.73. Hence δ is the ageing interaction at average democracy, and the ageing interaction at democracy level D is $\delta + \theta_4(D - \bar{D})$. The framework implies $\theta_4 < 0$. We estimate equation (22) with the specifications of Table 5, adding the four democracy terms as constant regressors in Models A and B.

Table 9 reports the results. The triple interaction is negative in every specification, between -0.0012 and -0.0019, so the dampening effect of ageing is larger in more democratic countries. In countries at the 90th percentile of the democracy index (0.89), the ageing interaction is between -0.0005 and -0.0009, statistically significant in all fixed-effects specifications and with a posterior probability of a negative effect above 0.99 in the Bayesian models. In countries at the 10th percentile (0.36), it is close to zero. The triple interaction itself, however, is imprecisely estimated: its posterior probability of being negative is about 0.85 across specifications and values of κ. This reflects limited variation in the data: democracies account for 83% of the observations, and the democracy index varies little within countries over time. Replacing the index with an indicator for electoral and liberal democracies (V-Dem Regimes of the World

classification) yields the same pattern: in Model A the ageing interaction is -0.00068 in democracies, with $P(\delta < 0) = 0.9997$, and -0.00037 in non-democracies, with $P(\delta < 0) = 0.65$. Overall, the evidence is consistent with the political-economy mechanism of Section 2, in that the dampening effect of ageing is concentrated in democracies, but the difference between democracies and non-democracies is not estimated precisely enough to be regarded as conclusive.

[***Table 9 goes here***]

7. Ageing and the interest–growth differential

Equation (11) implies that the dampening effect of ageing is proportional to R_t: the higher the effective interest rate on debt relative to growth, the larger the fall in fiscal responsiveness associated with a given increase in the old-age dependency ratio. We examine this implication by distinguishing between periods in which the interest–growth differential is positive and periods in which it is negative. Let $P_{it} = 1$ if the lagged real long-term interest rate exceeds lagged real GDP growth, $r_{i,t-1} - g_{i,t-1} > 0$, and $P_{it} = 0$ otherwise; both variables are already included among the controls, so the regime is predetermined. In the sample, 952 observations have $r - g > 0$ and 1,405 have $r - g < 0$, and 61 of the 62 countries experience both regimes.

Since the regime is strongly concentrated in particular periods (Figure 7, panel a), with $r - g > 0$ prevailing mainly in the 1980s, 1990s and early 2000s and $r - g < 0$ in the 1970s and after 2008, a simple split of the sample confounds the regime with time. Our main specification therefore estimates a single model in which the ageing interaction differs across regimes:

$$y_{it} = \alpha_i + \lambda_t + \beta_t\, b_{i,t-1} + \delta\big(b_{i,t-1} \times \tilde{a}_{it}\big) + \gamma\, \tilde{a}_{it} + \rho\, y_{i,t-1} + \theta_1 P_{it} + \theta_2\big(b_{i,t-1} \times P_{it}\big) + \theta_3(\tilde{a}_{it} \times P_{it}) + \theta_4\big(b_{i,t-1} \times \tilde{a}_{it} \times P_{it}\big) + X_{i,t-1}'\boldsymbol{\eta} + \varepsilon_{it}, \qquad (23)$$

where y_{it} is the primary balance, primary spending or total revenue and β_t follows the random walk (20). The ageing interaction is δ when $r - g < 0$ and $\delta + \theta_4$ when $r - g > 0$, and θ_2 allows the response to debt to differ across regimes. For the

primary balance, equation (11) implies $\theta_4 < 0$. We estimate equation (23) with fixed effects and Driscoll–Kraay standard errors, with a constant debt coefficient and with debt interacted with decade and year dummies, and with Model A. For comparison, we also estimate the baseline specifications separately for the two subsamples.

Table 10 reports the results. For the primary balance (Panel A), the ageing interaction is negative in both regimes and larger in absolute value when $r - g > 0$, as the framework predicts. In Model A it is -0.000437 when $r - g < 0$ and -0.000726 when $r - g > 0$, with posterior probabilities of a negative effect of 0.985 and 0.997, and the fixed-effects estimates show the same ordering in every specification. The difference between the two regimes, however, is imprecisely estimated: $\theta_4 = -0.000289$, with a posterior probability of being negative of 0.89 (between 0.86 and 0.90 across $\kappa = 0.05$, 0.10 and 0.20), and it is not statistically significant in the fixed-effects regressions. The response of the primary balance to debt is also somewhat stronger when $r - g > 0$ ($\theta_2 \approx 0.006$), in line with Proposition 1, in which the debt coefficient increases with R_t. The decomposition points in the same direction. In the primary spending equation (Panel B), the interaction is positive in both regimes and larger when $r - g > 0$ (0.000498 against 0.000361 in Model A), whereas in the revenue equation (Panel C) it is close to zero in both regimes. Panels (b)–(d) of Figure 7 show the posterior distributions of the ageing interaction in the two regimes. For the primary balance the distribution under r − g > 0 lies to the left of that under r − g < 0, and for primary spending to the right, but in both cases the two distributions overlap substantially; for revenue both are centred close to zero.

[***Table 10 goes here***]

[***Figure 7 goes here***]

The split-sample estimates are less informative. In each subsample the interaction keeps the sign predicted by Proposition 2 for the primary balance and primary spending, but it is imprecisely estimated, and the ordering across regimes is not stable: for the primary balance, Model A yields -0.000502 when $r - g < 0$ and -0.000401 when $r - g > 0$, with posterior probabilities of a negative effect of 0.99 and 0.86. Because each subsample covers largely different years, and the debt coefficient and the year effects are estimated separately in each, the split cannot separate the role of the interest–growth differential from that of time. Overall, the dampening effect of ageing is present

whether the interest–growth differential is positive or negative. The pooled estimates suggest that it is stronger when $r - g > 0$, as the framework implies, but the evidence on the difference between regimes is not conclusive.

8. Conclusions and policy implications

This paper examines whether population ageing affects governments' fiscal responsiveness to public debt, using a panel of 62 advanced and developing economies over 1962–2024. A simple political-economy framework with overlapping generations predicts that, because older cohorts expect to bear a smaller share of future debt-servicing costs, a rising old-age dependency ratio weakens the equilibrium response of the primary balance to inherited debt. We test this prediction by estimating a fiscal reaction function à la Bohn (1998) in which the response to lagged debt varies with the old-age dependency ratio.

Five findings stand out. First, governments respond positively to rising public debt, a pattern broadly consistent with fiscal sustainability, and the adjustment operates mainly through primary expenditure. Second, the response is weaker in more aged societies; with a constant debt coefficient, however, this effect is imprecisely estimated, because the response to debt has risen over time at the same time as populations have aged. Third, once common changes in fiscal responsiveness over time are absorbed, through debt-by-year interactions or Bayesian time-varying-parameter models, the dampening effect of ageing is clear and stable over time: moving from the 25th to the 75th percentile of the old-age dependency ratio lowers the response of the primary balance to debt by about one third. Fourth, the evidence comes mainly from OECD economies, where ageing is most advanced: the dampening effect is present within the OECD sample and in an independent panel of OECD economies, although within the OECD it is about half as large as in the full sample, whereas the data for non-OECD economies are not informative about it. Fifth, the dampening effect operates through the expenditure side: once common changes over time are absorbed, more aged societies cut primary spending by less in response to debt, while the interaction between debt and ageing in the revenue equation is close to zero. Finally, the comparative political-economy analysis suggests that the relationship between ageing and fiscal responsiveness is conditioned by political institutions. The dampening effect is

concentrated in democratic economies, consistent with the electoral influence of older cohorts, although the difference relative to less democratic countries is estimated imprecisely. This evidence is suggestive rather than conclusive, but it highlights the potential importance of political institutions in shaping how demographic change translates into fiscal policy decisions. The dampening effect is present whether the interest–growth differential is positive or negative and appears stronger when it is positive, as the framework implies, although the difference between the two regimes is imprecisely estimated.

