



An estimate of the European Union's long-term borrowing cost bill

KEY FINDINGS

The costs related to the payment of the interest and principal on the European Union debt issued to finance the non-repayable part of post-pandemic recovery programme must be covered by the EU budget. It is therefore crucial for the EU to understand how these costs could evolve up to 2058, when the debt is expected to be fully reimbursed. Our median estimates show that **yearly interest costs borne by the EU budget could increase quickly in the next few years to reach 10.8 EUR billion** (i.e. 0.05% of EU GDP) in 2030, before decreasing gradually up to 2058. Overall, total costs over the whole life of the NGEU borrowing scheme could amount to **around 222 EUR billion – i.e. 0.6% of one year of average EU GDP over the whole programme** – a number that could be reduced by 25 EUR billion if the EU spread vs the Bund was normalising to its early 2022 level. Taking also into account the repayment of the debt, total annual financial needs could reach 25 EUR billion in 2030, before declining gradually towards 14 EUR billion per year by the end of the programme. **The 'Own Resources' package proposed by the European Commission in June 2023 could thus be enough to cover these costs**, under two strong conditions: its estimates are accurate and it is accepted by EU countries in its current form. However, our analysis also emphasises the very large uncertainty surrounding interest rates during the next three-and-a-half decades of the programme.

Introduction

The European Union's economic policy response to the COVID-19 crisis led to a radical change in the scale and nature of borrowing by the bloc. Given the newfound relevance of EU borrowing rates for the EU budget, in Claeys *et al.* (2023), we examined the main drivers behind their evolution since the launch of the borrowing programme put in place in 2021 to finance NextGenerationEU (NGEU). We also discussed how these interest rates could evolve in the future and estimated what the interest costs borne directly by the EU budget could amount to until the end of the 2021-27 Multiannual Financial Framework (MFF). Finally, we made recommendations on how to reduce the costs of EU borrowing for European taxpayers.

This follow-up briefing written for the European Parliament's BUDG committee provides an **update on the situation concerning EU interest rates and NGEU disbursements, and examines additional questions raised by Members of the European Parliament** (MEPs) after our previous background briefing.

We address several key questions. First, how might EU borrowing costs evolve until the expected end of the borrowing programme and full repayment of the NGEU debt in 2058? Second, what funds will be needed during the 2028-2058 period to cover both interest and principal reimbursements of EU debt related to the NGEU's non-repayable part? Third, will the revenues expected from the 'Own Resources Package' proposed by the European Commission in June 2023 be sufficient to repay NGEU's interest and principal? And fourth, how much would EU debt costs be reduced if spreads between EU and German rates were narrowed to the levels experienced before their early-2022 divergence? Finally, we discuss if measures other than those previously recommended should be implemented to reduce interest rates costs.

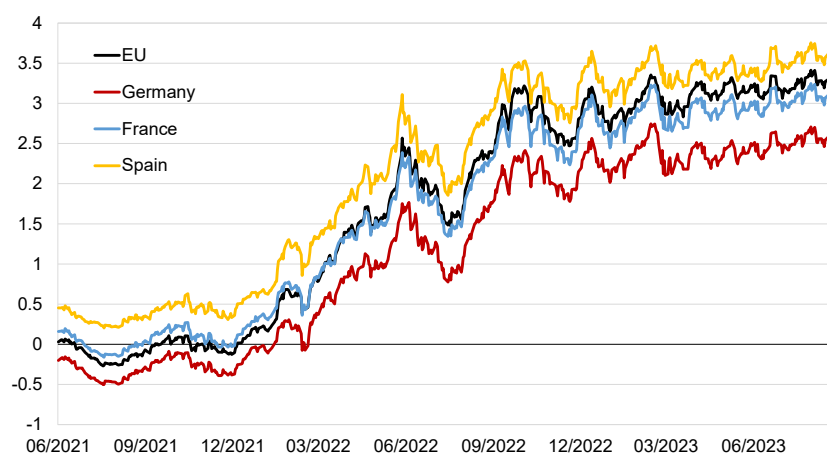


Update of the situation since our previous briefing

Evolution of EU and major issuers' financing conditions since May 2023

With the European Central Bank having increased its key policy rates on three more occasions since May 2023 – in June, August and September – the **borrowing costs faced by the EU and by other major**

Figure 1: 10-year benchmark yields for the EU and selected issuers (in %)



Source: Bruegel based on Bloomberg

European issuers have continued to rise, albeit at a slower rate than during the sharp increases that occurred in the first half of 2022 (Figures 1 and 2).

The performance of EU bonds relative to those issued by major European sovereigns has remained broadly unchanged in recent months. Although yields on all maturities have increased for all European issuers, EU yields have remained by and large between French and Spanish yields, and well above German yields (Figure 2). The spread – i.e. the difference between the yields faced by two issuers – between EU bonds and the German Bund has remained

elevated far above the levels of 2021 and early 2022, but has largely tracked the swap-bund spread (Figure 3), suggesting that the main drivers of the EU-bund spread remain unchanged since our previous analysis¹.

