GENERALI INSURANCE ASSET MANAGEMENT

CORE MATTERS

Where is R-star headed amid climate change and higher inflation?

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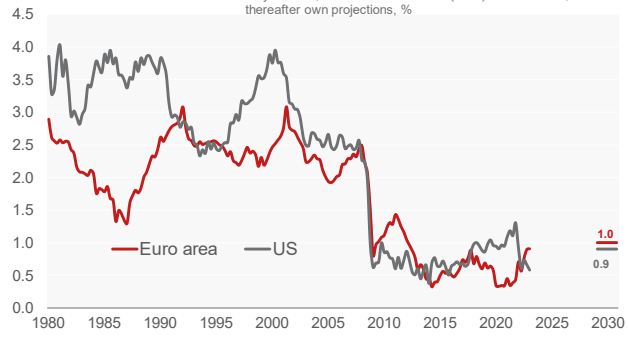
Our Core Matters series provides thematic research on macro, investment, and insurance topics

- R-star or the equilibrium real natural rate of interest serves as a benchmark for monetary policy and investors. Fundamental developments such as climate change and the return of inflation may well move R-star to new values.
- While conceptually straightforward, R-star is not directly observable and has been interpreted differently in terms of maturity (short-term vs long-term), asset class (risk-free vs risky), and estimation methodology.
- Against this backdrop, empirical estimates of R-star are subject to high uncertainty and vary considerably within and across model classes.

R-star set to rise over the medium term
natural interest rate calculation by Holston, Laubach and Williams (HLW) until Q1/2023, thereafter own projections, %



Source: HLW, GIAM calculations

- To gauge the future direction of R-star, we show that the commonly used short-term estimates by Holston, Laubach and Williams (HLW) can be inferred from not only traditional real variables – like potential growth and the savings/investment balance – but also from inflation expectations and monetary policy variables in the US and euro area.
- Our findings suggest that R-star cannot be treated as fully exogenous by monetary policymakers. The upward effects from higher inflation expectations vs post-GFC nadir in the euro area and the shift towards monetary policy tightening will more than offset the dampening effects from falling potential growth, while the effects of climate change on R-star are likely to remain small. As of late, R-star rose in the euro area but fell in the US. On balance, we expect R-star to inch up only marginally from current levels to about 1% in the euro area and rise somewhat more visibly to 0.9% in the US by 2030.
- R-star is a major driver for government bond yields in the medium term. We find that apart from other fundamental factors like the term premium and future key rates especially the forecast increase in R-star will lift 10-year government equilibrium bond yields to 2.3% in the euro area and 2.9% in the US.
- The outlook becomes more uncertain when considering financial stability issues. Latest research suggests that taking financial stability into account lowers R-star in case of high bank leverage. Hence R-star might in the future lose importance for central banks or be altered by financial stability variables.

1. Introduction

R-star or the real natural (or neutral) rate of interest is an important reference point for central banks, investors, and economic stability. Economically, it is **the real interest rate (i.e. after subtracting inflation) that would prevail if the economy were in equilibrium**. This demands price stability, a closed output gap, and full employment. This is a very comprehensive concept as changes by any fundamental imply a change in the real interest rate. Although the idea of a natural rate dates back to the Swedish economist Knut Wicksell (1898), it has gained much prominence since the 1990s. Central banks have tried to determine whether their key rates could be considered expansionary or contractionary relative to the "benchmark" of the natural rate. Moreover, as central banks would want to conduct their monetary policy in a way that the economy shall achieve equilibrium over the medium term, the actual rate would be bound to converge. In this regard, the natural real rate has also gained in importance for financial markets as a predictor for central banks' medium-term monetary policy stances.

There is currently **much uncertainty** about R-star. We see three lines of issues that might influence its outlook:

- First, **monetary policy has tightened at an unprecedented pace** following the inflation shock. The world of ultra-low interest rates and quantitative easing (QE) suddenly vanished. The inflation shock challenged the 'secular stagnation' hypothesis, in which the negative value of R-star justified both ultra-low market interest rates and QE. While R-star is often seen as independent from monetary policy and only influenced by real economic variables, the period of ultra-easy monetary policy has prompted researchers to challenge this proposition. This line of thinking is summarised in the so-called "financial cycle hypothesis". If this thinking is well-founded, will monetary tightening also push R-star higher?
- Secondly, **R-star** reflects the relation between (global) savings and investment which is traditionally seen as determined by factors like productivity growth, globalisation, demographics, and technological change. The **greening of the economy adds new dimensions** to these factors. Will these new investment needs also push R-star higher?
- Third, **R-star is not directly observable but must be estimated** in models, that reflect underlying (controversial) macroeconomic concepts. This also encompasses the questions of whether R-star is a short-term or long-term equilibrium rate, and whether the rate reflects risky or risk-free assets. Estimates have traditionally shown a wide variety. The Fed even temporarily suspended publishing its model outcomes during Covid.

We shed some light on the conceptual issues in Chapter 2, take stock of commonly used concepts and present our new results in Chapter 3. We dedicate Chapters 4 and 5 to the impacts of the green transition and the central bank's turnaround. This policy change has also put the question of financial stability to the fore, which is reflected in an extended concept of R** (Chapter 6). We go on to our R-star outlook (Chapter 7) and draw implications for core government bond markets in Chapter 8.

