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Stock-flow adjustments, public debt management and interest costs[☆]

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ABSTRACT

Data on government debt and deficits are not mutually consistent because they are obtained from cash and accrual accounting, respectively. Such aggregates are reconciled through accounting items known as stock-flow adjustments. In spite of the evidence from several studies that they are dependent on macroeconomic indicators, empirical analyses of debt sustainability disregard stock-flow adjustments. We study thirty-two economies over the period 1999–2019, finding that stock-flow adjustments are a hidden component of interest costs, largely produced by governments' debt management activities. An alternative, stock-flow consistent variable measuring interest costs is larger, more volatile and sensitive to macroeconomic indicators than standard interest costs, featuring dynamics strongly influenced by US interest rates. This broader measure of interest costs rises with debt levels in high-debt countries, while standard interest costs do not. Hence, when ignoring the non-linear responses captured by stock-flow adjustments we underestimate the acceleration in debt costs caused by higher debt.

1. Introduction

Stock-flow consistency is a pillar of dynamic macroeconomic models developed since the 1960s. In some instances, however, it is not easy to reconcile rigorous theoretical modeling with the available data. Such an issue becomes apparent when dealing with government data, because figures on debt levels and interest payments track changes in cash accounting, whereas figures on tax revenues, expenditure, and primary deficits are obtained from accrual-based accounting reflecting the need to plan the budget. Data on stocks (debt) and flows (deficits) are therefore not mutually consistent, and the reconciliation of government accounts is typically obtained by creating an artificial accounting figure known as stock-flow adjustments. This last is produced by several different factors, such as net acquisitions of financial assets; transactions in liabilities that are excluded from standard government debt definitions, like derivatives; valuation effects caused by debt issuance above/below par, or redemption of debt above/below par; appreciation/depreciation of foreign-currency debt.[1]

Debt sustainability analyses are based on accounting figures for current and expected budget surpluses or deficits. In such a context, the government's inter-temporal budget constraint can originate highly non-linear debt accumulation dynamics to the extent that the measurement errors captured by stock-flow adjustments are not pure white-noise processes over long time horizons, and this would be the case even when adjustments are negligible in magnitude. Fig. 1 displays the effect of stock-flow adjustments on the dynamics of debt accumulation for six high-debt economies: the US, Japan, Italy, Greece, Spain, and the UK. Such diagrams compare the actual debt accumulation dynamics (solid lines) with two calculated series.[2] The former (dashed lines) is produced under the assumption of the absence of stock-flow adjustments. The latter (dotted lines) captures the effects of adding stock-flow adjustments to a stabilization rule designed to perfectly stabilize debt under the assumption of zero adjustments. The first comparison suggests that even when adjustments are negligible – as it was the case for the six countries considered – the calculated debt

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[1] Net acquisitions of financial assets are always sizable and the main drivers normally involve transactions in shares, following privatizations or bail-outs of private-sector firms, and changes in the deposit position with the central bank. Valuation effects are largely the results of the issuance of short-term treasuries such as zero-coupon bonds. Changes in the value of foreign-currency debt are normally relevant for developing countries, while transactions in derivatives are relevant in developed ones.

[2] Such calculated series are obtained by combining observations of public deficit, GDP growth, interest cost on debt, and stock-flow adjustments over the period 1980–2019 that we retrieve from the World Economic Outlook (WEO) database.

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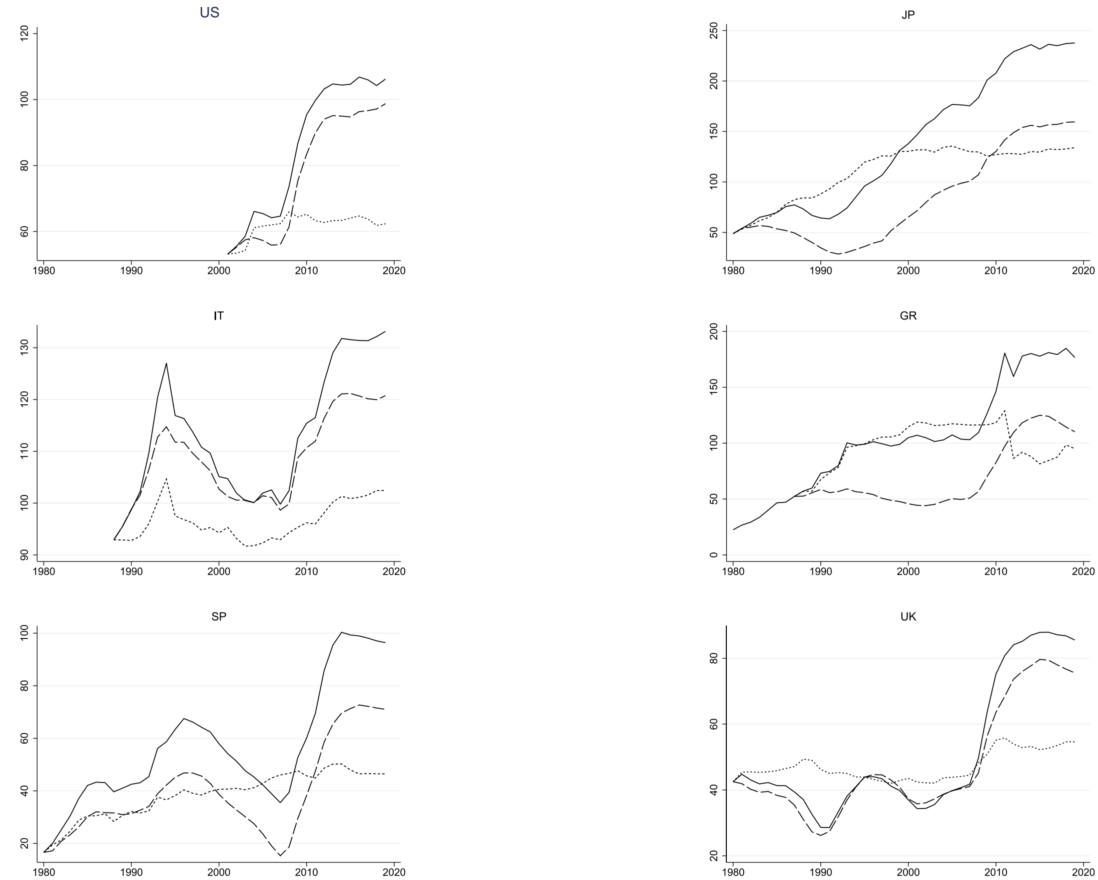

Fig. 1. The graphs compare actual debt dynamics (solid line), calculated debt dynamics according to the government inter-temporal budget constraint where debt is cumulated in the absence of stock-flow adjustments (dashed line), and calculated debt dynamics obtained by adding the stock-flow adjustments to a stabilization rule designed to perfectly stabilize debt when not considering the effect of adjustments (dotted line) for the US, Japan, Italy, Greece, Spain, and the UK.

trajectories in case of the absence of stock-flow adjustments drastically differ from the actual ones after just two decades. For instance, in the case of Japan, the calculated debt almost halves, whereas in all other cases, such trajectories remain consistently lower.[3] The third calculated debt accumulation trajectories suggests instead that when adding stock-flow adjustments to the standard debt stabilization rule, debt levels diverge meaningfully from the initial value. Although the relevance of stock-flow adjustments has been acknowledged in several studies, the literature on debt stability and sustainability has so far implicitly assumed that accounting inconsistencies generate measurement errors that are purely erratic and quickly revert to a zero mean.

In this study, we gather data for thirty-two countries over the period 1980–2019 and show that stock-flow adjustments depart from white-noise processes and do not revert to a zero mean.[4] Indeed, we show that stock-flow adjustments are largely produced by active management of government debt and the issuance of short-term debt. Hence, they represent a hidden component of interest costs whose stochastic properties are different between low- and high-debt economies. We then propose a new measure of interest cost on debt that accounts for such features of stock-flow adjustments and discuss the implications for debt sustainability.

An early strand of literature has studied the properties of stock-flow adjustments, finding that they are nearly always and everywhere of relevant size. For instance, Campos et al. (2006) or Abbas et al. (2011) found that such adjustments are as important as government deficits in explaining fluctuations of government debt. Moreover, Weber (2012) found that stock-flow reconciliations can be only partially explained by balance sheet effects and realizations of contingent liabilities. Indeed, they also reflect macroeconomic factors such as foreign exchange fluctuations and inflation in developing countries, whereas in developed ones they are associated with large declines in GDP and one-off disbursements ensuing financial crises. A more recent strand of research has focused on the institutional and political factors behind stock-flow adjustments. Beetsma et al. (2009) provide evidence that stock-flow adjustments are positively linked to GDP forecasts and negatively related to the current levels of debt. Von Hagen and Wolff (2006) investigate whether stock-flow adjustments represent accounting stratagems that governments operate to dodge EU budget rules, finding evidence that such adjustments are used to manipulate deficits. The results from Afonso and Jalles (2020), by contrast, indicate that fiscal rules do not induce governments to make systematic use of stock-flow adjustments to manipulate government deficits, confirming the findings from Seiferling (2013) that, in most cases, stock-flow residuals can be fully explained by changes in the volume and valuation of financial assets, and are not correlated with fiscal transparency. Finally, Jaramillo et al. (2017b) find that large spikes in government debts have been driven by peaks in stock-flow adjustments, especially in the case of advanced economies, and are often associated with financial market distress. Jaramillo et al. (2017a) find instead that countries plagued with a substantial accumulation of stock-flow adjustments also feature a greater probability of experiencing non-declining debt trajectories in

[3] Using longer datasets the difference would become even more striking, but we prefer to work with the most recent and consistent available cross-country data.

[4] The cohort of countries consists of Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, South Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the UK, and the US.

the aftermath of government debt spikes. To summarize, the literature has provided strong evidence that stock-flow adjustments are not purely erratic processes, being influenced by several macroeconomic variables such as output, inflation, and debt.

In the first part of this study, we advance our understanding of the driving forces behind stock-flow adjustments for the cohort of the thirty-two countries previously specified. To capture the effects of the international business cycle beyond the control of individual governments, we use Augmented Mean Group (AMG) estimators which are robust to cross-sectional dependence and allow the detection of common factors.[5] We provide three new sets of results. First, we find a non-linear relationship between stock-flow adjustments and debt levels, which affects debt dynamics differently in low- and high-debt economies. Second, we provide evidence supporting the hypothesis that stock-flow adjustments are largely a by-product of debt management conducted by adjusting the maturity structure as the market's appetite for government bonds shifts, and by using financial derivatives. Third, we show the existence of a common global factor, which is strongly significant in stock-flow adjustment regressions, and correlated with U.S. interest rates.