Update of EU borrowing plans since May 2023

In its funding plan for the second half of 2023, the European Commission announced its intention to issue 40 EUR billion worth of bonds under its unified funding strategy. The proceeds will be used to fund both NGEU disbursements and concessional loans to Ukraine under the MFA+ (European Commission, 2023b). This amount represents only half of the 78 EUR billion issued in the first half of 2023, marking a substantial reduction in the total issuance projected by the Commission at the close of 2022, which had aimed to reach "up to EUR 170 billion" for the entire year 2023 (European Commission, 2022b). **The main reason for this slowdown in borrowing is that EU countries delayed drastically their disbursement requests when they revised their respective Recovery and Resilience Plans (RRPs)**².

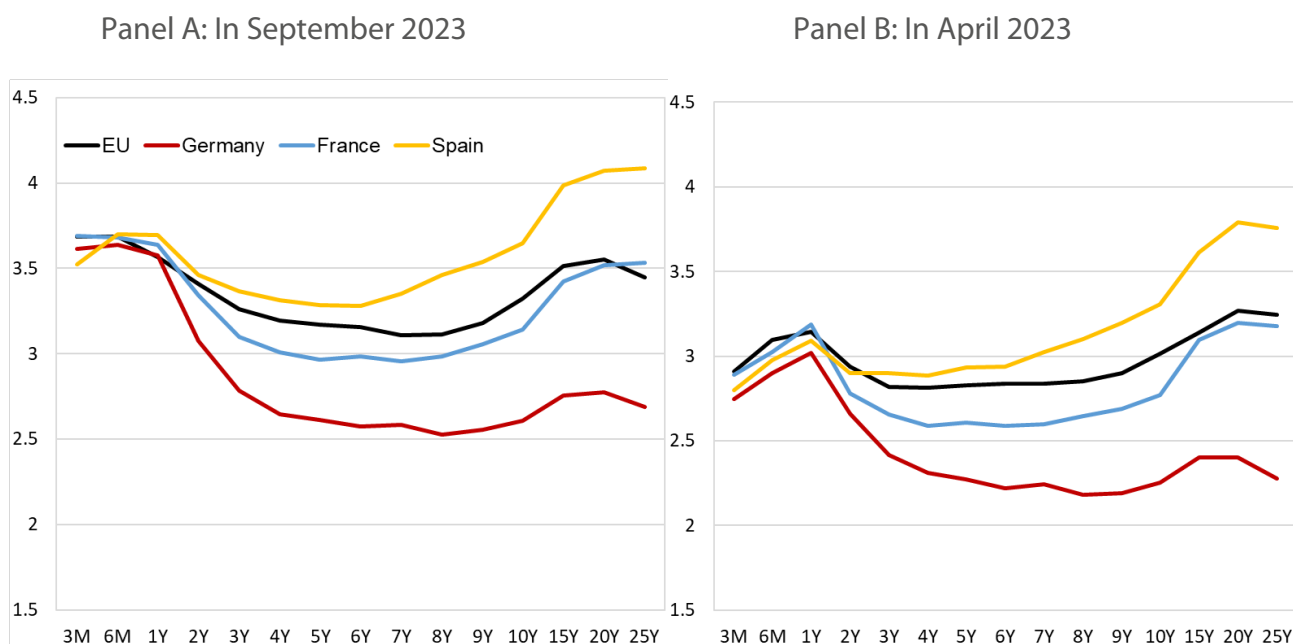
While market participants could have perceived this lower-than-expected borrowing as evidence of the unreliability of the EU as a large-scale issuer, this was not reflected in the performance of EU bonds relative

¹ Some of the fluctuations in the EU-Bund spread such as the one observed at the end of April 2023 can be explained by periodic shifts in the specific EU bond used as the 10-year benchmark in the Bloomberg time series. Unlike Bunds or French OATs, EU bonds hold a lower level of prominence in the bond market, and consequently, Bloomberg has not yet established constant-maturity generic bonds for the EU. As a result, as the maturity of the chosen bond gradually deviates from the 10-year mark, it becomes necessary to substitute the benchmark EU bond in the time series with one having a remaining maturity more closely aligned with the 10-year mark.

² This delay in disbursement requests was already visible in the first half of 2023 in the mismatch between the amounts borrowed (78 EUR billion) and the amounts disbursed by the European Commission (a total of 30.6 EUR billion: 9 EUR billion to Ukraine, 14.7 EUR billion for the RRF, and 6.9 EUR billion to EU budget programmes) (European Commission, 2023c).

to those of other issuers. Spreads relative to the Bund have been broadly unaffected by this announcement (Figure 3).

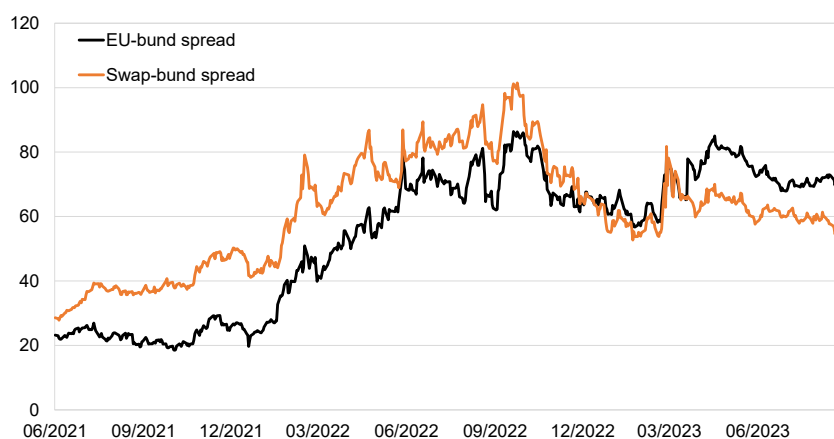
Figure 2: Yield curves of the EU and selected issuers (in %)



Source: Bruegel based on Bloomberg. Notes: The September and April values are for 08/09/2023 and 11/04/2023 respectively.