These results have two policy implications. First, the fiscal reaction to debt that underpins sustainability assessments is not a fixed parameter: as populations age, governments become less responsive to rising debt, so debt sustainability analyses based on historical average reaction coefficients may overstate future fiscal adjustment in ageing economies. Second, if, as our framework suggests, ageing weakens fiscal discipline through the rising political weight of cohorts with shorter horizons, institutional arrangements that strengthen fiscal commitment, such as credible fiscal rules and independent fiscal institutions, together with pension and health reforms that contain the growth of age-related spending, may be needed to sustain fiscal responsiveness as dependency ratios rise. These implications concern above all the OECD economies, in which the effect is most clearly identified and population ageing is most advanced. Because the weaker response operates through smaller expenditure cuts, reforms that contain the growth of age-related spending appear particularly relevant. From a comparative institutional perspective, these findings also suggest that the fiscal consequences of demographic ageing may depend on the political environment in which adjustment decisions are made. However, the evidence on differences across political regimes remains suggestive, and the results should not be interpreted as establishing that democratic institutions themselves weaken fiscal discipline.

The analysis has limitations that point to future research. The theoretical framework is deliberately simple and partial-equilibrium, and the empirical analysis relies on aggregate primary spending and revenue, so it cannot identify the categories of expenditure, such as pensions and health care, through which ageing weakens the response to debt. Examining how institutional features, such as fiscal rules and the design of pension systems, condition the effect of ageing on fiscal responsiveness is a

natural next step. In addition, the effect of ageing cannot be estimated with precision for non-OECD economies, where population ageing is still at an early stage; longer samples will be needed to assess whether these economies follow the OECD pattern as they age.

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Appendix A. Derivations for Section 2

A.1 Cohort-specific fiscal rules

Substituting (1) into (2), the first-order condition of cohort j is

$$\left(pb_t - \bar{p}_j\right) - \theta_j(R_t\, b_{t-1} - pb_t) = 0 \quad \Rightarrow \quad \left(1 + \theta_j\right) pb_t = \bar{p}_j + \theta_j R_t\, b_{t-1} \qquad \text{(A1)}$$

which gives (4). The second-order condition $1 + \theta_j > 0$ holds for all $\theta_j \geq 0$. Since $\partial\beta_j / \partial\theta_j = R_t/\left(1 + \theta_j\right)^2 > 0$ for $R_t > 0$, and $\theta_Y > \pi\theta_Y = \theta_O \geq 0$, condition (5) follows.

A.2 Political weights

Two office-seeking parties choose platforms. Let σ_j denote the electoral responsiveness of cohort j (the density of its swing voters). Electoral competition leads both parties to the platform that minimises $\sigma_Y L^Y + \sigma_O\, a_t\, L^O$, the loss of each cohort weighted by its size and responsiveness (Lindbeck and Weibull, 1987; Persson and Tabellini, 2000). Normalising the weights to sum to one gives (6) with

$$\mu(a_t) = \frac{\sigma_O\, a_t}{\sigma_Y + \sigma_O\, a_t}, \qquad \mu'(a_t) = \frac{\sigma_Y\, \sigma_O}{(\sigma_Y + \sigma_O\, a_t)^2} > 0 \qquad \text{(A2)}$$

When $\sigma_O = \sigma_Y$, the weight of the old equals their population share $a_t/(1 + a_t)$; when $\sigma_O > \sigma_Y$, it exceeds that share.

B.3 Political equilibrium

Minimising (6) subject to (1), the first-order condition is

$$[1 - \mu][(pb_t - \bar{p}_Y) - \theta_Y(R_t b_{t-1} - pb_t)] + \mu[(pb_t - \bar{p}_O) - \theta_O(R_t b_{t-1} - pb_t)] = 0$$

Collecting terms gives $[1+\bar{\theta}(a_t)]pb_t = \bar{p}(a_t) + \bar{\theta}(a_t)\, R_t\, b_{t-1}$, which yields (7)–(8). The objective is strictly convex in pb_t, with second derivative $1+\bar{\theta}(a_t) > 0$, so the solution is unique.

A.4 Comparative statics

Write $D \equiv 1+\bar{\theta}(a_t)$. With $\theta_O = \pi\theta_Y$, (9) becomes $\bar{\theta}' = -\mu'(1-\pi)\theta_Y$.

Proposition 2. Differentiating $B = R_t\bar{\theta}/D$ with respect to a_t gives $\partial B/\partial a_t = R_t\,\bar{\theta}'/D^2$, which is (11).

Level effect. Differentiating $A = \bar{p}/D$, with $\bar{p}' = \mu'(\bar{p}_O - \bar{p}_Y)$,

$$A'(a_t) = \frac{\bar{p}'\,D - \bar{p}\,\bar{\theta}'}{D^2} = \frac{\mu'[(\bar{p}_O - \bar{p}_Y)D - \bar{p}(\theta_O - \theta_Y)]}{D^2}. \qquad \text{(A3)}$$

The first term is negative when $\bar{p}_O < \bar{p}_Y$ and the second is positive when $\bar{p} > 0$, so the sign of A' is not determined by the model.