In the second part, we deal with the implications of stock-flow dynamics for debt sustainability. The motivation for such an analysis is that most studies on debt sustainability assume *a priori* that stock-flow adjustments are white-noise processes, and therefore disregard the impact that they might exert on debt dynamics.[6] However, if such an assumption does not hold then stock-flow adjustments become an omitted variable that may be relevant in many instances. Indeed, we provide evidence that stock-flow adjustments are too large and persistent to be swept aside, and they should instead be treated as an essential part of a more comprehensive measure of interest costs that embeds both the accounting figures for interest costs and stock-flow adjustments. This alternative measure of interest costs, which we dub shadow interest costs, shares some characteristics with the measures of government debt costs already proposed by Berndt and Yeltekin (2015), Ellison and Scott (2020), and Hall and Sargent (2011). On the one hand, like such measures, shadow interest costs also recover a measure of debt costs consistent with the government debt accumulation process. We do so for the whole stock of debt, hence enabling international comparisons on a consistent, measurement error-free basis. On the other hand, our measure of shadow interest costs departs from those proposed in the above studies because it is not based on market values of debt, but rather on their book-value counterparts that are normally used in government debt analyses, public finance studies and, more importantly, government budgets.[7]

We carry out a comparative analysis between the shadow and accounting interest costs, finding that the former are far more sensitive to changes in macroeconomic conditions than the latter. In particular, the non-linear response of shadow interest costs to debt levels is way beyond that of accounting interest costs, whereas the response of shadow costs to short-term rates is substantially weaker. The implications for debt sustainability analyses are therefore substantial, because ignoring the non-linear responses captured by stock-flow adjustments might result in underestimations of the acceleration in debt costs caused by higher debt.

Finally, we uncover a structurally different pattern of shadow interest costs between high- and low-debt economies. Such a stark difference is produced by a different correlation between accounting interest costs and stock-flow adjustments in the two cases: for low-debt countries the correlation is negative, while for high-debt ones it is positive, therefore making shadow interest costs far more volatile for the latter cohort of economies. Consequently, shadow costs respond to macroeconomic variables and risks in structurally different ways in the two cohorts, reflecting different debt management strategies. As widely acknowledged in the literature, various countries, particularly those that are highly indebted, do not manage debt in order to smooth taxes, they do it to minimize accounting interest costs, seek insurance against macroeconomic shocks or reduce the risk of deficits spiraling out of control.[8] Our evidence suggests that in the case of high-debt countries, the dynamics of shadow interest costs reflect the constraints imposed by the need to roll over debt, which is highly cyclical. In low-debt countries, by contrast, debt issuance is neither constrained by interest expenditure, nor by the need to finance current expenditure. Our empirical evidence is consistent with the hypothesis that such countries issue debt opportunistically to benefit from market-making activities, by providing either risk-free securities or liquidity when the risk appetite of the private sector shifts.

Our results suggest that shadow costs do not peak during recessions and that high-debt countries exercise discipline in debt management, although their space to implement counter-cyclical fiscal policies may be far more limited than usually assumed. For instance, peaks in market interest rates have a rather limited influence on accounting interest costs, while they exert a strong negative impact on shadow costs in high-debt countries. Hence, debt-management policies are effective in curbing interest costs; however, the benefits from persistently low market interest rates may be far smaller than usually expected. Finally, we find that common global factors, strongly correlated with U.S. interest rate dynamics, are important drivers of both accounting and shadow interest costs, in particular in high-debt countries.

The remainder of this study is organized as follows: Section 2 introduces the data, discusses the relationship between stock-flow adjustments and debt, and formulates our measure of shadow costs. Section 3 defines the empirical specifications that we estimate, the related hypothesis testing, and the empirical methods used. Section 4 discusses our empirical results, while Section 5 concludes.

2. Data

We gather series from the World Economic Outlook (WEO) database for stock-flow adjustments, government debt (at book value), budget and primary balance, revenues, expenditure, and interest paid on government debt (throughout the paper we refer to this last series as accounting interest costs) spanning the period 1980–2019 for the sample of thirty-two economies previously specified. We then use the OECD database to supplement our main dataset with series for inflation, output gaps, yield spreads, and governments' financial assets and liabilities.[9] These last track changes in governments' portfolios of financial assets, which become relevant following the bailout of private

[5] These techniques are standard in government debt stability analyses (see, e.g., Beqiraj et al., 2018, and Cerniglia et al., 2020), but have not been used yet in studies that focus on stock-flow adjustments.

[6] Recent examples include Beqiraj et al. (2018), Casalin et al. (2020), Fournier and Fall (2017), and Gnegne and Jawadi (2013).

[7] Our measure is not directly influenced by the changes in market rates that affect bond prices, which influence government debt management only indirectly by affecting the cost of new issuance.

[8] See Missale (2001, 1999) for an analysis focused on the European Union.

[9] The output gap is defined as GDP growth minus the long-run trend. The yield spread is specified as the difference between long- and short-term yields on government bonds. Government financial assets include shares, other securities, loans, deposits, and other account receivables. In 2009 the average composition of such aggregates in the Euro area was: shares 37.5%, currency and deposits 19.2%, loans 13.3%, securities other than equity 10.3%, other receivables 18.6%, with a residual aggregate consisting of derivatives and insurance technical reserves. See ECB Monthly Bulletin, June 2010. The above composition remained substantially unchanged in subsequent years, as shown in Mink and Rodríguez Vives (2004). More recently, EUROSTAT has started publishing detailed data on the composition of the stocks of financial assets. For example, for 2018 the average changes in the composition were: shares 25.8%, currency and deposits 55.9%, loans −6.8%, securities other than equity −6.5%, and other receivables 39.9%. See EUROSTAT (2020).

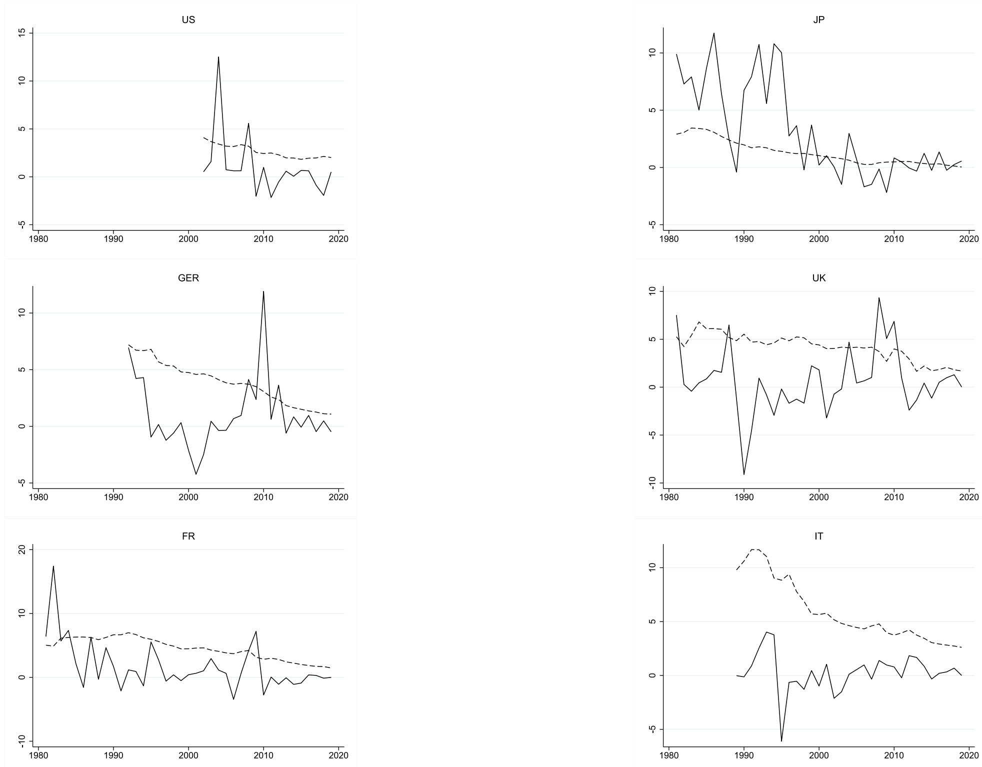

Fig. 2. Annual stock-flow adjustments (solid line) and accounting interest cost $i_{j,t}$ (dashed line) for the US, Japan, Germany, the UK, France, and Italy. Stock-flow adjustments calculated as a ratio to debt.

sector firms, as in the case of retail banks during financial crises, or conversely, after the privatization of government-owned enterprises.

We use series for liabilities at market value that we match with their counterparts at book value from WEO, to compute a market-to-book spread defined as the difference between the market and the book value of general government liabilities. One can think of this spread as a proxy for the duration of the stocks of government debt, which widens or shrinks because of decreases or increases in market rates, in proportion to the average duration of the existing stock of debt.

Since our dataset is a combination of WEO and OECD series, in Appendix A we carry out two different checks to verify the full consistency between the two sources.

2.1. Stock-flow adjustments and debt

To simplify the analysis, in this section, we define stock-flow adjustments as a ratio to debt, unlike the standard definition as ratios to output. This allows for a more straightforward comparison with accounting interest costs. Fig. 2 displays data for adjustments and accounting interest costs for several countries, showing that the former is always relevant in size, normally larger, and way more volatile than the latter.

We start our analysis by shedding light on the relationship between stock-flow adjustments and debt levels. We show that such a relationship is strong, but also highly non-linear, making the behavior of the adjustments of high- and low-debt countries very different. More specifically, we calculate average means (denoted with $\overline{SFA_i}$) and standard deviations ($\sigma(SFA_i)$) of the stock-flow adjustments, as well as of debt levels ($\overline{D}_i$) for each country. We then carry out OLS-HAC estimates of the following specifications:

$$\overline{SFA_i} = \alpha_0 + \alpha_1 \times \overline{D}_i + \epsilon_i \tag{1}$$

$$\sigma(SFA_i) = \alpha_2 + \alpha_3 \times \overline{D}_i + e_i \tag{2}$$

where $i = 1, .., 32$. The slopes α_1 and α_3 are of the order of -0.138 and -0.199 respectively, and significant at the 1% level, showing that both the size and volatility of stock-flow adjustments are much larger for countries that feature low levels of debt. But is the relationship between adjustments and debt linear? We answer this question by estimating recursively both Eqs. (1) and (2). We sort the countries according to their respective debt levels in ascending order; we then consider an initial sample of as many as 11 observations comprising only the most virtuous countries. As the upper bound of the sample shifts forward, countries are added one at a time, so that the same sample gradually embeds those economies featuring larger debts. We estimate the slopes for each sample.

The left and right panels of Fig. 3 display the recursive slopes of Eq. (1) and (2) in the samples sorted in ascending order from low- to high-debt countries.[10] The relationship is remarkably different for low- and high-debt economies, with responses of adjustments – in both level and volatility – that are far stronger for low-debt economies. The slope estimates show a marked change in their patterns in correspondence with the UK. Thus, we take this country as the cut-off unit to partition the full sample of thirty-two units into two separate cohorts of low- and high-debt economies, implicitly setting a debt threshold equal to 50 percent. Table 1 shows the composition of these two cohorts, together with their average levels of debt, accounting interest costs, and stock-flow adjustments.[11]

With such a partition in mind, in Appendix B we carry out a further analysis to gauge the mean reversion of the adjustments series. This is important because the overall impact of stock-flow adjustments on

[10] Such a sample features Estonia (with an average debt-to-GDP ratio as low as 6.8%) and Japan (with an average ratio as high as 138.9%) as first and last observation, respectively.

[11] Eminidou et al. (2021) also emphasize that differences in the cross-sectional dimension of government debt play an important role in the impact of fiscal policy, and provide a similar partition of EU countries.

Fig. 3. Recursive estimates of the slope (solid lines) of Eq. (1) (left) and (2) (right panel), with upper and lower 95% confidence intervals (dotted lines). Samples sorted in ascending order from low- to high-debt economies.