In September 2023, the European Commission also published the final breakdown of countries' loan requests under the RRF (European Commission, 2023d). Countries were entitled to claim loans of up to 6.8% of their respective GNI before 31 August 2023. Only seven countries requested loans in their original national RRP, for a total amount of 165.4 EUR billion. However, after the revisions to their RRP (which still need to

Figure 3: The evolution of spreads between swaps and EU bonds and bunds (on 10-year benchmarks, in basis points)



Source: Bruegel based on Bloomberg

be approved by the Council at time of writing), the number of countries now requesting loans through the joint EU borrowing facility increased to 13, for an updated total amount of loans to be disbursed of 292.6 EUR billion.

The cost of financing this borrowing will be borne directly by its beneficiaries and will therefore not directly be serviced through the EU budget. However, subject to Council approval, these additional borrowing requests will increase the overall issuance of EU bonds until 2026, which could have some ambiguous impact on EU borrowing costs: it will increase

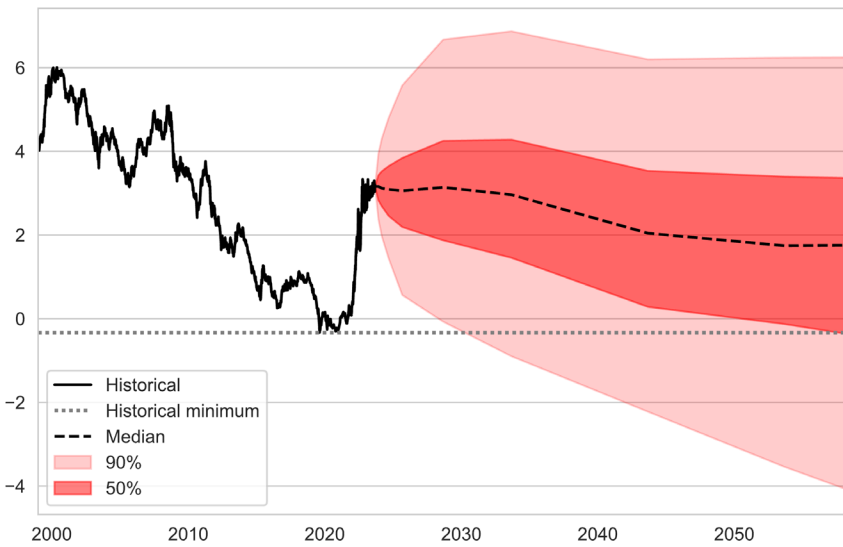
the supply of bonds, which could have a positive impact on yields if demand does not follow, but it should also further increase their liquidity and enhance the standing of the European Commission as a large-scale issuer on financial markets, which could ultimately reduce the spread versus Germany.

A longer-term view: EU borrowing costs until 2058

How will the interest rate costs of EU debt issued to cover grants evolve up to 2058?

As discussed in detail in Claeys *et al.* (2023), under the NGEU programme, the European Union intends to borrow around 421 EUR billion (in current prices) before the end of 2026 to fund “non-repayable support” to EU countries. This comprises RRF grants and supplementary financing for EU programmes. As the expenses related to the payment of the interest and of the principal on this debt should be covered by the EU budget, it is of utmost importance for European institutions to understand how these costs could evolve during the current 2021-27 MFF, but also up to 2058, by when the debt must be fully reimbursed.

Figure 4: 10-year swap rate, expected rate and option-implied confidence intervals (in %)



Source: Bruegel based on Danske Bank and Bloomberg. Notes: The chart displays historical and possible future values of the 10-year euro swap rate. The 10-year euro swap rate reflects market expectations of the average short-term rate over the next 10 years and can thus be interpreted as a good proxy for the 10-year EU yields. Dark and light red shaded areas correspond to the 50 and 90 percent confidence intervals, respectively, as defined by risk-neutral probabilities derived from the option prices on 10-year-swap rates.

These costs will depend mainly on the future trajectory of interest rates paid by the EU on its debt until 2058. Although it is very difficult to make interest rate forecasts for such a long-time horizon, one can rely on market expectations to establish scenarios. Currently, the median expectation among market participants suggests that **rates will remain relatively stable until the end of the decade, before slowly decreasing and stabilising below 2% in the long run.** Indeed, investors anticipate a decline in the 10-year euro swap rate, which closely mirrors EU yields (with a small spread, typically around 10 basis points on 10-year rates), reaching approximately 1.8% by 2058 (as depicted in Figure 4).

To gauge the uncertainty surrounding this baseline projection, it is possible to derive probability distributions using swap option prices. This method suggests that there is considerable uncertainty about the future path of nominal rates in Europe. Specifically, **there is a 50 percent probability that rates will fall within the range of -0.4 percent to 3.4 percent in 2058, while the 90 percent probability interval spans from -4.1 percent to 6.2 percent** (Figure 4).