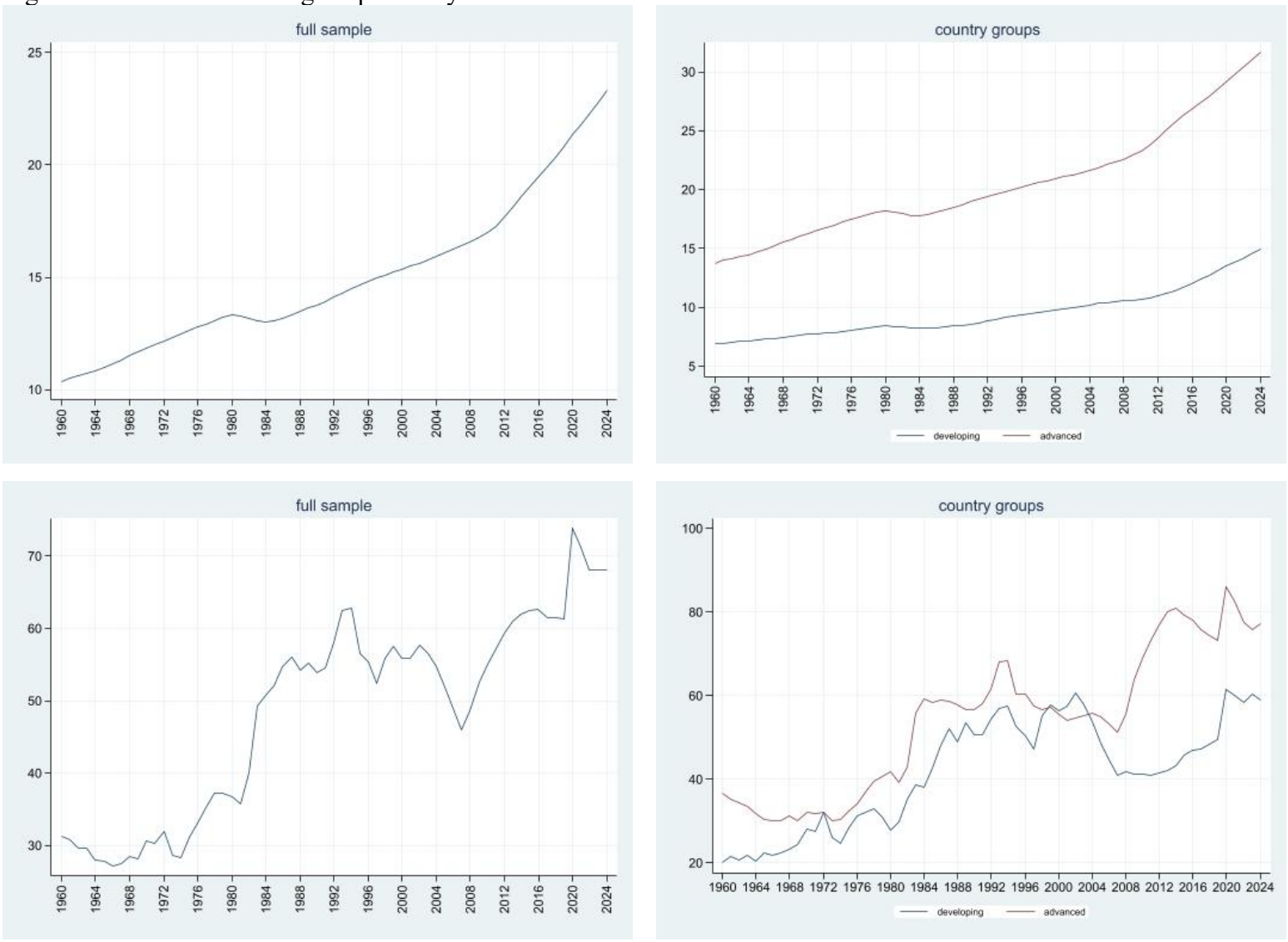
A.5 Linearisation

A first-order expansion around $\bar{a}$ gives $A(a_{it}) \simeq A(\bar{a}) + A'(\bar{a})\,\tilde{a}_{it}$ and $B(a_{it}) \simeq B(\bar{a}) + B'(\bar{a})\,\tilde{a}_{it}$. Substituting into (12) and absorbing $A(\bar{a})$ into the fixed effects gives (13)–(14).

Since a_{it} is measured in percent in the data, δ in (13) equals $B'(\bar{a})/100$ when a is expressed as a fraction.

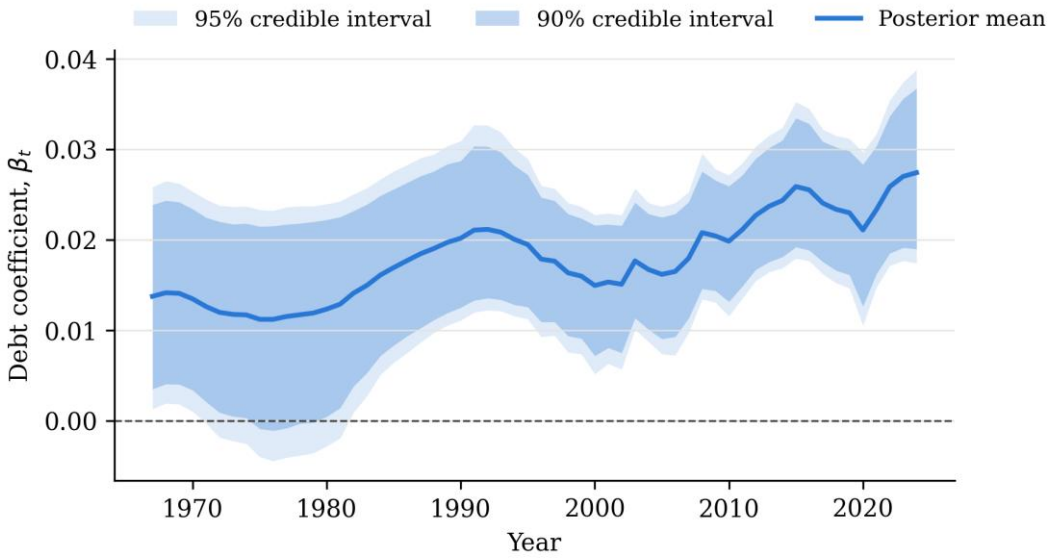
Figures

Figure 1. Evolution of old-age dependency and debt to GDP ratios.



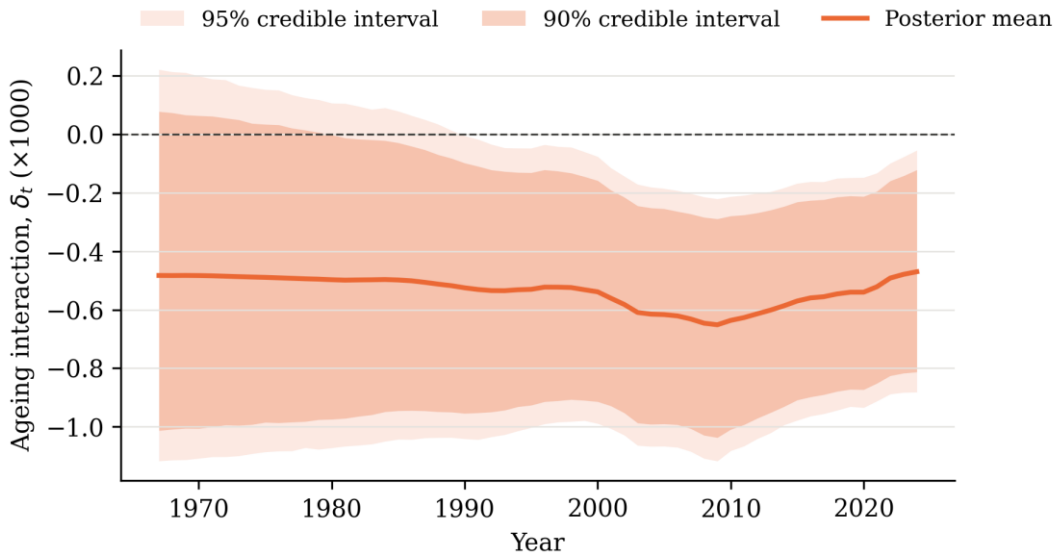
Notes**:** Average values of the old-age dependency ratio (top row) and the debt-GDP ratio (bottom row) for the full sample case (left panel) and based on level of economic activity (right panel).

Figure 2. Time-varying response of the primary balance to public debt (Model A).