Table 1
Partition between high- and low-debt economies.
Source: WEO database.

HIGH				LOW			
Country	$\overline{D}_i$	$\bar{i}_i$	$\overline{SFA}_i$	Country	$\overline{D}_i$	$\bar{i}_i$	$\overline{SFA}_i$
Japan	138.9	1.300	3.144	Sweden	49.21	1.914	1.937
Italy	113.2	5.932	0.286	Denmark	48.33	2.644	1.823
Belgium	110.5	5.795	0.605	Switzerland	47.39	1.273	1.806
Greece	103.8	6.581	2.754	Iceland	47.24	3.962	12.62
US	85.44	2.650	1.007	Slovakia	41.86	4.288	−1.846
Portugal	80.18	5.843	−0.294	Slovenia	41.34	4.252	7.724
Canada	78.48	3.332	2.686	Finland	38.85	−2.465	17.27
Israel	73.76	3.913	−1.062	New Zealand	37.76	7.310	4.623
Austria	69.15	3.501	0.756	Norway	36.93	−6.001	29.986
Germany	63.10	3.840	1.037	Czech Republic	28.75	2.488	−3.681
Malta	61.87	5.023	0.202	Lituania	28.73	3.188	−1.976
Ireland	61.14	3.526	4.026	Latvia	26.58	4.613	7.483
Netherlands	60.47	3.539	−0.399	Australia	24.29	3.569	3.655
France	59.84	4.504	1.695	South Korea	23.22	1.507	23.22
Spain	56.85	4.632	2.688	Luxembourg	13.77	−8.286	33.67
UK	51.28	4.161	0.600	Estonia	6.882	−1.235	16.61

Note: $\overline{D}_i$, $\bar{i}_i$, and $\overline{SFA}_i$ are average means of the level of debt, accounting interest costs, and stock-flow adjustments expressed as a ratio to debt over the period 1989–2019. All values are in percentage terms. HIGH denotes the cohort of economies with average debt equal or greater than the UK's. LOW denotes the cohort of economies with an average debt smaller than the UK's.

debt depends not just on their level, but also on their persistence to shocks. Empirical results suggest that stock-flows are by and large stationary, with the cohort of low-debt countries featuring more persistent adjustments than those holding high debt.

2.2. Accounting and shadow interest costs

We start by providing a formal definition of accounting interest costs i_t as the interest paid in year t divided by the nominal value of debt at year $(t-1)$, i.e. $i_t = \frac{IC_t}{D_{t-1}}$. Defining PS_t as the primary surplus at time t, due to the lack of stock-flow consistency, typically:

$$i_t \neq \frac{D_t - D_{t-1} + PS_t}{D_{t-1}}. \tag{3}$$

We then introduce our measure of shadow interest costs, specified as $i_t^* = \frac{IC_t^*}{D_{t-1}}$ where this time $IC_t^* = IC_t + SFA_t$, and we can write that:

$$i_t^* = \frac{D_t - D_{t-1} + PS_t}{D_{t-1}}, \tag{4}$$

where the term SFA_t captures the stock-flow adjustments. From Eq. (4) it follows that:

$$i_t^* = i_t + \frac{SFA_t}{D_{t-1}}. \tag{5}$$

This last relationship highlights several interesting features. First, it shows that shadow interest costs could depart (positively or negatively) from their accounting counterparts as they also embed the stochastic properties of stock-flow adjustments. Second, shadow interest costs should normally feature larger volatility than accounting costs, unless the correlation between these last and stock-flow adjustments is negative. Third, stock-flow adjustments expressed as a ratio of nominal debt enable a more straightforward comparison with both shadow and accounting interest costs.[12] Finally, from the same relationship, we can write:

$$SFA_t = D_t - D_{t-1} + PS_t - IC_t = D_t - D_{t-1} - DEF_t, \tag{6}$$

which is the standard definition of stock-flow adjustments, where $DEF_t = IC_t - PS_t$ are the reported government deficits. The cash balances that correspond to the accrual deficits or surpluses are always measured with an error that feeds into the stock-flow adjustments. For instance, if the actual, unobserved, primary surplus $\hat{ps}_t$ is larger than its accounting counterpart, then the new debt levels will be lower than those predicted by accrual accounting, and a negative adjustment is posted. Similarly, if an actual deficit is larger than its accounting counterparts, then debt levels rise more than expected, originating a positive adjustment.

2.3. Stock flow adjustments and primary deficits

In treating stock-flow adjustments as unreported interest costs, we have neglected the alternative hypothesis that the same adjustments might be instead a hidden component of general government deficits. EUROSTAT provides a detailed analysis of stock-flow adjustments for the European Union in the years between 2016 and 2019.[13] During such period, the average values of stock-flow adjustments for the EU 21 and the EU 17 were positive. The component of the stock flow adjustments produced by mismatches between the accrual figures for the net balance between revenues and expenditure and the correspondent cash revenues or disbursement is defined as "Net incurrence of other accounts payable". This item is always large and negative, suggesting that the actual average cash expenditure is normally smaller than the corresponding average accrual figure and/or that the actual average cash revenues are larger than the figures in accrual accounting. A similar pattern emerges also from the figures for individual countries. Hence these figures apparently do not correspond to hidden deficits, but rather to hidden surpluses. We find similar evidence in our data, where the pairwise correlation between stock-flow adjustments and primary surpluses is positive and statistically significant at the 1 percent level. Consequently, adjustments are large and persistent in spite of the structural *negative* contribution from primary deficit accounting. This correlation, already reported by Von Hagen and Wolff (2006), indicates that accounting figures for primary surplus are systematically overestimated, and according to the authors may indicate accounting

[12] More specifically, from Eq. (5) it follows that stock-flow adjustments expressed as a ratio of nominal debt can be computed through the spread $(i_t^* - i_t)$.

[13] See EUROSTAT (2020).

manipulations to dodge constraints imposed by budget rules such as the Stability and growth pact of the European Union. However, the same correlation suggests that large accounting deficits are associated with smaller adjustments. Hence, in the case of countries reporting large deficits the actual increase in debt is normally proportionally smaller than expected, therefore generating a negative component of adjustments. The financial component of adjustments is consequently larger than the reported figure and, in principle, a better availability of data will allow in the future to rigorously separate the two. We will treat all of the adjustments as financial costs even if our figures are net of the negative component from primary deficits or surpluses, implicitly treating the cash savings generated from accrual accounting of revenues and expenditures as financial revenues.

We further inquiry if primary surpluses respond to the unaccounted component of government debt by running fiscal reaction functions following the approach of Bohn (2008) and Canzoneri et al. (2001) recently adopted by Afonso and Coelho (2023) in a panel setting. We find that lagged values of stock-flow adjustments are never statistically significant in the regressions.[14]

3. Empirical models

The first part of our study analyzes the variables that influence stock-flow adjustments. We start by reproducing the standard results obtained in the literature, but we also split the sample into the two cohorts of high- and low-debt economies, to show that the sensitivity to macroeconomic determinants is very different for the two groups. We then propose a few macroeconomic indicators that can account for the ways governments manage their debt, and provide evidence that such indicators influence stock-flow adjustments. Finally, we provide evidence that such adjustments are in part driven by international macroeconomic factors that are beyond the control of national governments. In line with the literature, we initially regress stock-flow adjustments specified as ratios to GDP (that we denote with $SFA_{j,t}$) on inflation ($\pi_{j,t}$) and output gap ($OUT_{j,t}$) as main determinants, and supplement such a specification with a set of explanatory variables that are potentially relevant.[15] We focus on government finance variables to investigate whether adjustments emerge because some costs are not properly recorded on government accounts. We consider the government primary surplus ($PS_{j,t}$), the accounting interest cost ($i_{j,t}$), and the book value of the stock of debt $D_{j,t}$, all expressed as ratios to GDP.[16] In addition, we also control for changes in the government's financial assets position ($\Delta ASST_{j,t} = ASST_{j,t} - ASST_{j,t-1}$) as in Seiferling (2013), again expressed as a ratio to GDP.[17] The volume of financial assets would rise, for instance, following the acquisition of financial institutions as a result of banking crises, while their market value varies with fluctuations of short-term interest rates and risk-premia. Thus, we consider the following baseline specification:

$$SFA_{j,t} = \beta_0 + \beta_1 \pi_{j,t} + \beta_2 OUT_{j,t} + \beta_3 PS_{j,t} + \beta_4 i_{j,t} + \beta_5 D_{j,t} + \beta_6 \Delta ASST_{j,t} + \epsilon_{j,t}, \tag{7}$$

where $SFA_{j,t}$ is measured as a ratio to GDP, in line with the literature. Unlike standard practice, we use estimation techniques that allow for the detection of global common factors. More specifically, we estimate Eq. (7) using AMG estimators that account for cross-sectional dependence in the disturbance terms, which may arise because of common shocks and unobserved components affecting our panel of countries.[18]

We then supplement the same specification with a set of explanatory variables, not previously considered, explaining the emergence of the adjustments as the by-product of debt management:

$$SFA_{j,t} = \beta_0 + \beta_1 \pi_{j,t} + \beta_2 OUT_{j,t} + \beta_3 PS_{j,t} + \beta_4 i_{j,t} + \beta_5 D_{j,t} + \beta_6 \Delta ASST_{j,t} + \beta_7 MtB_{j,t} + \beta_8 s/t_{j,t} + \beta_9 YS_{j,t} + \epsilon_{j,t}, \tag{8}$$

where $MtB_{j,t}$ is the market-to-book ratio of debt, $s/t_{j,t}$ is the yield on short-term government bonds and $YS_{j,t}$ is the slope of the term structure. To understand the rationale for including such variables, it must be noted that one of the main sources of stock-flow adjustments consists of the reimbursements of treasuries (mainly zero-coupon bonds) issued below or above par (see, e.g., Von Hagen and Wolff, 2006). As short-term yields rise, the issuance price of treasuries, like for instance T-bills, falls progressively below par, whereas with declining yields, the same price goes above par. Consequently, increasing market yields produce positive adjustments, while declining yields generate negative ones.[19] The same mechanism is in place when long-term debt is repurchased above or below par and therefore the adjustments may respond not only to short-term but also to long-term yields, since variations in the latter generate the incentives to actively trade debt: for instance, higher long-term yields make it possible to repurchase debt at a price below par, generating negative stock-flow adjustments.

Derivatives are a further important source of adjustments, because interest rate swaps have become an important tool for debt management operations, and the cash flows produced by such transactions are recorded as stock-flow adjustments. A survey conducted by the OECD in 2011 on a sample of 32 countries largely overlapping with our own, found that interest rate swaps had been used for more than 15 years by 9 countries, while 24 had been using derivatives well before 2005. The average notional amount of derivatives outstanding, for the 2007–2010 period was around 8 percent of central government debt, with five countries in the 20-to-50 percent range and two countries above 100 percent.[20] Small countries with limited amounts of outstanding debt typically undertake interest rate swap contracts as receivers, paying a variable interest rate to receive a fixed one. This strategy allows them to increase the liquidity of the outstanding bonds by concentrating the issuance on a few maturities only (typically 10 years), but without losing the benefits produced by low short-term rates.[21] The cash flows received are in this case negatively correlated to interest rates and

[14] The results are available from the authors upon request.