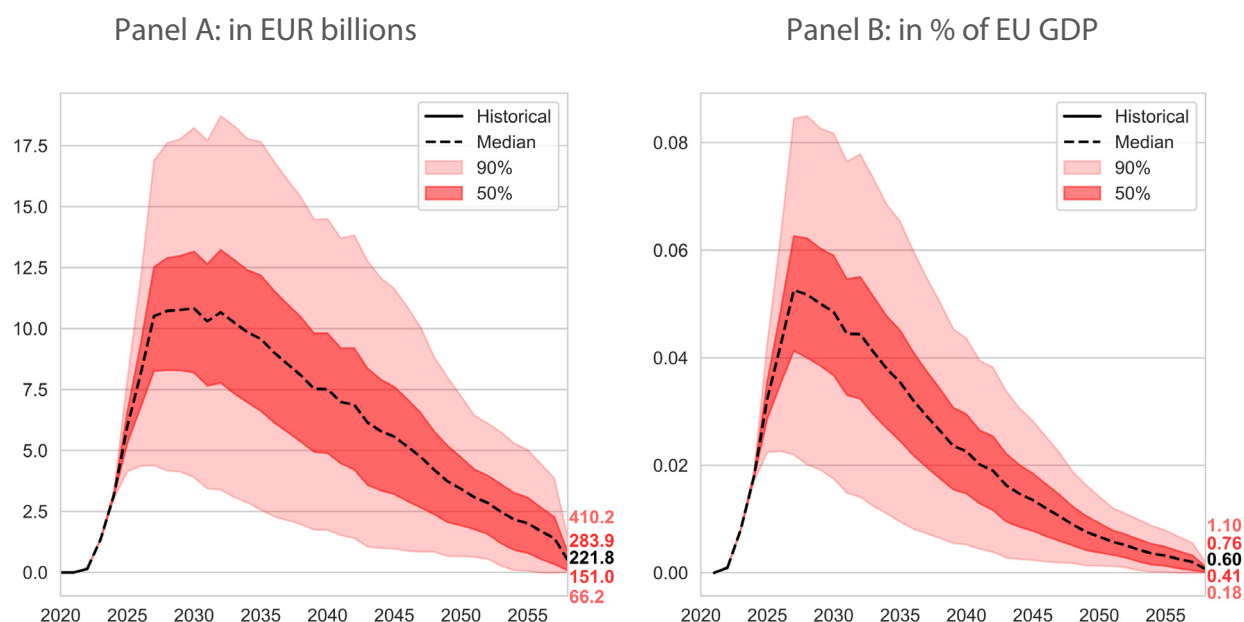
What are the implications of these scenarios for the actual interest expenses incurred by the EU? To project the yearly interest expenditures that will be serviced by the EU budget, we combine these market expectations for future interest rates and their volatility with information on the EU stock of debt, projections for future funding needs, the current distribution of debt maturities and spreads between swap rates and EU bond yields (see the Annex for details on the methodology). However, as we believe that the probability of extreme negative rates (anticipated by the market and resulting from the methodological assumptions

of the pricing model) is exaggerated³, we adjust the market interest rate scenarios shown in Figure 4 by assuming that future European interest rates cannot drop below their historical minimum, i.e. that 10-year swap rates will not go below minus 0.33%, the level reached in 2020 (dashed grey line in Figure 4).

Our results, shown in Figure 5, show that **yearly interest costs should increase in the next few years to reach 10.8 EUR billion in 2030 in the baseline scenario** (i.e. 0.05% of EU GDP⁴), before decreasing gradually up to 2058. Overall, total interest costs over the whole life of the NGEU borrowing scheme would amount to around 222 EUR billion (i.e. 0.6% of one year of average EU GDP over the whole programme; see bold numbers in the right-hand panels of Figure 5a and 5b)⁵.

Nonetheless, due to the significant uncertainty associated with future interest rates, as indicated by the wide confidence intervals in Figure 4, interest expenditures may exhibit substantial variation around this baseline estimate. For instance, **with a 50 percent probability, interest costs are expected to fall within the 8.2 EUR billion to 13.2 EUR billion range in 2030, while the 90% probability interval extends from 3.9 EUR billion to 18.2 EUR billion**, as illustrated in Figure 5, panel A.

Figure 5: Projected annual and total interest costs borne by the EU



Source: Bruegel based on Danske Bank, Bloomberg and European Commission. Notes: Panel A presents historical and projected annual interest rate costs (lines, LHS) and total costs (numbers in bold, RHS) borne by the EU, in current prices. 50% and 90% confidence intervals are based on option implied interest rate volatilities (see methodology detailed in the Annex). Panel B presents the same costs over projected nominal EU GDP, as well as the estimated share of total costs in average annual EU GDP (numbers in bold, RHS).

³ The reason why we believe this is rooted in the concept of the 'effective lower bound' of monetary policy. In essence, it would become challenging for the ECB to set rates lower than the policy rate reached at the time (-0.5%), because commercial banks would start storing cash (with an interest rate of 0%) to avoid negative rates (as explained in detail in Claeys *et al.*, 2019). As a result, longer-term rates would also not fall below the level reached at the time.