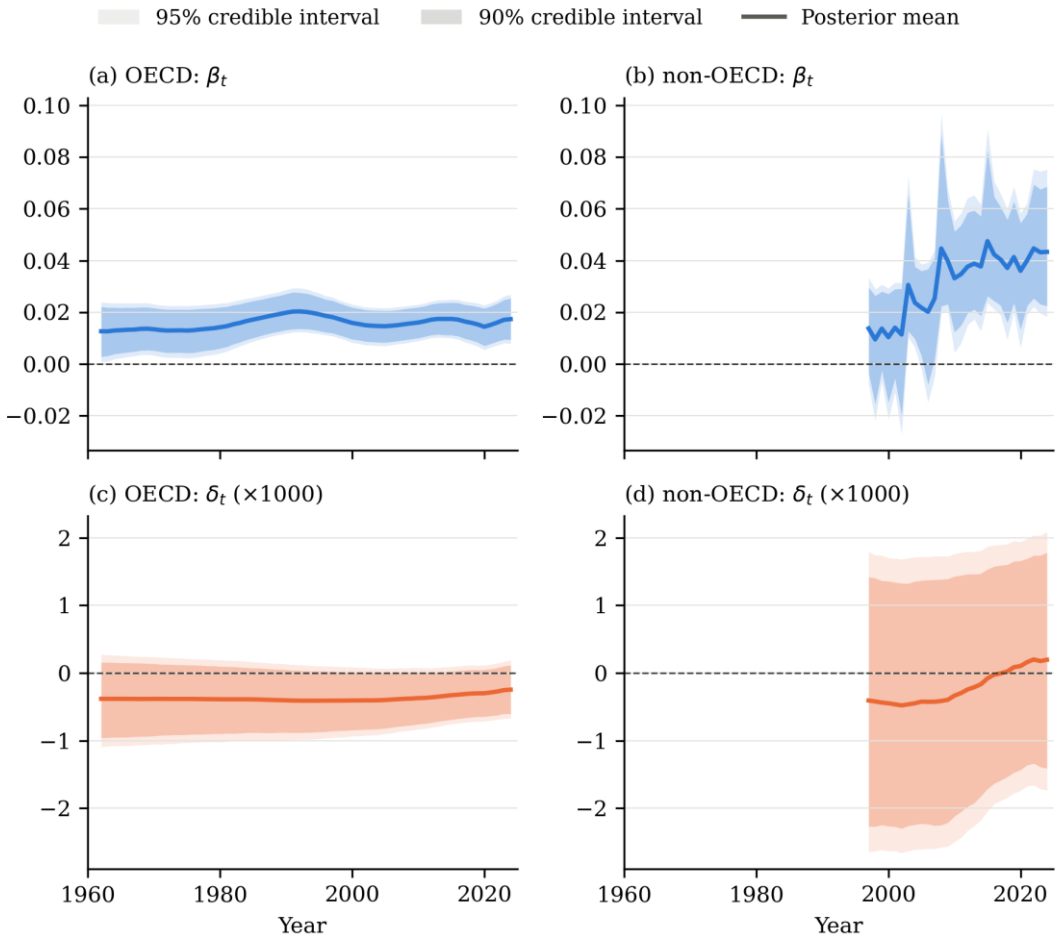
Notes: Posterior mean and 90% (darker band) and 95% (lighter band) credible intervals of βt in equations (19)–(20), κ = 0.10. Years with at least 20 countries in the sample (1967–2024).

Figure 3. Time-varying interaction between public debt and population ageing (Model B).



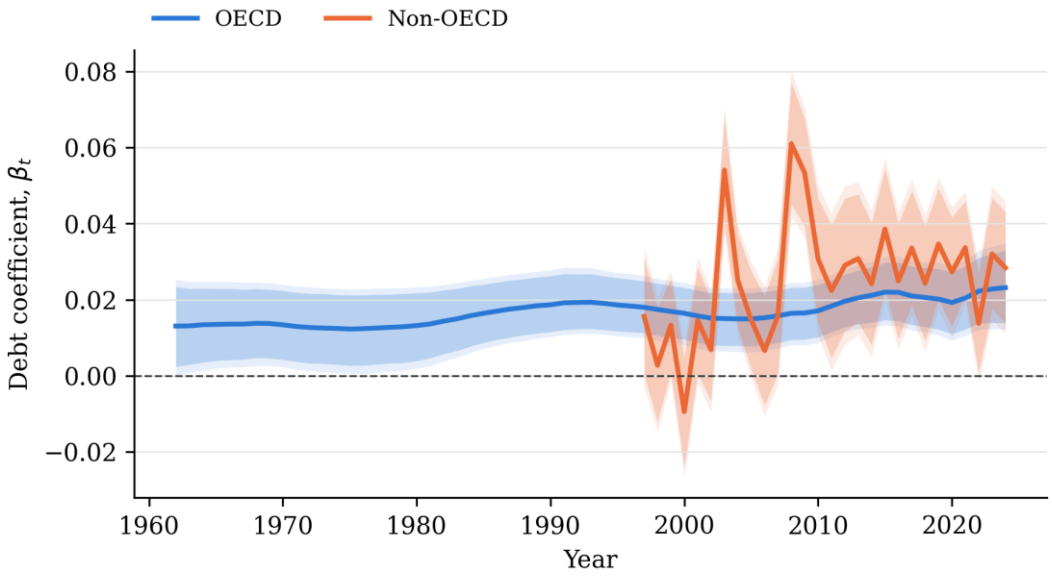
Notes: Posterior mean and 90% (darker band) and 95% (lighter band) credible intervals of δt (multiplied by 1,000) in equations (19)–(21), κ = 0.10. Years with at least 20 countries in the sample (1967–2024).

Figure 4. Time-varying estimates for OECD and non-OECD economies.



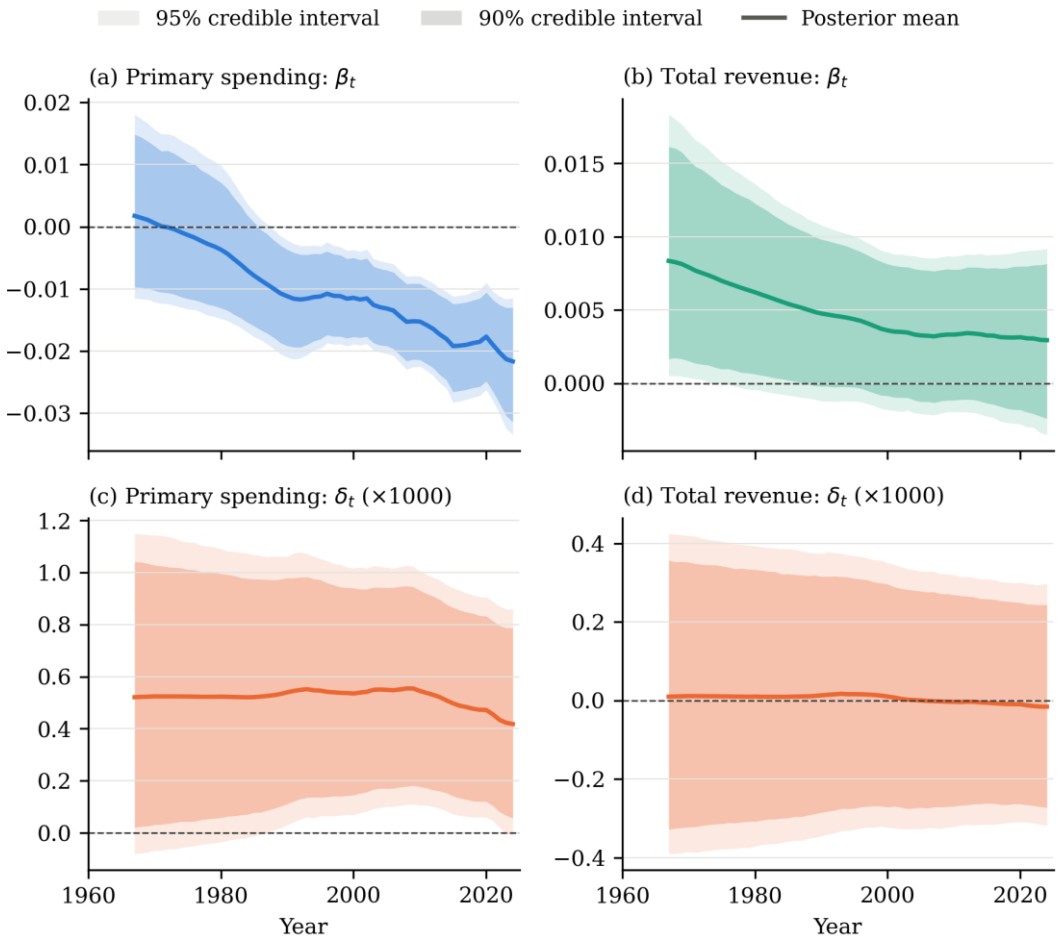
Notes: Panels (a) and (b): posterior mean and 90% (darker band) and 95% (lighter band) credible intervals of βt in Model A; panels (c) and (d): posterior mean and 90% (darker band) and 95% (lighter band) credible intervals of δt (multiplied by 1,000) in Model B; κ = 0.10. Models estimated separately for the 33 OECD and the 29 non-OECD economies of the sample (Table 7); years with at least 10 countries in the group.