[15] This specification follows Campos et al. (2006).

[16] For example, Beetsma et al. (2009) show that adjustments and levels of debt are negatively correlated.

[17] The series measure the outstanding volumes of assets at market value held by governments.

[18] To test for cross-sectional dependence we make use of both the Breusch and Pagan (1980) and Pesaran (2021) tests. Since our analysis is based on data featuring similar values for T and N, we choose to rely on both the aforementioned tests, with the caveat of privileging the outcomes obtained from the Breusch–Pagan statistics in case of conflicting results.

[19] This effect is offset by the difference between interest rates accrued and paid, since reported government expenditure on interests is spread over time, in line with the accrual principle, whereas the cash impact occurs only when interests are actually paid. Given that debt is measured on a cash basis, accrued interests are excluded from the stock of debt. In the case of short-term debt, therefore, accrued interests are reported as interest costs, and the overall amount becomes correspondingly higher than the actual cash disbursement. So the higher the yields, the greater the interest costs reported, and also the corresponding stock-flow adjustment produced by a below-par issuance. To avoid double counting, an accounting item reports the difference between interest accrued and paid. However, this figure is typically smaller than its counterpart measuring the impact of issuance below or above par, probably because accrual accounting does not fully reflect expected trends in interest costs. See the data reported in EUROSTAT (2020).

[20] See OECD (2011).

[21] This strategy has been widely adopted in Europe following the introduction of the common currency, as discussed in Wolswijk and De Haan (2005).

positive cash flows generate negative adjustments.[22] Highly indebted countries need to stabilize interest costs and often choose to forego benefits deriving from lower rates to reduce interest-rate risks. They do so by entering interest rate swap contracts as payers, hence paying a fixed amount to receive a variable rate. This strategy allows fixing the cost of the short-term portion of the debt, with benefits similar to those produced by an extension of the average debt maturity, while managing debt issuance to fully satisfy market demand for securities of different maturities. The high-debt countries that adopted this strategy, like Italy before the financial crisis, have benefited from positive cash flows in years when interest rates were rising while taking losses in the face of declining rates, as such cash flows are recorded as stock-flow adjustments (negative, or positive, respectively).[23]

We control for these two effects by analyzing the impact of short-term yields ($s/t_{j,t}$) and yield spreads ($YS_{j,t}$) — as a proxy of the opportunity cost of long- versus short-term debt. On top of these effects, whenever short-term yields increase, another related effect might be in place — as governments that actively manage issuance to minimize the cost of debt may respond by substituting short- with long-term securities. Indeed, Missale et al. (2002) find evidence that when high-debt countries join stabilization programs, they increase the share of fixed-rate long-term debt denominated in the domestic currency, proportionally more as the level of current and expected long-term interest rates decline.[24] More recently, Beetsma et al. (2021) find a strong negative correlation between the average maturity of new debt issued by European economies and both the level and the slope of their yield curves. Since no comprehensive data on debt maturities are available, we use as a proxy the difference between the market and book value of outstanding government liabilities ($MtB_{j,t}$).[25] Indeed, this variable changes over time because of fluctuations in market interest rates, and it does so in proportion to the average duration of the existing stock of debt. Hence, higher short-term rates induce a decline in the ratio which is proportional to the duration of debt, and vice-versa. When controlling for short-term rates, this variable provides information on the role of the average maturity.

The hypotheses under scrutiny are thus the following:

(a) Higher short-term yields may be related to lower stock-flow adjustments in high-debt countries if such countries respond by issuing proportionally fewer short-term debt.
(b) Higher short-term yields may be associated with larger adjustments in low-debt countries that use swap contracts as receivers and with smaller adjustments for the high-debt ones that enter the same contracts as payers.
(c) Wider yield spreads – by signaling that long-term debt is relatively more expensive – can induce governments to issue debt at shorter maturities and this would eventually result in larger adjustments.
(d) A larger market-to-book value ($MtB_{j,t}$), typically associated with longer average maturities, is expected to be associated with lower adjustments.

Having previously defined our measure of shadow interest costs, we investigate whether this last differs from accounting interest costs. We conduct a preliminary analysis to gauge to what extent stock-flow adjustments drive a wedge between shadow and accounting costs. We then carry out a set of new regressions to compare the driving forces of the two interest costs, by estimating the following two specifications:

$$i^*_{j,t} = \gamma_0 + \gamma_1\pi_{j,t} + \gamma_2 OUT_{j,t} + \gamma_3 PS_{j,t} + \gamma_4 \Delta ASST_{j,t} + \gamma_5 D_{j,t} + \gamma_6 MtB_{j,t} + \gamma_7 s/t_{j,t} + \gamma_8 YS_{j,t} + \epsilon_{j,t} \quad (9)$$

$$i_{j,t} = \beta_0 + \beta_1\pi_{j,t} + \beta_2 OUT_{j,t} + \beta_3 PS_{j,t} + \beta_4 \Delta ASST_{j,t} + \beta_5 D_{j,t} + \beta_6 MtB_{j,t} + \beta_7 s/t_{j,t} + \beta_8 YS_{j,t} + \epsilon_{j,t}. \quad (10)$$

By analyzing Eqs. (9)–(10) we investigate whether shadow interest costs ($i^*_{j,t}$) and accounting ($i_{j,t}$) interest costs are broadly similar processes or if, on the contrary, they respond to different macroeconomic determinants. The gauging of such differences is important because governments, rating agencies, and international organizations evaluate the stability and sustainability of debt based on the accounting interest costs, but arguably the shadow costs should embed a more comprehensive information content.[26]

3.1. Estimation methods

A distinctive property of the variables of our analysis is that they feature cross-sectional dependence (CSD).[27] Thus, we apply Eberhardt and Teal's (2010) Augmented Mean Group (AMG) estimator (see also Eberhardt (2012)) that has the desirable feature of providing a time-series estimation of the common factor.[28] Hence, we can gauge the relative importance of global drivers in stock-flow adjustments, as well as the shadow and accounting interest costs. We, therefore, adopt the following common factor specification where $j = 1, 2, \ldots, N$, $t = 1, 2, \ldots, T$, and K is the number of common factors affecting both the disturbance term as well as the explanatory variables:

$$y_{j,t} = \beta_i' x_{j,t} + u_{j,t} \quad (11)$$

$$u_{j,t} = \alpha_j + \lambda_j' f_t + e_{j,t} \quad (12)$$

$$x_{j,t} = \pi_j + \sum_{k=1}^{K} \delta_{k,j}' g_{kt} + \sum_{k=1}^{K} \phi_{k,j} f_{k,t} + \upsilon_{j,t} \quad (13)$$

$$f_t = \rho f_{t-1} + \epsilon_t \quad (14)$$

$$g_{j,t} = \chi' g_{j,t-1} + \epsilon_t', \quad (15)$$

where $y_{j,t}$ represents, one at time, the stock-flow adjustments ($SFA_{j,t}$), the shadow ($i^*_{j,t}$) and accounting ($i_{j,t}$) interest costs, $x_{j,t}$ is a vector of observables, f_t is a vector of k factors, and λ_j is a vector of unit-specific sensitivities. We account for the presence of common factors through a combination of a country-specific intercept α_j, and a set of common factors f_t with country-specific factor loadings λ_j. We then complete the setup by specifying an AR law of motion for both the sets of common factors and specific factors $g_{j,t}$. Eq. (13) provides an empirical representation of the explanatory variables, which are modeled as linear combinations of both unobserved common factors f_t and country-specific factors $g_{j,t}$, with country-specific factor loadings.

The distinctive feature of the AMG method is that the common factors f_t are obtained from the residuals of Eq. (11) without imposing any *a priori* structure beyond that of being AR(1) processes. More importantly, since these processes are taken from the residuals, they are obtained after controlling for the impact of explanatory variables, but they are not obtained by imposing a predefined structure such as, e.g., a linear combination of cross-sectional averages.[29] Hence, they can be seen as latent variables capturing any dynamic process that jointly affects the dependent variables of all countries at the same time.

When the results of our estimations suggest that the common factor is not significant, yet cross-sectional dependence remains an issue, we rely on fixed effects estimation with the Driscoll–Kray correction for standard errors.

[22] See Luby (2012).
[23] See Bucci et al. (2020).
[24] Equiza-Goñi (2016) documents such a substitution effect between short- and long-term debt for several European economies.
[25] The liabilities evaluated at market and book value are taken from the OECD and WEO database, respectively.
[26] Cerniglia et al. (2020) discuss the issue of stability versus sustainability.
[27] Cross-sectional dependence can severely affect the empirical results, especially when the explanatory variables are correlated with unobserved common

Table 2
Empirical estimates of Eqs. (7) and (8).

	ALL		HIGH		LOW	
	(1)	(2)	(3)	(4)	(5)	(6)
π	0.256**	0.262**	0.116	0.230**	0.354***	0.403**
	(0.116)	(0.123)	(0.178)	(0.115)	(0.095)	(0.106)
OUT	0.006	−0.020	0.115	0.055	−0.065	−0.162
	(0.060)	(0.068)	(0.121)	(0.069)	(0.073)	(0.128)
PS	0.379***	0.367***	0.295*	0.313***	0.502***	0.494***
	(0.101)	(0.085)	(0.155)	(0.093)	(0.121)	(0.142)
i	−0.101	0.161	0.445	0.522	−0.501**	−0.417***
	(0.188)	(0.282)	(0.302)	(0.339)	(0.218)	(0.138)
$\Delta ASST$	0.250***	0.282***	0.255**	0.383***	0.212***	0.263***
	(0.073)	(0.054)	(0.121)	(0.070)	(0.072)	(0.079)
D	0.100***	0.135***	0.091***	0.077***	0.196**	0.179*
	(0.026)	(0.039)	(0.036)	(0.025)	(0.098)	(0.099)
MtB	–	−0.211***	–	−0.189***	–	−0.391***
		(0.059)		(0.058)		(0.116)
s/t	–	−0.457*	–	−0.881**	–	−0.177
		(0.275)		(0.338)		(0.151)
YS	–	−0.451***	–	−0.778***	–	−0.270
		(0.164)		(0.349)		(0.217)
CF	0.200***	0.316***	0.225**	0.352**	0.300**	0.302***
	(0.064)	(0.111)	(0.111)	(0.158)	(0.141)	(0.093)
N	24	23	14	14	10	9
Obs	689	658	410	410	279	248
Method	AMG	AMG	AMG	AMG	AMG	AMG

Note: The dataset consists of annual series spanning the 1980–2019 period. The dependent variable is stock-flow adjustments (SFA). The explanatory variables are inflation (π), output gap (OUT), accounting interest cost (i), primary surplus (PS), market-to-book spread (MtB), changes of government assets ($\Delta ASST = ASST_t - ASST_{t-1}$), debt ($D$), short-term interest rate (s/t), and yield spread (YS). Sources: WEO and OECD databases. Primary surplus is defined as revenues minus expenditures (other than interest costs). Output gap is defined as GDP growth minus its long-run trend. The yield spread is defined as the difference between long-term and short-term yields on government bonds. The panel of 24 countries is divided into two cohorts featuring high-debt (Japan, Italy, Belgium, Greece, US, Portugal, Canada, Austria, Germany, Ireland, Netherlands, France, Spain, UK), and low-debt (Sweden, Denmark, Slovakia, Slovenia, Finland, New Zealand, Norway, Australia, Luxembourg, Estonia). Eq. (8) is estimated by dropping Estonia from the above samples as data on long-term interest rate for this country are not available. The term CF is the common factor obtained from pooled regressions in first differences of Eq. (7) or (8). AMG is the Eberhardt and Teal's (2010) Augmented Mean Group estimator. Standard errors in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels.