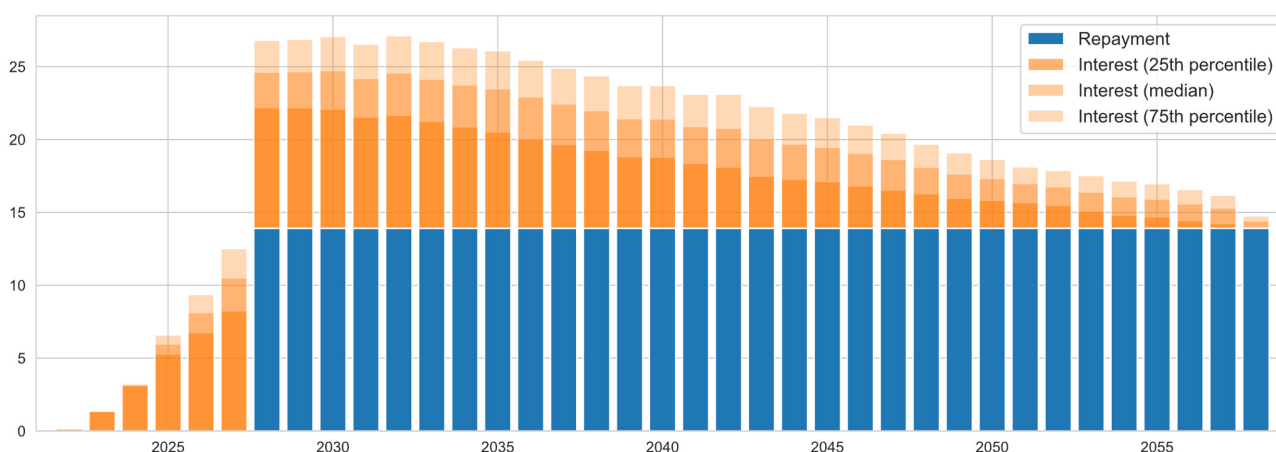
⁴ This could represent around 5% of the EU budget assuming that it will still represent roughly 1% of EU GNI in 2030, and that GNI and GDP are of similar magnitude.

⁵ Assuming that MFFs will keep their 7-year periodicity in the future, this can be decomposed into 19 EUR billion for the MFF 2021-27, 73 EUR billion for the MFF 2028-34, 57 EUR billion for the MFF 2035-41, 38 EUR billion for the MFF 2042-2048, 20 EUR billion for the MFF 2049-55, and 3.6 EUR billion for the MFF 2056-62.

How much money will be needed from 2028-2058 to cover both interest and principal reimbursements of EU debt related to the NGEU non-repayable part?

Starting in 2028, in addition to interest costs, **the EU budget will also have to include provisions to repay the EU debt until it extinguishes in 2058**. However, the debt issued between 2021 and 2026 will not necessarily need to be reimbursed immediately when it matures, as the legislation allows for some rollover of the EU debt after 2027, to enable a smooth decline of the EU debt incurred for the EU recovery programme. In our simulations, from 2028, we thus assume some rollover of the debt to ensure a linear decline in the total debt stock until 2058 (see the Annex for a detailed description of the methodology). As a result, we estimate that the annual principal repayments will be around 13.9 EUR billion per year from 2028 to 2058. This implies that, starting in 2028, the EU budget will be required to allocate a significantly larger sum of money to deal with its debt obligations. **Focusing on the scenarios with a 50% probability, the total annual financial needs could reach between EUR 22 billion and 27 billion in 2030 before declining gradually towards 13.9 EUR billion at the end of the programme** (Figure 6). In total, this means that between about 582 billion and 715 EUR billion will most probably be spent over the whole period by the EU budget to pay interest and to reimburse the debt for NGEU non-repayable support to EU countries⁶.

Figure 6: Projected annual principal repayments and interest costs borne by the EU (in EUR billions)



Source: Bruegel based on Danske Bank, Bloomberg, and European Commission. Notes: The chart presents historical and projected annual interest rate costs (orange) and principal repayments (blue) borne by the EU budget. Percentile estimates are based on option implied interest rate volatilities (see methodology detailed in the Annex).

Will the revenues expected from the Own Resources Package proposed by the European Commission in June 2023 be sufficient to repay the NGEU interest and principal?

In its June 2023 proposal for a new package for own resources, the European Commission (2023a) estimated that, overall, the package proposed will raise on average 36.5 EUR billion (in 2018 prices) for the EU budget annually between 2028 and 2030: 19 EUR billion will come from the Emissions Trading Scheme, 1.5 EUR billion from the Carbon Border Adjustment Mechanism (CBAM), and 16 EUR billion from a newly proposed temporary statistics-based own resource on companies' profits (to be replaced if a separate proposal on an aggregated tax base for large companies, BEFIT, is adopted). Adjusting for inflation⁷, this means that in current prices this new package is supposed to raise approximately 50 EUR billion annually between 2028

⁶ Assuming that MFFs will keep their 7-year periodicity in the future, this amount can be decomposed into between 25 and 33 EUR billion for the MFF 2021-27, between 151 and 188 EUR billion for the MFF 2028-34, between 136 and 171 EUR billion for the MFF 2035-41, between 120 and 150 EUR billion for the MFF 2042-2048, between 108 and 125 EUR billion for the MFF 2049-55, and between 43 and 47 EUR billion for the MFF 2056-62.