Figure 5. Separate time-varying debt coefficients for OECD and non-OECD economies.



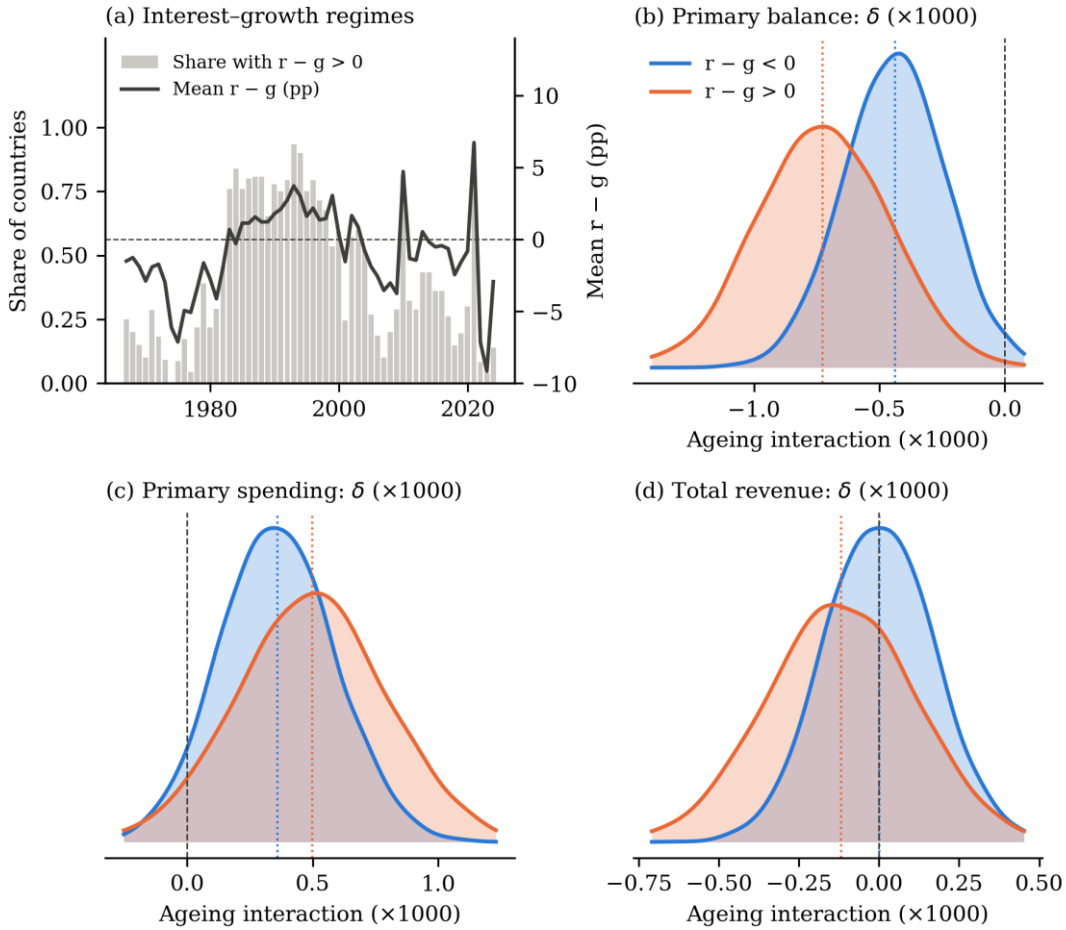
Notes: Posterior means and 90% (darker band) and 95% (lighter band) credible intervals of the group-specific debt coefficients βt in a version of Model A estimated on the full sample (N = 2,357), with separate random walks for the 33 OECD and the 29 non-OECD economies, a common ageing interaction δ and common year effects; κ = 0.10. Non-OECD coefficients are shown for the years with at least 10 countries in the group.

Figure 6. Time-varying estimates for primary spending and total revenue.



Notes: Panels (a) and (b): posterior mean and 90% (darker band) and 95% (lighter band) credible intervals of βt in Model A for primary spending (equation 17) and total revenue (equation 18); panels (c) and (d): posterior mean and 90% (darker band) and 95% (lighter band) credible intervals of δt (multiplied by 1,000) in Model B; κ = 0.10. Years with at least 20 countries.

Figure 7. Ageing and fiscal responsiveness in the two interest–growth regimes.



Notes: Panel (a): share of countries with a positive interest–growth differential ($r - g > 0$, lagged real long-term interest rate minus lagged real GDP growth; bars, left axis) and the cross-country mean of $r - g$ in percentage points (line, right axis), years with at least 20 countries. Panels (b)–(d): posterior densities of the ageing interaction (multiplied by 1,000) when $r - g < 0$ (δ) and when $r - g > 0$ ($\delta + \theta 4$) in the pooled Model A of Table 10, column (4), $\kappa = 0.10$; dotted lines mark the posterior means.

Tables

Table 1. Summary statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Revenue to GDP	3,272	30.62	13.15	1.940	63.00
Primary spending to GDP	3,140	30.87	12.64	1.819	65.10
Primary balance to GDP	3,140	0.161	3.771	-28.17	25.97
Inflation rate	3,580	20.16	169.87	-98.70	7544.81
Debt to GDP	3,192	51.16	34.44	0.971	284.0
Real long-term interest rates	2,475	2.227	6.197	-145.0	73.78
Real GDP growth rate	3,694	3.735	4.390	-32.91	62.18
Old age dependency ratio	4,030	14.97	8.032	4.010	50.66

Notes: This table shows the descriptive statistics of the main variables used in our analysis.

Table 2. Effects of old age on fiscal responsiveness.

	(1)	(2)	(3)
Dependent variables:	Primary balance	Primary spending	Total revenue
Dependent var. (t-1)	0.673***	0.721***	0.837***
	(0.0311)	(0.0298)	(0.0204)
Real GDP growth (t-1)	0.0829***	-0.0265	0.0587***
	(0.0144)	(0.0173)	(0.0191)
Inflation (t-1)	0.0189***	-0.00938	0.00811
	(0.00540)	(0.00855)	(0.00660)
Real long-term interest (t-1)	-0.0102	0.0202	0.00868
	(0.0112)	(0.0198)	(0.0126)
Old age (t)	-0.0451**	0.0891***	0.0470
	(0.0221)	(0.0316)	(0.0288)
Debt (t-1)	0.0247***	-0.0164***	0.00498
	(0.00599)	(0.00550)	(0.00422)
Oldage (t) * debt (t-1)	-0.000290*	0.000180	-5.34e-05
	(0.000174)	(0.000157)	(0.000122)
Revenue (t-1)		0.186***	
		(0.0319)	
Total spending (t-1)			0.0596***
			(0.0196)
	Marginal effect		
at p25 old age	0.022***	-0.015***	0.004
	(0.004)	(0.004)	(0.003)
at p50 old age	0.020***	-0.013***	0.003
	(0.003)	(0.004)	(0.008)
at p75 old age	0.018***	-0.012***	0.003
	(0.003)	(0.004)	(0.007)
Observations	2,357	2,357	2,365
R-squared	0.620	0.888	0.828
Country effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes

Notes: OLS with time and country fixed effects. Driscoll-Kraay standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3. Effects of old age on fiscal responsiveness - with IV instruments.