4. Empirical results

4.1. Baseline regression

Columns (1), (3), and (5) of Table 2 display the estimates of Eq. (7) for the full cohort and the partitions of high- and low-debt economies.[30] We initially observe that all our results for the full sample are in line with the literature, as we find strong positive effects of inflation and changes in the assets position. The strong effect of inflation has been reported in previous studies but has largely remained unexplained.[31] Our hypothesis is that higher inflation compels governments to change the maturity structure of debt favoring shorter maturities because savers are less willing to hold long-term debt. And since short-term debt is largely composed of zero-coupon bonds, a larger issuance should be associated with larger stock-flow adjustments.

The effect of primary surpluses is strong and very consistent across all our estimates. We have observed from Eq. (6) that when the actual, unobserved, primary surplus is larger than the accounting counterpart, debt levels decline more than expected and a negative adjustment is registered, while a positive adjustment follows a realized deficit that is larger than the accounting one. A positive and significant estimated parameter indicates that a larger surplus is associated with higher adjustments, suggesting that accounting figures are more and more overestimated as the size of the surplus necessary to stabilize debt grows. On the one hand, this result, which is in line with the findings from Eichengreen and Panizza (2016), is reassuring because it suggests that large accounting deficits are recorded conservatively. On the other hand, it is far less reassuring since it also suggests that highly indebted countries that need to achieve a substantial primary surplus fall systematically short of their targets.[32]

Higher debt levels are associated with significant and positive stock-flow adjustments, and this result is stronger for low-debt economies. Hence, although high-debt economies feature adjustments far smaller than the average when higher debt builds up a significant share of new debt issuance is systematically unreported in accounting figures. These results can be explained by the findings of Missale and Blanchard (1994) that high-debt European countries were forced to issue more short-term debt since zero-coupon bonds produce adjustments.[33] The weaker positive link between debt and adjustments for high-debt countries suggests instead that financial investors require better disclosure and more transparency from large issuers of bonds.[34] On a more positive note, however, the level of interest costs is not associated with adjustments in high-debt countries, so stock-flows do not emerge as a response to a rising interest burden. In low-debt countries instead, adjustments decline when interest costs rise, operating as a hedge against rising costs of government debt. Low-debt economies can therefore manage their financial asset positions to offset higher interest costs.

Changes in the volume of the market value of financial assets represent an important explanatory variable, but more so in the case of high-debt countries, suggesting that such governments use debt more actively to acquire or sell financial assets than their low-debt counterparts. Finally, the estimated parameters measuring the impact of common factors are sizeable and strongly significant for the full sample as well as the partitions of high- and low-debt countries, indicating that common dynamics induced by the international business cycle are a major driver of adjustments.

4.2. Debt management and stock-flow adjustments

Columns (2), (4), and (6) of Table 2 display the estimates of Eq. (8) for the full sample and the cohorts of high- and low-debt countries.[35]

macroeconomic shocks. In such an instance, the slope parameters of the estimated specifications become unidentified (see, e.g., Eberhardt, 2012).

[28] Such a feature of the AMG estimators makes the inclusion of lagged dependent variables somehow redundant to the extent that similar dynamics are already detected by the common factors.

[29] This is what makes the AMG method different from Pesaran's (2006) CCEMG method. Indeed, this last accounts for cross-sectional dependence by supplementing the baseline specification of each unit-specific regression with cross-sectional averages of both the dependent and explanatory variables. However, as far as our empirical analysis is concerned, the AMG method proved more capable of detecting global factors than the CCEMG method.

[30] From the initial sample, we drop Israel, Malta, Switzerland, Iceland, Czech Rep, Lituania, Latvia and South Korea because data on output gap, or governments' financial assets and liabilities are not available.

[31] See, for instance, Campos et al. (2006).

[32] Eichengreen and Panizza (2016) find that primary surplus spells are more likely when growth is strong, and levels of debt are high. Fiscal data revisions are large and the cyclical component of fiscal policies is more counter-cyclical when real-time data are used in place of standard ex-post data normally used in policy analyses (see Cimadomo (2016)).

[33] Estimates for the subset of European only high-debt economies produce results that are very similar to those reported for high-debt countries and are available on request.

[34] See Bassanetti et al. (2018) find that the ability of high-debt countries to tap markets for debt refinancing in periods of financial distress declines.

[35] From the initial sample, we drop Israel, Malta, Switzerland, Iceland, Czech Rep, Lituania, Latvia, South Korea and Estonia because data on output gap, governments' financial assets and liabilities, governments' liabilities at market value, short- or long-term interest rates are not available.

Such a specification embeds the full array of debt-management variables, i.e. short-term interest rates, yield spreads, and market-to-book value. The striking result is that while in the full sample all variables are significant, this result is mainly due to the high-debt countries. Just as importantly, when adding up these variables the response to interest costs, which is insignificant for high-debt economies and marginally significant for the full sample, becomes stronger in low-debt economies. The picture that emerges is that stock-flow adjustments are a substitute for interest costs in low-debt countries only. This dynamic fades away for high-debt economies, where instead the adjustments are strongly influenced by market interest rates. This result confirms that low-debt countries behave remarkably differently from high-debt economies, up to the extent that in several instances it may be safer to focus on the latter to carry out empirical analyses of debt dynamics. Moreover, stock-flow adjustments in high-debt countries should be treated as a very important component of the cost of debt, since they are, to a large extent, a by-product of governments' debt management.

Indeed, we find that the sign of the coefficient attached to the market-to-book spread is negative, and strongly significant for both classes of economies, suggesting that the duration of debt plays an important role in debt management. Since a wider market-to-book spread is associated with longer maturities, adjustments are larger in countries where the average maturity of debt is shorter indicating that, to a large extent, the same adjustments are associated with short-term debt issuance. In addition, we find a strong and negative link between adjustments and short-term interest rates for high-debt countries. This result suggests that declining rates induce a larger issuance of short-term debt that is associated with adjustments because a large share of the issuance costs of zero-coupon bonds is not recognized timely in accrual accounting.[36] We also find a negative, strongly significant response of adjustment to positive variations in the yield spread, but only in the case of high-debt economies that we explain as the result of payoffs from derivatives purchased to offset increases in long-term interest costs, since these countries take payer positions in interest rate swaps.[37] To sum up, our evidence suggests that stock-flow adjustments in high-debt countries are largely a by-product of debt management activities conducted to minimize the overall cost of debt and the risk that exogenous shocks may induce.

In the case of low-debt economies, the strongly significant and negative responses of adjustments to higher accounting interest costs indicate that debt levels not only do not rise in the same proportion of interest costs, but they actually decline. The explanation of this apparent paradox is that these countries always have financial slack allowing them to repurchase existing debt substantially below par when higher market rates reduce bond prices and, vice-versa, they expand debt issuance when interest costs decline. Our results are consistent with the hypothesis that low-debt countries not only create tax smoothing by allowing debt levels to fluctuate in response to shocks, but they manage leverage efficiently in light of changing market conditions, by exploiting the risk-free nature of their liabilities. They do so by providing insurance to the private sector, either by injecting liquidity when bond prices decline or by taking receiver positions in interest rate swaps contracts. This is an extremely profitable activity because such countries can raise funds at comparatively minimal costs when those of the private sector rise because of changing risk premia, or even better because they can use the funds raised during periods of favorable market conditions. Hence, low-debt economies issue debt opportunistically to profit from market-making activities, by providing either risk-free securities or liquidity as demand from the private sector shifts.

4.3. *The sensitivity of accounting and shadow interest costs*

In this section, we build on Eq. (5) to investigate to what extent shadow and accounting interest costs feature different properties. More specifically, we start our analysis by testing for the presence of unit-root in the two interest costs and stock-flow adjustments (calculated as a ratio to debt) series.[38] Table A.1 in the Appendix shows that all the statistics in use soundly reject the null of unit-root so that the series under scrutiny are stationary processes. We then compute some preliminary statistics as displayed in Table 3. The first three columns display the average mean values, while the fourth shows the result of tests for equality of means between the two interest costs. The difference between the average means of such series is always sizeable and significant, and accounting interest costs are responsible for 26% of the total variability of shadow costs, and just 0.09% for the low-debt economies. We then finally test for the null that the correlation between the shadow and accounting interest costs is equal to zero. We soundly reject the null of no correlation at the 1% level, finding positive and negative correlations for the cohorts of high- and low-debt economies, respectively.

Finally, we investigate whether shadow and accounting interest costs share the same determinants by using a standard specification used in the literature positing that accounting interest costs must be a function of their own lagged values, and short- and long-term yields. We estimate such a specification for both the accounting and shadow interest costs by using OLS panel methods with both cross-sectional and time-fixed effects and the Driscoll–Kray correction for cross-sectional dependence.[39] The last two columns of Table 3 display the auto-regressive coefficients obtained from the panel estimation of the accounting and shadow interest costs specifications.[40] Such coefficients are remarkably different, with those of the accounting interest costs being of the order of 0.8 or above, whereas those of shadow costs take values around 0.3 or lower.[41]

Overall, this preliminary analysis shows that accounting and shadow interest costs are two different stochastic processes that are loosely interconnected: the accounting interest costs are much more persistent than their shadow counterparts because the dynamics of these last are largely driven by stock-flow adjustments, which are not persistent. Given the stark difference between the two interest costs, we take the analysis forward by gauging what drives such differences. More specifically, we estimate Eqs. (9)–(10) to investigate whether the same variables that explain stock-flow adjustments can

[36] This hypothesis is compatible with the evidence for the U.K. provided by Ellison and Scott (2020) that the cost-benefits from short-term issuance normally outweigh the risks so governments should favor issuing short-term bonds.

[37] Our results are also in line with the evidence provided by Schalck (2019) for France, suggesting that the French Treasury responds to both lower short-term rates and a steeper yield curve by increasing the share of short-term debt issuance and these responses become stronger during crises. Missale et al. (2002), in contrast, studied a large number of fiscal stabilization programs during the 1975–1988 period, finding a positive relationship between the share of long-term debt and the slope of the yield curve, whereas they found a strong negative relationship with long-term interest rates.

[38] We make use of the statistics proposed by Choi (2001), Im et al. (2003), and Levin et al. (2002).

[39] The specifications in use for both the accounting and shadow interest costs suffer from endogeneity problems which should be treated using dynamic panel methods and instrumental variables. However, several studies show that for large values of T – like those of our dataset – such endogeneity problems tend to fade away (see, e.g., Roodman, 2009). On top of that, dynamic panel methods have been devised for large N and small T, and they underperform standard OLS fixed effects when the time dimension gets longer.

[40] In all these estimation exercises, both the Breusch and Pagan's (1980) and Pesaran's (2021) statistics signal strong presence of cross-sectional dependence. Thus, we apply the Driscoll–Kray correction of standard errors.