⁷ Using historical inflation rates from 2018 to 2022 and inflation forecasts up to 2028 from the April 2023 IMF World Economic Outlook.

and 2030 for the EU budget⁸. Given the scarcity of forecasts on carbon prices, carbon emissions, ETS and CBAM coverage, and the current lack of details on the future revenues that could be derived from corporate profit taxes and that would accrue to the EU budget, estimating revenues after 2030 is a challenge beyond the scope of this paper.

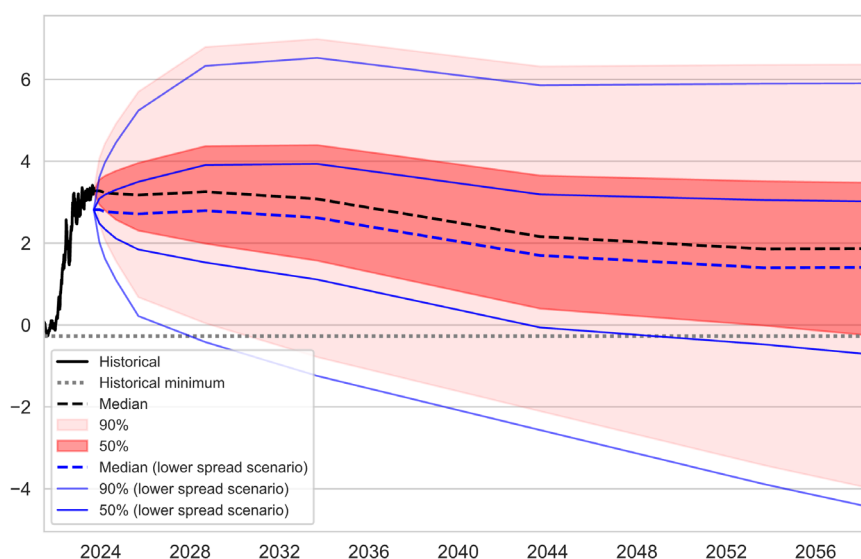
However, based on the results presented in the previous sub-section, and even if the rationale behind introducing new own resources is not only to service the debt contracted for NGEU, **50 EUR billion annually should, in theory, be sufficient to cover the costs associated with the joint borrowing for NGEU** (as our analysis suggests that these costs could reach a maximum of 27 EUR billion in 2030 in the 75th percentile scenario, or 32 EUR billion in the 95th percentile scenario). **But this assumes that the estimates made by the European Commission are realistic and that the package will be approved in its current form.** These are strong assumptions as the package is far from being even approved by EU countries, and has been received with strong scepticism by some governments (in particular the statistics-based own resource on companies' profits)⁹. Moreover, parts of the ETS revenues are expected to be earmarked to finance the Social Climate Fund and the Innovation Fund, which should reduce substantially the amount that could be used to service NGEU debt. Given that the costs associated with EU borrowing will peak as soon as 2028-2030, it is crucial that a sufficient package of own resources is in place by then if countries do not want to reduce other EU budget expenditures, or to increase their national contributions to finance the expenses related to EU debt.

By how much would the costs of EU debt be reduced if spreads were narrowed to the levels experienced before the 2022 divergence?

As discussed in Claeys *et al.* (2023), in 2022, the EU faced a widening of the spread between its yields and those of major European issuers, including France and Germany. This widening was driven by a combination of market features, circumstantial factors and institutional features.

The European Commission should try to narrow these spreads by further developing the relevant market infrastructure and improving its issuance strategy. However, institutional developments, including progress on the development of new genuine own resources and a long-term substantial presence in the bond market, will also be necessary to fully reap the benefits of EU borrowing.

Figure 7: EU yields scenarios, current spreads and lower spreads vs Bund (in %)



Source: Bruegel based on Danske Bank and Bloomberg. Notes: The chart displays historical and possible future values of the 10-year EU yields based on various scenarios for the spread level. Dark and light red shaded areas correspond to the 50 and 90 percent confidence intervals, respectively, as defined by risk-neutral probabilities derived from the option prices, and spreads observed in September 2023. Blue lines are derived using lower spread from January 2022.

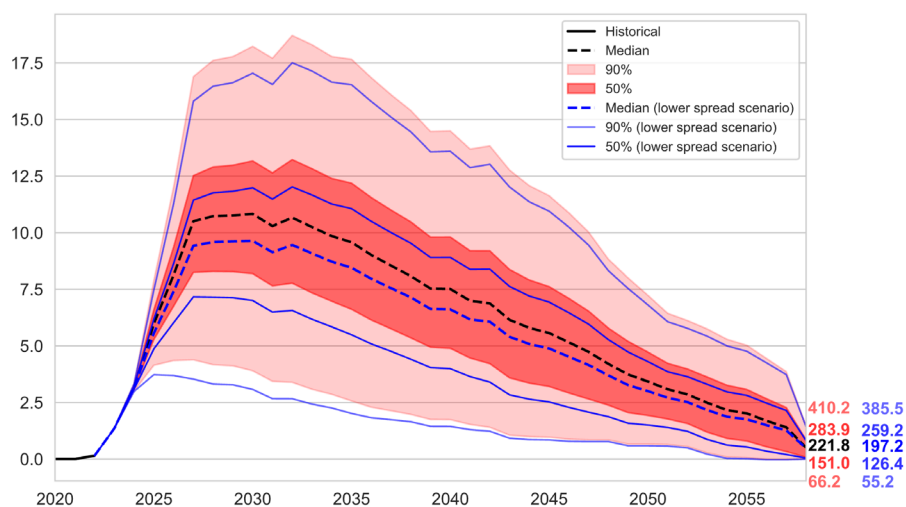
⁸ Regarding the proposed new Own Resource from Pillar 1 of the OECD tax agreement, the EU Tax Observatory (2023) estimates that the EU would have received approximately 1.9 EUR billion in 2020. Adjusting for inflation, this would result in approximately 2.55 EUR billion in additional revenue for the EU budget in 2030. However, given the lack of progress in this area, it is prudent to omit this when forecasting EU revenues.