VARIABLES	(1) Primary balance	(2) Primary spending	(3) Total revenue
Dependent var. (t-1)	0.673***	0.719***	0.841***
	(0.0305)	(0.0316)	(0.0260)
Debt (t-1)	0.0208***	-0.0103	0.00786
	(0.00711)	(0.00649)	(0.00541)
Real GDP growth (t-1)	0.0828***	-0.0247	0.0589***
	(0.0221)	(0.0248)	(0.0166)
Inflation (t-1)	0.0207**	-0.00929	0.00986
	(0.00807)	(0.0133)	(0.00993)
Real long-term interest (t-1)	-0.00125	0.0115	0.00880
	(0.0114)	(0.0190)	(0.0147)
Oldage (t)	-0.0704**	0.109***	0.0423*
	(0.0309)	(0.0341)	(0.0257)
Oldage (t) * debt (t-1)	-0.000113	-1.53e-05	-7.87e-05
	(0.000191)	(0.000185)	(0.000140)
Revenue (t-1)		0.186***	
		(0.0322)	
Total spending (t-1)			0.0512**
			(0.0208)
	Marginal effect		
at p25 old age	0.019***	-0.010**	0.007
	(0.005)	(0.005)	(0.004)
at p50 old age	0.019***	-0.010**	0.006*
	(0.004)	(0.004)	(0.003)
at p75 old age	0.018***	-0.010***	0.006**
	(0.003)	(0.003)	(0.003)
Observations	2,307	2,307	2,312
R-squared	0.743	0.959	0.974
Kleibergen-Paap rk LM statistic	197.4***	207.8***	225.5***
Kleibergen-Paap rk Wald F statistic	3303.8	618.0	516.4
Hansen J statistic	1.23	5.91*	3.36
Country effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes

Notes: Instrumented variables: lag of debt and the interaction term. Instruments used: the second and third lags of debt and interaction term (in a similar vein as Fatás and Mihov, 2003). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The Kleibergen–Paap rk LM statistic tests for underidentification, i.e. whether the excluded instruments are sufficiently correlated with the endogenous regressors. In all specifications, the test strongly rejects the null of underidentification, indicating that the model is identified. The Kleibergen–Paap rk Wald F statistic assesses the strength of the instruments; the reported values are well above conventional thresholds (e.g. Stock–Yogo critical values), suggesting that weak instrument concerns are not relevant in this setting. Finally, the Hansen J statistic evaluates the validity of the overidentifying restrictions, testing the joint exogeneity of the instruments. The null hypothesis cannot be rejected in specifications (1) and (3), supporting the validity of the instrument set, while in specification (2) the p-value lies close to conventional significance levels. Overall, the diagnostic tests indicate that the instrumental variable strategy is well-identified, based on strong instruments, and broadly consistent with the exogeneity assumptions required for valid inference.

Table 4. Effects of old age on fiscal responsiveness - excluding high debt countries.

VARIABLES	(1) Primary balance	(2) Primary spending	(3) Total revenue
Dependent var. (t-1)	0.672***	0.731***	0.823***
	(0.0309)	(0.0321)	(0.0200)
Real GDP growth (t-1)	0.103***	-0.0456***	0.0607***
	(0.0150)	(0.0132)	(0.0173)
Inflation (t-1)	0.0202***	-0.00881	0.00960
	(0.00495)	(0.00896)	(0.00631)
Real long-term interest (t-1)	-0.0111	0.0216	0.00947
	(0.0128)	(0.0226)	(0.0120)
Old age (t)	0.00546	0.0641**	0.0732**
	(0.0222)	(0.0276)	(0.0284)
Debt (t-1)	0.0323***	-0.0144*	0.0136***
	(0.00830)	(0.00857)	(0.00417)
Oldage (t) * debt (t-1)	-0.000646*	0.000154	-0.000380**
	(0.000383)	(0.000334)	(0.000186)
Revenue (t-1)		0.179***	
		(0.0348)	
Total spending (t-1)			0.0708***
			(0.0192)
	Marginal effect		
at p25 old age	0.027***	-0.013**	0.010***
	(0.005)	(0.006)	(0.003)
at p50 old age	0.022***	-0.012**	0.007***
	(0.003)	(0.005)	(0.002)
at p75 old age	0.019***	-0.011***	0.005**
	(0.003)	(0.004)	(0.002)
Observations	2,224	2,224	2,232
R-squared	0.640	0.895	0.919
Country effects	Yes	Yes	Yes
Time effects	Yes	Yes	Yes

Notes: OLS with time and country fixed effects. Driscoll-Kraay standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5. Fiscal responsiveness with a time-varying debt coefficient.

	(1)	(2)	(3)	(4)	(5)
Estimator	FE-OLS	FE-OLS	FE-OLS	Bayesian TVP	Bayesian TVP
Debt coefficient	Constant	By decade	By year	Random walk	Random walk
Ageing interaction	Constant	Constant	Constant	Constant	Random walk
Oldage (t) * debt (t-1)	-0.000290*	-0.000432*	-0.000615**	-0.000540	-0.000536
	(0.000174)	(0.000242)	(0.000269)	(0.000190)	(0.000222)
P(δ < 0)				0.998	0.991
Dependent var. (t-1)	0.673***	0.671***	0.677***	0.672	0.671
	(0.0311)	(0.0311)	(0.0307)	(0.0154)	(0.0153)
Old age (t)	-0.0451**	-0.0307	-0.0118	-0.0218	-0.0220
	(0.0221)	(0.0237)	(0.0249)	(0.0290)	(0.0294)
Change in debt coefficient, p25 to p75 old age	-0.0033	-0.0049	-0.0070	-0.0061	-0.0061
Controls	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes	Yes
Observations	2,357	2,357	2,357	2,357	2,357

Notes: Dependent variable: primary balance (% of GDP). Columns (1)–(3): OLS with country and time fixed effects (equation 16); Driscoll-Kraay standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Column (1) reproduces Table 2, column (1). Columns (2) and (3) interact lagged debt with decade and year dummies, respectively. Columns (4)–(5): Bayesian panel time-varying-parameter models, equations (19)–(21); posterior means with posterior standard deviations in parentheses (95% credible intervals for the interaction are reported in Table 4); three chains and 18,000 retained draws, $\kappa = 0.10$. Column (5) reports the time average $\bar{\delta}$ of δ_t over the years with at least 20 countries. Controls: lagged real GDP growth, inflation and real long-term interest rate. The row "Change in debt coefficient" multiplies the interaction coefficient by the interquartile range of the old-age dependency ratio (12.2 to 23.5).

Table 6. Bayesian estimates: sensitivity to the prior on the innovation variances.

	Model A: β time-varying, δ constant			Model B: β and δ time-varying ($\bar{\delta}$)		
κ	Mean	95% credible interval	P(δ < 0)	Mean	95% credible interval	P($\bar{\delta}$ < 0)
0.05	-0.000438	[-0.000799, -0.000092]	0.994	-0.000442	[-0.000822, -0.000076]	0.992
0.10	-0.000540	[-0.000915, -0.000169]	0.998	-0.000536	[-0.000971, -0.000099]	0.991
0.20	-0.000598	[-0.000986, -0.000214]	0.999	-0.000537	[-0.001032, -0.000035]	0.982

Notes: Posterior means, 95% equal-tail credible intervals and posterior probabilities of a negative effect. κ scales the prior mean of the innovation variances q_β and q_δ: $E[q] = (\kappa s)^2$, where s is the absolute value of the corresponding pooled coefficient, or twice its standard error if larger. Model B reports $\bar{\delta}$, the average of δ_t over the years with at least 20 countries. Each specification: three chains, 18,000 retained draws; N = 2,357.