[41] We do not report the full results of the regression, because the short- and long-term yield parameters are not consistently significant. We will further explore these issues in the next section.

Table 3
Preliminary statistics for stock-flow adjustments (measured as a ratio to debt), shadow interest costs, and accounting interest costs.

	$\overline{SFA}$	$\overline{i^*}$	$\overline{i}$	Equality	$\sigma(SFA)$	$\sigma(i^*)$	$\sigma(i)$	$\sigma(i)/\sigma(i^*)$	$Corr(i^*;i)$	AR_{i^*}	AR_i
ALL	5.660	8.545	2.885	5.661***	15.97	16.32	4.314	0.264	−0.253***	0.285***	0.875***
										(0.119)	(0.044)
HIGH	1.284	5.624	4.34	1.284***	4.445	5.252	2.715	0.517	0.529***	0.018	0.781***
										(0.068)	(0.047)
LOW	9.151	10.28	1.136	9.151***	21.03	18.36	1.655	0.090	−0.384***	0.296***	0.882***
										(0.052)	(0.051)

Note: $\overline{SFA}$, $\overline{i^*}$, and $\overline{i}$ are average means of stock-flow adjustments (measured as a ratio to debt), shadow interest costs, and accounting interest costs calculated over the period 1989–2019 for the cohorts of economies denoted with ALL, HIGH, and LOW. ALL denotes the full sample of countries. HIGH includes the cohort of countries featuring high debt: Japan, Italy, Belgium, Greece, US, Portugal, Canada, Israel, Austria, Germany, Malta, Ireland, Netherlands, France, Spain, UK. LOW includes the economies featuring low debt: Sweden, Denmark, Switzerland, Iceland, Slovakia, Slovenia, Finland, New Zealand, Norway, Czech Rep, Lithuania, Latvia, Australia, South Korea, Luxembourg, and Estonia. Equality denotes the paired t-test for the null of equality of means between $i_{j,t}$ and $i^*_{j,t}$. $\sigma(\cdot)$ denotes standard deviations. $Corr(i^*;i)$ denotes the test for the null of correlation between $i^*_{j,t}$ and $i_{j,t}$ equal to zero. AR_{i^*} denotes the panel estimates of the auto-regressive coefficients of order 1 for the regression of shadow interest costs on its own lag, short- and long-term yields. AR_i denotes the same auto-regressive coefficient estimates for the specification in which shadow interest costs are replaced with accounting costs. Driscoll–Kray standard errors in parentheses. *, **, *** denote significance at the 10, 5, and 1 percent.

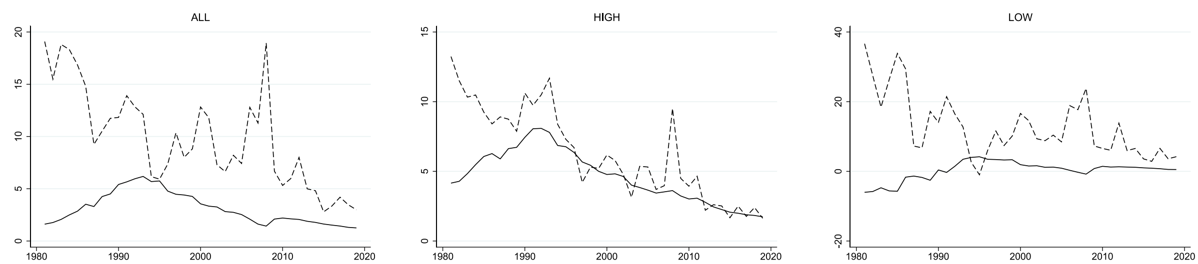

Fig. 4. Cross-sectional averages of accounting interest cost i_t (solid line) and shadow interest cost i^*_t (dashed line) for the full set of countries (ALL), and for the cohorts of high- (HIGH) and low-debt (LOW) economies.

also drive accounting and shadow interest costs. Fig. 4 displays the cross-sectional averages of accounting and shadow interest costs. From a visual inspection, one can anticipate that the two interest costs feature quite different dynamics.

4.3.1. Macroeconomic drivers of accounting and shadow interest costs

Table 4 displays the results of the estimation of Eqs. (9) and (10) for, respectively, the full sample in columns (1) and (2), high-debt in columns (3) and (4), and low-debt economies in columns (5) and (6).[42] The comparison for the full sample suggests that the differences between $i_{j,t}$ and $i^*_{j,t}$ are remarkable. On the one hand, accounting interest costs respond exclusively to short-term interest rates and the common factor. On the other hand, shadow costs respond to the full array of variables that also influence stock-flow adjustments. Hence shadow costs rise with inflation, debt, and changes in the net asset position, but also with the primary surplus; this last effect is produced by measurement errors in the primary surplus that generate a systematic distortion of shadow costs. In practice, it means that the over-reporting of accounting measures of the primary surplus more than offsets any benefit that the primary surplus produces on interest costs. Finally, shadow interest costs decline with the market-to-book spread. Since this spread widens in proportion to the average debt duration when interest rates decline, this result indicates that a low-yield environment generates larger benefits for countries that have a longer average maturity of debt. Hence, a short debt duration not only makes debt riskier but also reduces the benefits of lower market rates.

Thus, focusing the analyses of debt sustainability exclusively on accounting interest costs would *a priori* rule out the important role played by both debt maturities and changes in the stock of assets. Even more striking, the level of debt has no impact whatsoever on accounting interest costs, while, on the contrary, in the sample of indebted economies the level of debt is extremely significant and positive, indicating that debt generates non-linear costs, but the costs are reported as stock-flow adjustments.

Another very important difference between the two measures of interest costs involves the relevance of common factors. While common factors, albeit strongly significant, have a relatively small impact on shadow costs, they are the only variables explaining accounting interest costs beyond the short-term interest rates.[43] Also, from a policymaker standpoint, shadow costs are less exposed to international factors, and therefore more easily manageable by national governments than their accounting counterpart. Table 5 compares our results with those of the corresponding Driscoll–Kraay regressions that do not generate a common factor, but that control for cross-sectional dependence, for the full sample and the cohort of high-debt economies. In the absence of common factors, short-term interest rates become strongly positive and significant; hence the common factor largely captures the international co-movement of short-term rates. In the next section, we dig deeper into the properties of such factors.

The partition between high- and low-debt countries provides results for the shadow cost that mirror those for stock-flow adjustments, but the same partition turns out to be highly relevant also for explaining accounting interest costs. While the output gap is not significant for the full sample, it becomes significant at the 10 percent level for high-debt countries. Moreover, for the same cohort of high-debt countries, the market-to-book ratio becomes significant for both notions of interest costs, suggesting that longer maturities influence accounting interest costs and not just shadow costs.

While shadow and accounting interest costs in high-debt countries are strongly influenced by common factors, their low-debt counterparts

[42] From the initial sample, we drop Israel, Malta, Switzerland, Iceland, Czech Rep, Lituania, Latvia, South Korea and Estonia as data on output gap, or governments' financial assets and liabilities, or governments' liabilities at market value, or short- and long-term interest rates are not available.

[43] This result suggests that any empirical analysis of interest costs that does not account for cross-sectional dependence may be biased.

Table 4
Empirical estimates of Eqs. (9) and (10).

	ALL		HIGH		LOW	
	(1)	(2)	(3)	(4)	(5)	(6)
	i^*	i	i^*	i	i^*	i
π	0.689**	−0.020	0.274	0.019	0.984	0.016
	(0.341)	(0.024)	(0.215)	(0.026)	(0.669)	(0.034)
OUT	−0.208	−0.058	0.055	−0.043*	−0.955	−0.005
	(0.231)	(0.038)	(0.247)	(0.025)	(0.673)	(0.138)
PS	0.246**	0.004	0.282***	−0.009	2.168***	0.132
	(0.106)	(0.026)	(0.108)	(0.016)	(0.471)	(0.108)
$\Delta ASST$	0.624***	−0.006	0.556***	0.008	0.582***	−0.011
	(0.134)	(0.012)	(0.178)	(0.008)	(0.151)	(0.018)
D	0.105***	0.004	0.181***	0.006	−0.094	0.048
	(0.033)	(0.008)	(0.041)	(0.007)	(0.094)	(0.068)
MtB	−0.295**	−0.006	−0.273***	−0.026**	0.049	−0.052
	(0.145)	(0.014)	(0.085)	(0.011)	(0.318)	(0.085)
s/t	−0.006	0.199***	−0.777**	0.097	0.858*	0.201
	(0.327)	(0.073)	(0.397)	(0.066)	(0.457)	(0.273)
YS	−0.475	0.018	−0.740	−0.008	0.123	0.159
	(0.464)	(0.054)	(0.588)	(0.046)	(0.565)	(0.126)
CF	0.227***	0.763***	0.564***	0.803***		0.675**
	(0.073)	(0.174)	(0.168)	(0.171)		(0.286)
N	23	23	14	14	9	9
Obs	658	658	410	410	284	284
	AMG	AMG	AMG	AMG	DK	AMG

Note: The dataset consists of annual series for the period 1980–2019. The dependent variables are shadow (i^*) and accounting (i) interest costs. The explanatory variables are inflation (π), output gap (OUT), primary surplus (PS), changes of government assets ($\Delta ASST = ASST_t - ASST_{t-1}$), debt ($D$), market-to-book spread (MtB), short-term interest rate (s/t), and yield spread (YS). Primary surplus is defined as revenues minus expenditures (other than interest costs). Output gap is defined as GDP growth minus its long-run trend. The yield spread is defined as the difference between long-term and short-term yields on government bonds. The panel of 23 countries is divided into two cohorts featuring high-debt (Japan, Italy, Belgium, Greece, US, Portugal, Canada, Austria, Germany, Ireland, Netherlands, France, Spain, UK), and low-debt (Sweden, Denmark, Slovakia, Slovenia, Finland, New Zealand, Norway, Australia, Luxembourg). The term CF is the common factor obtained from pooled regressions in first differences of Eq. (9) or (10). AMG is Eberhardt and Teal's (2010) Augmented Mean Group estimator. DK is Driscoll and Kraay's estimator. Standard errors in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent level.

are much less exposed to the international business cycle. And since several low-debt countries are small open economies, potentially more exposed to exogenous shocks, such results suggest that these countries are insulated from common shocks because their debt levels do not pose any constraint to debt management.

4.4. Global common factors

Table 5 provides a comparison of the results for Eqs. (9) and (10) obtained by applying the AMG estimator that includes a common factor, with those from a fixed effects specification with the Driscoll–Kray correction for cross-sectional dependence. The results highlight that when introducing a common factor, the impact of domestic interest rates, yield spreads and inflation become much weaker or even of the opposite sign, as in the case of domestic interest rates in high-debt economies. Hence, the estimated common factor captures international business cycle dynamics that are very important for both shadow and accounting interest costs.