⁹ See e.g. <https://www.euractiv.com/section/economy-jobs/news/eu-budget-member-states-pull-the-break-on-new-revenue-sources/>.

But how much money would be saved if the spreads were to be reduced to their pre-divergence level? Figure 7 displays two different scenarios for EU yields: The baseline scenario, based on the higher spreads observed in September 2023 (black/red), and a lower spread scenario based on the spreads observed in January 2022 (blue).

Comparing these two interest-rate scenarios allow us to estimate how much could be saved by reducing spreads to their previous level. As Figure 8 shows, the amount of potential savings is significant. For instance, **in the median scenario, total interest costs would be reduced from 221.8 to 197.2 EUR billion, i.e. by around 25 EUR billion or 10%.**

Figure 8: Projected annual and total interest costs borne by the EU (in EUR billions) depending on spreads' levels



Source: Bruegel based on Danske Bank and Bloomberg. Notes: The chart presents historical and projected annual interest rate costs (lines, LHS) and total costs (numbers in bold, RHS) borne by the EU, in current prices. 50% and 90% confidence intervals are based on option implied interest rate volatilities.

Conclusions and additional recommendations

The costs associated with EU debt incurred by the EU budget over the long run are not insignificant. Our estimates suggest that, with a 90% probability, these costs will fall within the range of 0.2% to 1.1% of average annual EU GDP during the programme. Given the level of resources at stake, it is important to minimise these costs. To do so, as advocated previously in Claeys *et al.* (2023), we believe that **the European Commission should continue to improve its issuance strategy and work on building market infrastructures for EU bonds, in order to increase their appeal for investors. We also continue to believe that these changes in market features will have to go hand-in-hand with some institutional development.** To be considered as a sovereign, and to benefit from the safe-asset status of a highly rated sovereign, the EU probably needs sovereign features.

Fortunately, one of the recommendations from our previous briefing (also recommended by the European Parliament, 2022) has already been picked up by the European Commission in its MFF review proposal (European Commission, 2023e). Given the higher costs than initially planned, and to ensure these do not exert undue pressure on important EU programmes, we recommended that the EU review how interest costs are accounted for in the EU budget and in the MFF, and that it should exclude the interest payments budget line from Heading 2b, and count it above the MFF expenditure ceilings. The Commission proposed exactly that in June when advocating that *“a new thematic special instrument (the ‘EURI Instrument’) should be established, over and above the MFF ceilings, until the end of the MFF, for the sole purpose of covering NextGenerationEU funding costs exceeding the amounts initially planned in 2020 under the expenditure ceiling of Heading 2b”*. Member states and the European Parliament should adopt this proposal.

In addition to the recommendations set out in the previous briefing, what other measures and market operations (such as debt buy-backs, issuance of zero-coupon bonds, inflation-linked bonds, etc.) could be implemented to reduce and optimise EU interest rate costs?

These specific measures will probably not have a meaningful impact on borrowing costs in the short term, unless they convince market participants that they should treat the EU as a sovereign issuer instead of an SSA issuer (i.e. supranationals, sub-sovereigns and agencies). However, when asked in a 2022 survey what factors would cause them to consider the EU more like a sovereign than an SSA issuer, investors put a much greater emphasis on factors including sovereign index eligibility (over 50% of respondents), well-functioning repo markets (46%) and a unified funding strategy (41%), than on the EU actively providing liquidity via retaining and buying back bonds (19%) (Eichert *et al.*, 2022). Respondents were not asked specifically about zero-coupon or inflation-linked bonds. However, some of these instruments could still play a role in the Commission's funding strategy in the future. For instance, debt buy-backs are frequently used by national debt management offices to smooth their repayment needs over time, with Agence France Trésor, for example, buying back 30 EUR billion in bonds on average annually between 2012 and 2021 (Copin and Dalbard, 2022). As EU repayments will begin in 2028 in a manner that must be compatible with "*a steady and predictable reduction of liabilities during the overall period*" (EU, 2020) the ability to further smooth redemption volumes provided by buy-backs could be useful in the Commission's toolbox.