Table 7. Robustness: OECD and non-OECD economies.

	(1)	(2)	(3)	(4)	(5)
Estimator	FE-OLS	FE-OLS	FE-OLS	Bayesian TVP	Bayesian TVP
Debt coefficient	Constant	By decade	By year	Random walk	Random walk
Ageing interaction	Constant	Constant	Constant	Constant	Random walk
Panel A: OECD (33 countries, 1962–2024)					
Oldage (t) * debt (t-1)	-0.000275	-0.000237	-0.000346	-0.000290	-0.000374
	(0.000191)	(0.000380)	(0.000442)	(0.000210)	(0.000250)
Dependent var. (t-1)	0.739***	0.732***	0.736***	0.738	0.738
	(0.0287)	(0.0293)	(0.0296)	(0.0166)	(0.0167)
Old age (t)	-0.0279	-0.0231	-0.0105	-0.0231	-0.0197
	(0.0282)	(0.0359)	(0.0400)	(0.0300)	(0.0302)
$P(\delta < 0)$				0.918	0.936
$P(\delta < 0)$, $\kappa = 0.05$ to 0.20				0.911–0.934	0.936–0.939
Change in debt coefficient, p25 to p75 old age	-0.0020	-0.0017	-0.0025	-0.0021	-0.0027
Observations	1,634	1,634	1,634	1,634	1,634
Panel B: non-OECD (29 countries, 1962–2024)					
Oldage (t) * debt (t-1)	0.000428	0.000106	0.000013	0.000092	-0.000216
	(0.000784)	(0.000927)	(0.000938)	(0.000901)	(0.000963)
Dependent var. (t-1)	0.533***	0.524***	0.561***	0.526	0.524
	(0.0581)	(0.0557)	(0.0569)	(0.0331)	(0.0332)
Old age (t)	-0.0977	-0.0589	-0.0384	-0.0414	-0.0654
	(0.0623)	(0.0718)	(0.0623)	(0.0805)	(0.0848)
$P(\delta < 0)$				0.461	0.591
$P(\delta < 0)$, $\kappa = 0.05$ to 0.20				0.392–0.475	0.438–0.670
Change in debt coefficient, p25 to p75 old age	0.0037	0.0009	0.0001	0.0008	-0.0019
Observations	723	723	723	723	723
Controls, country and time effects	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variable: primary balance (% of GDP). Panel A: the 33 current OECD members in the sample; Panel B: the remaining 29 economies (Argentina, Bosnia and Herzegovina, Brazil, China, Croatia, Cyprus, Ethiopia, Fiji, Ghana, Hong Kong SAR, India, Indonesia, Kyrgyz Republic, Malaysia, Maldives, Moldova, Morocco, Namibia, Pakistan, Panama, Philippines, Romania, Russia, Seychelles, Solomon Islands, South Africa, Tanzania, Thailand and Vanuatu). Specifications as in Table 5, estimated separately for each group. Columns (1)–(3): OLS with country and time fixed effects; Driscoll–Kraay standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Columns (4)–(5): Bayesian panel time-varying-parameter models, equations (19)–(21); posterior means with posterior standard deviations in parentheses; three chains and 18,000 retained draws, $\kappa = 0.10$. Column (5) reports the time average $\bar{\delta}$ of δ_t over the years with at least 10 countries in the group. Controls: lagged real GDP growth, inflation and real long-term interest rate. The row "Change in debt coefficient" multiplies the interaction coefficient by the interquartile range of the old-age dependency ratio in each group (17.7 to 24.9 in Panel A, 6.4 to 15.1 in Panel B).

Table 8. Time-varying estimates for primary spending and total revenue.

	(1)	(2)	(3)	(4)	(5)
Estimator	FE-OLS	FE-OLS	FE-OLS	Bayesian TVP	Bayesian TVP
Debt coefficient	Constant	By decade	By year	Random walk	Random walk
Ageing interaction	Constant	Constant	Constant	Constant	Random walk
Panel A: Primary spending, equation (17)					
Oldage (t) * debt (t-1)	0.000180	0.000426**	0.000656***	0.000471	0.000521
	(0.000157)	(0.000195)	(0.000234)	(0.000216)	(0.000235)
Dependent var. (t-1)	0.721***	0.718***	0.720***	0.718	0.717
	(0.0298)	(0.0302)	(0.0311)	(0.0183)	(0.0181)
Old age (t)	0.0891***	0.0645**	0.0403	0.0631	0.0633
	(0.0316)	(0.0319)	(0.0351)	(0.0331)	(0.0331)
Revenue (t-1)	0.186***	0.178***	0.175***	0.181	0.182
	(0.0319)	(0.0318)	(0.0330)	(0.0187)	(0.0186)
$P(\delta > 0)$				0.987	0.988
$P(\delta > 0)$, $\kappa = 0.05$ to 0.20				0.951–0.994	0.962–0.991
Change in debt coefficient, p25 to p75 old age	0.0020	0.0048	0.0074	0.0053	0.0059
Observations	2,357	2,357	2,357	2,357	2,357
Panel B: Total revenue, equation (18)					
Oldage (t) * debt (t-1)	-0.000053	0.000029	0.000061	-0.000013	0.000005
	(0.000122)	(0.000179)	(0.000190)	(0.000156)	(0.000168)
Dependent var. (t-1)	0.837***	0.827***	0.830***	0.836	0.836
	(0.0204)	(0.0197)	(0.0208)	(0.0159)	(0.0157)
Old age (t)	0.0470	0.0372	0.0322	0.0434	0.0431
	(0.0288)	(0.0304)	(0.0323)	(0.0264)	(0.0263)
Total spending (t-1)	0.0596***	0.0648***	0.0623***	0.0591	0.0592
	(0.0196)	(0.0203)	(0.0214)	(0.0152)	(0.0151)
$P(\delta > 0)$				0.465	0.510
$P(\delta > 0)$, $\kappa = 0.05$ to 0.20				0.387–0.540	0.412–0.618
Change in debt coefficient, p25 to p75 old age	-0.0006	0.0003	0.0007	-0.0001	0.0001
Observations	2,365	2,365	2,365	2,365	2,365
Controls, country and time effects	Yes	Yes	Yes	Yes	Yes

Notes: Dependent variables: primary spending (Panel A, equation 17) and total revenue (Panel B, equation 18), % of GDP. Specifications as in Table 2, columns (2) and (3), with the debt coefficient and the ageing interaction modelled as in Table 5. Column (1) reproduces Table 2. Columns (1)–(3): OLS with country and time fixed effects; Driscoll-Kraay standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Columns (2) and (3) interact lagged debt with decade and year dummies, respectively. Columns (4)–(5): Bayesian panel time-varying-parameter models, equations (19)–(21) with the dependent variable replaced; posterior means with posterior standard deviations in parentheses; three chains and 18,000 retained draws, $\kappa = 0.10$. Column (5) reports the time average $\bar{\delta}$ of δt over the years with at least 20 countries. Because Proposition 2 implies a smaller expenditure cut and a smaller revenue increase in more aged societies, the table reports the posterior probability of a positive interaction. Controls: lagged real GDP growth, inflation and real long-term interest rate, plus lagged total revenue in Panel A and lagged total spending in Panel B. The row "Change in debt coefficient" multiplies the interaction coefficient by the interquartile range of the old-age dependency ratio (12.2 to 23.5 in Panel A, 12.0 to 23.5 in Panel B).