Fig. 5 displays the underlying common factors obtained for stock-flow adjustments, shadow, and accounting interest costs for the cohort of high-debt economies. All these factors exhibit strong trends, which is surprising in principle since if adjustments are the sole result of reconciliations of national accounts then their time dynamics should be purely erratic. Thus, we formally test the hypothesis that the above factors series do not feature a stochastic trend. We do so by fitting AR(1) processes to the three series and find that the AR coefficients are significant at the 1% level. We thus reject the null that such series are white-noise processes.[44]

In each of the panels of Fig. 5, together with the common factors, we plot both the short- and long-term US interest rates. From a visual inspection, one can see that the three common factors share the same interest rate trend, with the match becoming particularly close in the case of the common factors obtained from stock-flow adjustments and shadow rates. We then investigate what macroeconomic variables influence the common factors extracted from stock-flow adjustments, shadow, and accounting interest costs. We do so by building on Byrne et al. (2012), Abbritti et al. (2018) and Del Negro et al. (2019) that show the presence of common factors in the term structure of interest rates. More specifically, we estimate Eq. (16), where the dependent variables consist of the above common factors and the explanatory variables are the cross-sectional averages of inflation ($\overline{\pi_t}$), output gap ($\overline{OUT_t}$), short-term yields $\overline{s/t_t}$ and yield spreads $\overline{YS_t}$, as well as their US counterparts:

$$CF_t = \alpha_0 + \alpha_1 \overline{\pi_t} + \alpha_2 \overline{OUT_t} + \alpha_3 \overline{s/t_t} + \alpha_4 \overline{YS_t} + \epsilon_t. \quad (16)$$

The empirical results are provided in Tables 6 and 7. The results using cross-sectional averages indicate that short-term yields and yield spreads are the main drivers of all the common factors previously identified. For both variables, the effect is much larger on the common factor of adjustments and shadow costs, and weaker for accounting costs. When we use US variables instead of cross-sectional averages, the results are very similar. The estimated coefficients, however, are much larger in this case, suggesting that the common factors are generated by the US term structure. Consequently, US interest rates exert substantial effects on government debt costs in high-debt countries that are normally neglected.[45]

Our results suggest that high-debt economies are exposed to peaks in inflation and interest rates occurring at the international level – and therefore beyond the control of national governments – which might translate into larger adjustments. These last would eventually be determined by variations in short-term rates via the influence on the maturity structure of debt and the costs of derivatives.

4.5. Robustness

We carry out several robustness checks on the estimates of Eqs. (1) and (2). We re-estimate such specifications by replacing the levels of debt with net liabilities held by governments, and net interest costs on debt. We then repeat the same exercise in a recursive setting where the sample of countries is sorted in ascending order according to net liabilities first, and net interest costs on debt thereafter. We obtain empirical estimates and diagrams for the recursive slopes fully consistent with those previously reported. Finally, an alternative sorting of the sample in descending order still identifies the UK as the cut-off country between the cohorts of high- and low-debt economies.

Focusing on panel estimations, we tweak the two partitions of high- and low-debt economies by changing the cut-off country from the UK

[44] Alternatively, the setting of Eqs. (11)–(15) makes it possible to tackle the same hypothesis from a different angle. In such a context, the null that the common factor does not exert any traction on the dependent variables of interest would consist of the restrictions $\rho = 0$ and $\lambda = 0$. Since we cannot impose such restrictions contemporaneously, we treat this as a sequential test. Thus, we apply the Bonferroni adjustment and tweak the p-values down to 0.025 (=0.05/2) from the standard benchmark of 0.05. Empirical results show that both the AR(1) coefficient ρ and the factor loading λ are statistically significant so we reject the null.

[45] These results mirror the findings by Del Negro et al. (2019) of a trend in global real interest rates that they identify as common component in the real yields on government debt. Similarly, Carriero et al. (2022) suggest that in recent decades, for a cohort of OECD countries largely overlapping ours, a global factor drives levels, persistence, and volatility of inflation.

Table 5
Empirical estimates of Eqs. (9) and (10).

	ALL				HIGH			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	i^*	i^*	i	i	i^*	i^*	i	i
π	0.689**	0.652**	−0.02	−0.316**	0.274	0.415**	0.019	−0.504***
	(0.341)	(0.292)	(0.024)	(0.101)	(0.215)	(0.165)	(0.026)	(0.125)
OUT	−0.208	−0.103	−0.058	0.185**	0.055	−0.133	−0.043*	0.194***
	(0.231)	(0.275)	(0.038)	(0.088)	(0.247)	(0.158)	(0.025)	(0.065)
PS	0.246**	0.887***	0.004	0.016	0.282***	0.175**	−0.009	−0.011
	(0.106)	(0.237)	(0.026)	(0.035)	(0.108)	(0.075)	(0.016)	(0.028)
$\Delta ASST$	0.624***	0.617***	−0.006	−0.023	0.556***	0.596**	0.008	−0.025
	(0.134)	(0.128)	(0.012)	(0.022)	(0.178)	(0.228)	(0.008)	(0.028)
D	0.105***	−0.009	0.004	0.013**	0.181***	−0.024**	0.006	0.005**
	(0.033)	(0.018)	(0.008)	(0.005)	(0.041)	(0.009)	(0.007)	(0.002)
MtB	−0.295**	−0.027	−0.006	0.002	−0.273***	−0.063	−0.026**	−0.011
	(0.145)	(0.082)	(0.014)	(0.021)	(0.085)	(0.061)	(0.011)	(0.009)
s/t	−0.006	0.537**	0.199***	0.412***	−0.777**	0.289	0.097	0.622***
	(0.327)	(0.259)	(0.073)	(0.075)	(0.397)	(0.191)	(0.066)	(0.058)
YS	−0.475	−0.221	0.018	0.332**	−0.740	−0.451	−0.008	0.253***
	(0.464)	(0.433)	(0.054)	(0.125)	(0.588)	(0.486)	(0.046)	(0.086)
CF	0.227***		0.763***		0.564***		0.803***	
	(0.073)		(0.174)		(0.168)		(0.171)	
N	23	23	23	23	14	14	14	14
Obs	658	658	658	658	410	410	410	410
	AMG	DK	AMG	DK	AMG	DK	AMG	DK

Note: The dataset consists of annual series over the period 1980–2019. The dependent variables are shadow (i^*) and accounting (i) interest costs. The explanatory variables are inflation (π), output gap (OUT), primary surplus (PS), changes of government assets ($\Delta ASST = ASST_t - ASST_{t-1}$), debt ($D$), market-to-book spread (MtB), short-term interest rate (s/t), and yield spread (YS). Primary surplus is defined as revenues minus expenditures (other than interest costs). Output gap is defined as GDP growth minus its long-run trend. The yield spread is defined as the difference between long-term and short-term yields on government bonds. The panel of 23 countries is divided into two cohorts featuring high-debt (Japan, Italy, Belgium, Greece, US, Portugal, Canada, Austria, Germany, Ireland, Netherlands, France, Spain, UK), and low-debt (Sweden, Denmark, Switzerland, Iceland, Slovakia, Slovenia, Finland, New Zealand, Norway, Czech Rep, Lithuania, Latvia, Australia, South Korea, Luxembourg). The term CF is the common factor obtained from pooled regressions in first differences of Eq. (9) or (10). AMG is Eberhardt and Teal's (2010) Augmented Mean Group estimator. DK is Driscoll and Kraay's estimator. Standard errors in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent level.

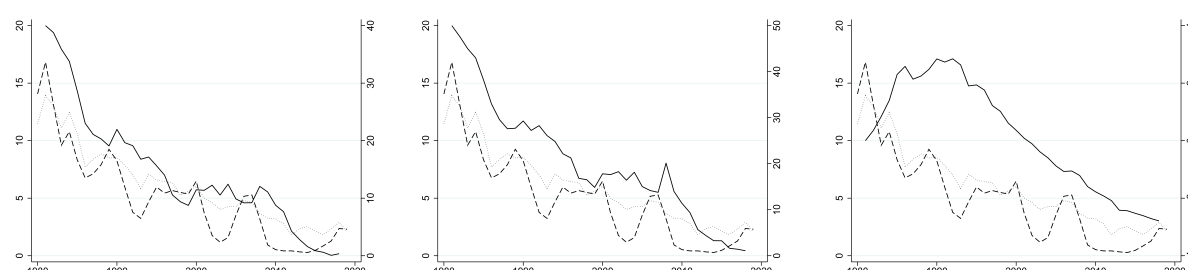

Fig. 5. The left, central, and right diagrams display the global common factor (solid lines) for stock-flow adjustments, shadow interest rate costs, and accounting interest rate costs, respectively. Such factors are extracted from the cohort of high-debt economies. The three diagrams depict also the series for the US short- (dashed line) and long-term interest rates (dotted line).

to the Netherlands, so that the cohort of high-debt countries shrinks from 14 to 11, and that of low-debt expands from 9 to 12, setting the threshold between high- and low-debt economies to 60 percent. We then repeat the exercise by setting Slovakia as the cut-off country, so that the cohort of high-debt countries expands from 14 to 17, and low-debt countries shrink from 9 to 6, setting the threshold between high- and low-debt economies at 40 percent. Armed with these modified cohorts, we carry out new estimates of Eqs. (7), (8), (9) and (10), and obtain results very similar to those previously reported. For instance, stock-flow adjustments for the modified cohort of high-debt economies still feature strong global common factors, respond positively to primary surpluses, government asset variations, and levels of debt, and respond negatively to market-to-book spreads, short-term rates, and yield spreads. Next, we supplement the previous specifications with a dummy variable for the year 2008 obtaining results in line with those previously reported. We also repeat the analysis for a smaller sample including only EU countries and the results remain robust.

Endogeneity issues can be a source of concern for the results of Section 4.3.1, because both the primary surplus and the level of debt may respond to accounting interest costs, inducing reverse causality. However, in every period, any variation in interest costs is generated by the most recent tranches of debt, which are priced at the corresponding market yields. Hence, such interest costs change only marginally, particularly when the average maturity of debt is long. As a matter of fact, neither debt levels, nor primary surpluses are ever significant in our regressions when interest costs are the dependent variable, so any potential bias should be negligible. Both variables are significant in the regressions including the shadow cost as a dependent variable, but since the significant effect is produced by stock-flow adjustments, endogeneity is not an issue even in this case.[46] We have also analyzed if stock-flow adjustments may be predictable because governments respond to past adjustments, by running panel VAR regressions of Eq. (6) finding in all cases no evidence whatsoever of any relevant dynamics.[47]

[46] Similarly, Hall and Sargent (2011) and Ellison and Scott (2020) assume that the yield curve is unaffected by issuance.

[47] These results are available from the authors upon request.

Table 6
Empirical estimates of Eq. (16) for common factors.

	ALL	HIGH	ALL	HIGH	ALL	HIGH
	$CF(SFA)$		$CF(i^*)$		$CF(i)$	
$\overline{\pi}$	0.164 (0.117)	0.293 (0.212)	0.738** (0.368)	0.278 (0.196)	−0.111 (0.077)	−0.109 (0.107)
$\overline{OUT}$	0.694 (0.369)	0.251 (0.365)	2.599*** (0.617)	0.357 (0.536)	−0.197 (0.111)	0.126 (0.158)
$\overline{s/t}$	1.647*** (0.205)	2.124*** (0.256)	3.009*** (0.61)	2.684*** (0.299)	0.486*** (0.085)	0.521*** (0.116)
$\overline{YS}$	1.314*** (0.689)	1.950*** (0.656)	3.353* (1.767)	1.646** (0.737)	0.156 (0.251)	0.251 (0.279)
$Adj-R^2$	0.918	0.935	0.894	0.935	0.769	0.718

Note: The dataset consists of annual series for the period 1980–2018 (T=38). Dependent variables are the common factors extracted from the panels of stock-flow adjustments (SFA), shadow interest costs (i^*), and accounting interest costs (i) obtained from the Eberhardt and Teal's (2010) Augmented Mean Group estimator. Common factors extracted from the full sample of countries (ALL), and the partition of high-debt (HIGH) countries (Japan, Italy, Belgium, Greece, US, Portugal, Canada, Austria, Germany, Ireland, Netherlands, France, Spain, UK). Explanatory variables are the cross-sectional averages of inflation ($\overline{\pi}$), output gap ($\overline{OUT}$), short-term interest rate ($\overline{s/t}$), and yield spread ($\overline{YS}$) calculated for the full sample and the partition of high-debt countries. Sources: WEO and OECD databases. Output gap is defined as GDP growth minus its long-run trend. The yield spread is defined as the difference between long-term and short-term yields on government bonds. Bootstrapped standard errors (50 re-samplings) in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent level.