Similarly, introducing different types of bonds, such as inflation-linked or zero-coupon bonds, may in the long-term help to appeal to a wider range of investors. For instance, at the end of 2022 inflation-linked bonds made up non-negligible shares of outstanding totals for large-scale sovereign issuers including Germany (4.4%), France (10%), Italy (10.2%) and Spain (5.3%) (Tesoro Público, 2022). However, and notwithstanding the unforeseen cost of these inflation-linked bonds during the recent inflation episode for the countries selling them, given that the liquidity of EU bonds is already lower than that of comparable sovereigns, the EU should continue, in our view, to prioritise increasing its presence along the whole the yield curve of vanilla bonds, before it thinks about issuing new types of bonds, which, in the absence of large-scale issuance, would also likely be plagued by liquidity concerns of their own.

In sum, new measures beyond those discussed in our May 2023 briefing (Claeys *et al.*, 2023) could in the future contribute to the better functioning of the EU's borrowing operations, and might help optimise EU borrowing costs. However, **we believe that at this stage and before thinking about any new market initiatives, the Commission should prioritise establishment of a repo facility, improve the collateral treatment of EU bonds by clearing houses and, above all, promote the inclusion of EU bonds in sovereign indices.**

Annex: Debt and interest cost projection methodology

Projections of future interest costs and debt issuance that will be borne by the EU are calculated by combining data on the EU's current debt stock with estimates of future financing needs, the original maturity structure of current debt and market expectations of future interest rates.

For issuance until the end of 2022, we use European Commission transaction data and press releases to identify historical interest costs for bills and for bonds that should be attributed to NGEU, i.e. the only programme with non-repayable components. Since interest costs of some NGEU bonds are borne by EU countries, we adjust the size of historical coupon payments by the non-repayable share of disbursed NGEU funds, as reported in the European Commission's reports on the implementation of borrowing, debt management and related lending operations (European Commission, 2021, 2022a, 2023f).

For the first half of 2023, we adjust issuance levels to account for the MFA+ support for Ukraine, before correcting by the share of non-repayable disbursements as a share of total NGEU disbursements for the first half of the year (calculated based on European Commission, 2023c). Outstanding borrowing needs in 2023

are estimated by applying the share of non-repayable support in total outstanding NGEU support to the NGEU borrowing included in the funding plan announced for the second half of 2023 (European Commission, 2023b). Borrowing needs for the subsequent years are based on estimates for outstanding disbursements of NGEU grants and rollover costs of existing and future debt. Given disbursement request delays and revisions to national RRP, these assumptions are challenging. We assume equal disbursement of outstanding non-repayable MFF programme support until the end of 2024 and equal disbursement of outstanding RRF grants until the end of 2026. As detailed in the May 2023 briefing, our findings are largely robust to different grant disbursement schedules, but different assumptions will ultimately lead to different results. Until 2027, borrowing needs are met by taking up new debt according to the original maturity profile of the current debt stock.

From 2028 onward, no new debt is issued except for the purposes of rollover. Rollover needs are calculated to ensure a linear decline of total liabilities, resulting in the full repayment of all debt by the end of 2058. During this period, a fixed amount of 10 EUR billion in bills is rolled over annually (corresponding to the average level of 2022 and 2023), with the shares of 3- and 6-month bills mirroring the distribution of the current debt stock. The maturity profile of rolled-over bonds is chosen to ensure full repayment by 2058 and a smooth distribution of rollover needs over time. Specifically, rolled-over bonds are issued according to a linearly declining maturity structure. In each year t , the share s of issued bonds with maturity m can be calculated as:

$$s_t^m = \frac{1 - \frac{m}{T - t + 1}}{\sum_{i=1}^{T-t+1} \left(1 - \frac{i}{T - t + 1}\right)}$$

Here, T denotes the final year of repayment. In 2055 for instance, 50% of issuance will be allocated to 1-year bonds, around 33% percent to 2-year bonds, and around 17% to 3-year bonds. Resulting annual rollover amounts are around 22.8 EUR billion from 2029 and 2038, 18.5 EUR billion from 2039 to 2048, and 16.9 EUR billion from 2049 to 2058.

Interest rates are based on forward swap data for each projection year and respective maturities, corrected by the monthly average spread between euro swaps and generic EU bonds, from September 2023. The lower spread scenario additionally corrects for the difference in monthly average EU-Bund spreads between January 2022 and September 2023. We use forwards of 3 months, 6 months, as well as 1-, 2-, 3-, 4-, 5-, 10-, 15-, 20-, 25- and 30-year swaps, correcting each by the spread with respective EU generic bonds and linearly interpolating missing rates along the yield curve.

50% and 90% confidence intervals reflect the volatility consistent with prevailing market expectations. Specifically, the upper and lower bounds for forward rates have been derived from the implied volatilities of option prices for 10-year euro swaps. Given observed pricing parameters, one can solve an option pricing model for the volatility parameter and thus derive the range of expected price swings of the underlying asset. The implied volatilities used in our calculations are based on Danske Bank's proprietary pricing model (whom we thank for providing us with this data). We repeat the projection of interest costs described above for each bound. This implicitly assumes a constant shape of future yield curves.

Real GDP projections up to 2027 are based on data by the Output Gaps Working Group of the Economic Policy Committee. Long-term projections are based on interpolated projections of the European Commission 2021 Ageing Report. The corresponding GDP deflator is based on Output Gaps Working Group data up to 2027, market expectations inferred from Bloomberg inflation swap data up to 2053, and the assumption of constant inflation thereafter.

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