Table 9. Ageing, democracy and fiscal responsiveness.

	(1)	(2)	(3)	(4)	(5)
Estimator	FE-OLS	FE-OLS	FE-OLS	Bayesian TVP	Bayesian TVP
Debt coefficient	Constant	By decade	By year	Random walk	Random walk
Ageing interaction	Constant	Constant	Constant	Constant	Random walk
Oldage (t) * debt (t-1) [δ]	-0.000288	-0.000434	-0.000669**	-0.000582	-0.000643
	(0.000281)	(0.000290)	(0.000327)	(0.000229)	(0.000270)
Oldage (t) * debt (t-1) * democracy (t) [θ4]	-0.001246	-0.001944	-0.001472	-0.001556	-0.001540
	(0.002193)	(0.001866)	(0.001953)	(0.001487)	(0.001508)
P(θ4 < 0)				0.852	0.846
P(θ4 < 0), κ = 0.05 to 0.20				0.842–0.852	0.839–0.846
Ageing interaction δ + θ4 (D − $\bar{D}$) at:					
low democracy (p10, D = 0.36)	0.000172	0.000284	-0.000125	-0.000007	-0.000075
	(0.001061)	(0.000911)	(0.000950)	(0.000669)	(0.000681)
P(< 0)				0.506	0.542
high democracy (p90, D = 0.89)	-0.000491**	-0.000751***	-0.000909***	-0.000836	-0.000894
	(0.000186)	(0.000238)	(0.000294)	(0.000265)	(0.000313)
P(< 0)				0.999	0.998
Democracy terms (D, debt*D, oldage*D)	Yes	Yes	Yes	Yes	Yes
Controls, country and time effects	Yes	Yes	Yes	Yes	Yes
Observations	2,357	2,357	2,357	2,357	2,357

Notes: Dependent variable: primary balance (% of GDP). Equation (22): equation (16) extended with the V-Dem electoral democracy index D (v2x_polyarchy, 0–1) at t, centered at its sample mean (0.73), and its interactions with lagged debt, the old-age dependency ratio and their product; δ is therefore the ageing interaction at average democracy. Columns (1)–(3): OLS with country and time fixed effects; Driscoll–Kraay standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Columns (2) and (3) interact lagged debt with decade and year dummies, respectively. Columns (4)–(5): Bayesian panel time-varying-parameter models, equations (19)–(21), with the democracy terms as constant regressors; posterior means with posterior standard deviations in parentheses; three chains and 18,000 retained draws, κ = 0.10. Column (5) reports $\bar{\delta}$, the time average of δt over the years with at least 20 countries. The ageing interaction at low and high democracy is evaluated at the 10th and 90th percentiles of D; Driscoll–Kraay standard errors by the delta method in columns (1)–(3) and computed draw by draw in columns (4)–(5). Controls: lagged real GDP growth, inflation and real long-term interest rate.

Table 10. Ageing, the interest–growth differential and fiscal responsiveness.

	(1)	(2)	(3)	(4)
Estimator	FE-OLS	FE-OLS	FE-OLS	Bayesian TVP
Debt coefficient	Constant	By decade	By year	Random walk
Panel A: Primary balance, equation (16)				
Pooled model, regime-specific ageing interaction				
δ when r − g < 0	-0.000194	-0.000371	-0.000544*	-0.000437
	(0.000218)	(0.000283)	(0.000313)	(0.000202)
δ when r − g > 0	-0.000470*	-0.000627**	-0.000836***	-0.000726
	(0.000240)	(0.000287)	(0.000281)	(0.000260)
Difference (r − g > 0 minus r − g < 0)	-0.000275	-0.000256	-0.000292	-0.000289
	(0.000314)	(0.000341)	(0.000308)	(0.000238)
P(δ < 0) when r − g < 0 / > 0				0.985 / 0.997
P(difference < 0)				0.887
Split samples				
r − g < 0 (N = 1,405)	-0.000277	-0.000402	-0.000571	-0.000502
	(0.000261)	(0.000349)	(0.000367)	(0.000231) [0.986]
r − g > 0 (N = 952)	-0.000240	-0.000368	-0.000431	-0.000401
	(0.000304)	(0.000488)	(0.000628)	(0.000368) [0.862]
Observations (pooled)	2,357	2,357	2,357	2,357
Panel B: Primary spending, equation (17)				
Pooled model, regime-specific ageing interaction				
δ when r − g < 0	0.000113	0.000362	0.000589*	0.000361
	(0.000213)	(0.000259)	(0.000305)	(0.000227)
δ when r − g > 0	0.000234	0.000473	0.000708**	0.000498
	(0.000304)	(0.000338)	(0.000349)	(0.000291)
Difference (r − g > 0 minus r − g < 0)	0.000121	0.000111	0.000119	0.000137
	(0.000392)	(0.000411)	(0.000444)	(0.000268)
P(δ > 0) when r − g < 0 / > 0				0.946 / 0.958
P(difference > 0)				0.696
Split samples				
r − g < 0 (N = 1,405)	0.000027	0.000339	0.000483	0.000178
	(0.000223)	(0.000318)	(0.000345)	(0.000237) [0.774]
r − g > 0 (N = 952)	0.000224	0.000395	0.000371	0.000434
	(0.000232)	(0.000364)	(0.000517)	(0.000412) [0.857]
Observations (pooled)	2,357	2,357	2,357	2,357
Panel C: Total revenue, equation (18)				
Pooled model, regime-specific ageing interaction				
δ when r − g < 0	-0.000038	0.000021	0.000055	0.000001
	(0.000132)	(0.000186)	(0.000206)	(0.000169)
δ when r − g > 0	-0.000159	-0.000105	-0.000075	-0.000119
	(0.000209)	(0.000255)	(0.000292)	(0.000228)
Difference (r − g > 0 minus r − g < 0)	-0.000121	-0.000127	-0.000130	-0.000119
	(0.000206)	(0.000217)	(0.000283)	(0.000222)
P(δ < 0) when r − g < 0 / > 0				0.498 / 0.699
P(difference < 0)				0.706
Split samples				
r − g < 0 (N = 1,410)	-0.000226	-0.000035	-0.000072	-0.000188
	(0.000161)	(0.000238)	(0.000268)	(0.000191) [0.839]
r − g > 0 (N = 955)	0.000042	0.000066	-0.000023	0.000083
	(0.000244)	(0.000361)	(0.000335)	(0.000299) [0.394]
Observations (pooled)	2,365	2,365	2,365	2,365
Controls, country and time effects	Yes	Yes	Yes	Yes

Notes: r − g is the lagged real long-term interest rate minus lagged real GDP growth; regime indicator P = 1(r − g > 0). Pooled model: equations (16)–(18) extended with P and its interactions with lagged debt, the old-age dependency ratio (centred at its sample mean) and their product, so that the ageing interaction is δ when r − g < 0 and δ + θ when r − g > 0; the row "Difference" reports θ. Split samples: the same equations

estimated separately on the observations with $r - g < 0$ and $r - g > 0$. Columns (1)–(3): OLS with country and time fixed effects; Driscoll–Kraay standard errors in parentheses (delta method for $\delta + \theta$); *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Columns (2) and (3) interact lagged debt with decade and year dummies. Column (4): Model A, equations (19)–(20), with the regime terms as constant regressors; posterior means with posterior standard deviations in parentheses; $\kappa = 0.10$; three chains and 18,000 retained draws. In the split samples, column (4) also reports in brackets the posterior probability of an effect with the sign predicted by Proposition 2 (negative for the primary balance and revenue, positive for primary spending), and years with fewer than 10 countries are excluded from the figures. Controls as in Table 2.

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