Table 7
Empirical estimates of Eq. (16) for common factors.

	ALL	HIGH	ALL	HIGH	ALL	HIGH
	$CF(SFA)$		$CF(i^*)$		$CF(i)$	
π_{US}	0.242 (0.609)	0.441 (0.520)	1.327 (1.227)	0.388 (0.661)	−0.361 (0.184)	−0.186 (0.261)
OUT_{US}	−0.212 (0.225)	−0.812*** (0.243)	−0.377 (0.628)	−0.519* (0.277)	0.138 (0.131)	0.242* (0.127)
s/t_{US}	2.291*** (0.234)	2.817*** (0.214)	4.144*** (0.681)	3.733*** (0.375)	0.627*** (0.101)	0.612*** (0.124)
YS_{US}	3.070*** (0.506)	3.282*** (0.395)	5.295*** (1.435)	4.682*** (0.643)	0.853*** (0.266)	1.081*** (0.293)
$Adj-R^2$	0.901	0.955	0.835	0.785	0.698	0.594

Note: The dataset consists of annual series for the period 1980–2018 (T=38). Dependent variables are the common factors extracted from the panels of stock-flow adjustments (SFA), shadow interest costs (i^*), and accounting interest costs ((i)) obtained from Eberhardt and Teal's (2010) Augmented Mean Group estimator. Common factors extracted from the full sample of countries (ALL), and the partition of high-debt (HIGH) countries (Japan, Italy, Belgium, Greece, US, Portugal, Canada, Austria, Germany, Ireland, Netherlands, France, Spain, UK). Explanatory variables are series for the US inflation (π_{US}), output gap (OUT_{US}), short-term interest rate (s/t_{US}), and yield spread (YS_{US}). Sources: WEO and OECD databases. Output gap and yield spread are defined as GDP growth minus its long-run trend, and the difference between long- and short-term yields on US government bonds, respectively. Bootstrapped standard errors (50 re-samplings) in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent level.

Finally, while the metric used to evaluate the statistical significance of the parameter estimates consists of standard Mean Group t-statistics, we also compute Pedroni's (2000) panel t-statistics. These two metrics lead to almost identical conclusions.

5. Conclusions

In our sample of developed economies, stock-flow adjustments reverting to a positive and significant mean, are larger and highly persistent in low-debt economies, while smaller and weakly persistent in their high-debt counterparts. The relationship between adjustments and debt is highly non-linear, with the size and dynamics of the adjustments being different between high- and low-debt economies. We also find evidence that stock-flow adjustments are largely a by-product of the management of government debt, conducted by tweaking the maturity of debt as the term structure changes and by using derivatives to smooth the impact of interest rate shocks. Hence, we suggest that stock-flow adjustments should be treated as a component of a more comprehensive measure of debt costs. Such a measure ensures stock-flow consistency. As such, it retains a superior information content in comparison to standard accounting measures of interest costs, making it possible to avert any bias produced by omitted variables.

Our analysis provides evidence of pervasive cross-sectional dependence in all our regressions featuring stock-flow adjustments, accounting interest costs, and shadow interest costs as a dependent variable. Hence, the international business cycle plays a major role in shaping these adjustments. We find that such common factors are largely the by-product of both the short-term interest rates and the slope of the US term structure.

We also find a structurally different pattern depending on the level of indebtedness that affects stock-flow adjustments, shadow interest costs, and accounting interest costs. Indeed, regressions conducted on the full sample of countries fail to detect several important variables that have an impact on low-and high-debt countries in opposite directions. Low-debt economies behave very differently from their high-debt counterparts because their debt levels do not impose any constraint, and hence they do not need to use the sophisticated and costly debt management procedures that high-debt countries adopt. In particular, shadow interest costs do not move in lock-step with actual accounting interest costs in low-debt countries, they rather move in opposite directions. In the case of high-debt economies, shadow costs are highly correlated with their accounting counterparts, even though the former is far larger, more persistent, and volatile. In addition, shadow costs rise substantially with debt levels in high-debt countries, while accounting interest costs do not, highlighting the presence of large non-linear debt costs that are not detected by standard accounting figures.

These results may be of some concern, because standard sustainability analyses typically fail to recognize the systematic and structural nature of stock-flow adjustments, nor the strong influence on government debt costs of factors outside the direct control of most governments, such as the dynamics of US interest rates.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Unit-root statistics

In this section, we show that stock-flow adjustments are stationary processes, albeit they do not revert to a zero mean. We then analyze their mean reversion since the overall impact of adjustments on debt depends not just on the levels, but also on their persistence. More specifically, we fit AR(1) processes to the adjustments using SURE methods. We do so by partitioning the full sample of thirty-two countries into the cohorts of high- and low-debt economies, and encoding restrictions such that the AR(1) coefficients are equal across units in each of the two cohorts.

We start our analysis by running a battery of panel unit-root statistics to investigate the stationarity of stock-flow adjustments series (expressed as a ratio to debt as per Eq. (5)). Table A.1 displays the results of the LLC, IPS, and Fisher tests applied to the full sample, as well as the two cohorts of high- and low-debt economies. Empirical

Table A.1
Unit-root tests for the series of stock-flow adjustments, accounting interest costs (i_t), and shadow interest costs (i^*_t).

	Stock-flow adjustments			i_t			i^*_t		
	LLC	IPS	Fisher	LLC	IPS	Fisher	LLC	IPS	Fisher
ALL	−12.22***	−8.66***	−11.73***	−7.89***	−3.86***	−10.24***	−12.22***	−8.66***	−11.73***
HIGH	−10.46***	−7.22***	−7.26***	−5.29***	−2.55***	−4.43***	−11.39***	−8.06***	−6.81***
LOW	−9.52***	−6.43***	−6.03***	−4.56***	−1.31*	−3.91***	−11.39***	−6.94***	−6.03***

Note: Annual series for stock-flow adjustments (expressed as a ratio to debt), accounting interest rate costs, and shadow interest costs for the period 1989–2019 for 32 countries (N=32, T=31). HIGH denotes the cohort of countries featuring high debt: Japan, Italy, Belgium, Greece, US, Portugal, Canada, Israel, Austria, Germany, Malta, Ireland, Netherlands, France, Spain, UK. LOW denotes the economies featuring low debt: Sweden, Denmark, Switzerland, Iceland, Slovakia, Slovenia, Finland, New Zealand, Norway, Czech Rep, Lithuania, Latvia, Australia, South Korea, Luxembourg, and Estonia. ALL denotes the full sample of countries. Levin et al. (2002) (LLC), Im et al. (2003) (IPS), and Choi's (2001) Fisher-type unit-root tests. The above statistics are designed for the null of unit-root against the alternative that all units feature the same AR parameter (LLC), or that the AR parameters are unit-specific (IPS and Fisher). All specifications are computed by subtracting from the original series across the panel the time-varying mean to account for cross-sectional dependence and include a time trend. Both the IPS and Fisher tests are computed over the full period, whereas LLC tests are calculated over the 2001–19 period. The reported values are the *t*-statistics. Lag length is based on the minimum of the AIC. Source: WEO database. *,**,*** denote significance at the 10, 5, and 1 percent.

Table A.2
Comparison between stock-flow adjustments and accounting interest costs series taken from WEO and AMECO.

Units	Stock-flow adjustments				Accounting interest costs			
	Ave(WEO)	Ave(AM)	Mean	Corr(WEO:AM)	Ave(WEO)	Ave(OECD)	Mean	Corr(WEO:OECD)
ALL	14.42	14.56	−0.131	0.989	1.966	1.885	0.111	0.974
			(0.631)	(0.000)			(0.000)	(0.000)
HIGH	3.010	3.242	−0.132	0.950	3.163	3.121	0.041	0.977
			(0.688)	(0.000)			(0.000)	(0.000)
LOW	26.28	25.67	0.610	0.995	0.853	0.741	0.112	0.955
			(0.158)	(0.000)			(0.000)	(0.000)

Note: Annual data for 32 countries over the period 1989–2019 (N=32. T=31). HIGH denotes the cohort of countries featuring high debt: Japan, Italy, Belgium, Greece, US, Portugal, Canada, Israel, Austria, Germany, Malta, Ireland, Netherlands, France, Spain, UK. LOW denotes the economies featuring low debt: Sweden, Denmark, Switzerland, Iceland, Slovakia, Slovenia, Finland, New Zealand, Norway, Czech Rep, Lithuania, Latvia, Australia, South Korea, Luxembourg, and Estonia. ALL denotes the full sample of countries. Mean denotes the paired t-test for the null of equality of average means between WEO and AMECO series. Corr(WEO;AM) and Corr(WEO;OECD) denote the tests for the null of zero correlation between WEO and AMECO, and WEO and OECD series, respectively. P-values for the above statistics in parentheses. *, **, *** denote rejection of the null at the 10, 5, and 1 percent levels.

results show that such series are strongly stationary, as the null of unit-root is consistently rejected at the 1% level for all the partitions under scrutiny.[48]

Appendix B. Consistency between datasets

In this section, we gather figures on stock-flow adjustments from the AMECO database and compare them with those previously obtained from the WEO database.[49] We start with a preliminary analysis to check whether the stock-flow adjustments calculated out of WEO data match with their counterparts from AMECO. We compare the two series by computing their correlation, as well as tests for equality of means. Table A.2 reports the results for the full sample, as well as the two cohorts of high- and low-debt countries. Our empirical results suggest that the series are highly correlated, featuring the same mean. Overall, the broad-brush picture we obtain is that both the WEO and AMECO adjustments series share very similar stochastic properties.

We then carry out a similar exercise by comparing the series for accounting interest costs obtained from WEO data with their counterparts from the OECD database. Also in this case, the gap between the two series is negligible for the vast majority of countries, with the only exception of the US and UK. We compare the two interest costs series by computing their correlation, as well as tests for equality of means for the full set of countries. The empirical results displayed in the same table suggest that the two series feature high correlation, yet different means. Thus, the two series feature slight differences in levels, whereas their time dynamics remain very similar. Also for this second exercise, empirical results show that both the WEO- and OECD-based series share similar stochastic properties.

[48] The same table displays the statistics applied to accounting and shadow interest rate costs, where the null of unit-root is always strongly rejected.

[49] The AMECO database – unlike the WEO data we use – gathers series for a smaller cohort of countries comprising of European economies plus Japan and the US.

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