2. R-star: One word, different meanings

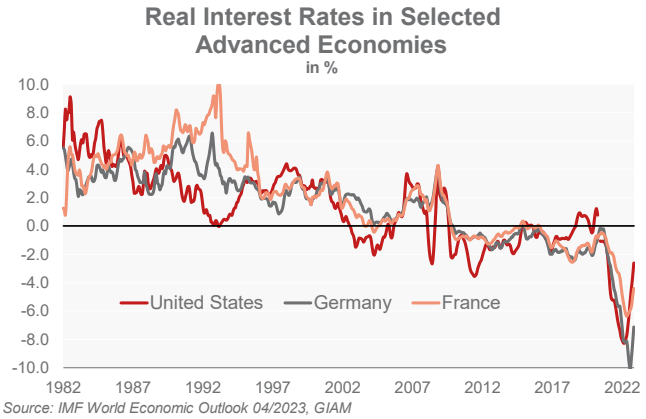
While there is general agreement that R-star refers to the equilibrium real interest rate, it is also a very controversial topic. The original concept dates back to **Wicksell** who first made the distinction between the "*market rate of interest*" (i.e. the actual value of the real interest rate) and its equilibrium value, the so-called "*natural rate of interest*". The latter reflects goods markets to be in balance, i.e. planned savings equal projected investments. Or put differently, the supply and demand for capital match each other. (see De Nederlandsche Bank, 2018).

Important lines of more **modern macroeconomic** research moved away from this "classical" approach. They typically refer to a **short-term, risk-free interest rate (**so-called neo-

Wicksellian" or "New Keynesian" approaches Woodford, 2003, De Nederlandsche Bank). Still, R-star is the interest rate consistent with a closed output gap and stable inflation. But the models allow for price rigidities and business-cycle shocks. For instance, the much-referred to Holston, Laubach, Williams (HLW) used at the Fed combines a goods market equilibrium condition with a Phillips curve, linking inflation to the output gap (for a literature review see e.g. IMF 2023 and DIW). Central banks can try to stir the economy back to a short-term equilibrium by using their monetary policy tools.

However, using these short-term approaches based on output gaps open up the question of how it relates to the long-term fundamental factors. In the HLW approach, they come as additional variables. Some authors try to reconcile them by introducing an additional distinction of a real "neutral rate" (consistent with stable inflation and output at potential) and an underlying, slow-moving "natural rate". However, these approaches have difficulties in explaining why monetary policy may be effective in steering the economy back to equilibrium while at the same time having no impact on longer-term fundamentals.

Independent of such controversies, empirically, **risk-free interest rates across all maturities have trended down over the past thirty/ forty years until recently** in **many advanced economies**.



Source: IMF World Economic Outlook 04/2023, GIAM

Macroeconomically, this fall corresponds to a **persistent excess of desired savings over planned investment** which caused downward pressures on rates. Apart from households' preference shifts, there has been a range of explaining factors (see IMF 2023b):

- A possible **decline in profitable investment opportunities** has often been attributed due to slowing growth in total factor productivity. Looking ahead digitalization and scientific advances stand against dampening factors from the stagnation of the quality of human capital, pressures from globalization, and the increase in the old-age dependency ratio.
- However, the **demographic factor** is also accounted for as increasing global savings: Given the population of working age (20-64 years) has relatively grown in recent years and since working people have the highest savings propensity, this has led to an increase in total savings. Alternatively, excess savings have been explained by **distributional effects**, as the income and wealth share of the "rich" has increased since the 80s while they have a lower marginal propensity to consume. Another explanation relies on **financial innovations**. The availability of finance has increased in recent decades and has therefore lowered interest rates.
- Additional factors considered are **market power**, **labour share**, **international capital flows**, the **scarcity of safe assets**, **risk aversion,** and **leverage cycles**

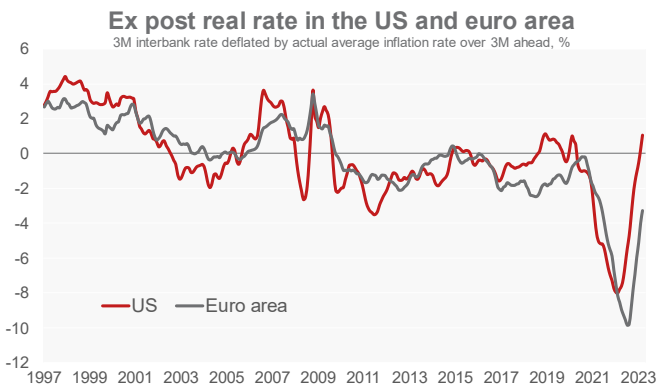
These real-economy factors are leading to a decline in the natural rate are often dubbed the "secular stagnation hypothesis". Because of the de-facto lower bound in the nominal policy rates amid (until recently) inflation close to zero, conventional monetary policy was not able to stimulate the economy sufficiently, which either can be mitigated by QE or expansionary fiscal policy.

In contrast, the **financial cycle hypothesis** – introduced by the Bank for International Settlements (BIS 2016) – sees the inability of monetary and fiscal policy makers to restrain financial booms adequately, creating deep and protracted recessions followed by weak and drawn-out recoveries. According to this approach, the period of **low or even negative interest rates drove R-star down** because it leads to an inefficient allocation of capital and hence lower growth. Seen from this perspective a low natural rate is not an equilibrium phenomenon but is associated with the course of the financial cycle (De Nederlandsche Bank, 2018) This approach hence broadens the scope to financial factors. For central banks, R-star is no longer exogenous (BIS 2016) and money is not neutral in the longer run.

3. Historic estimates of R-star vary considerably

R-star is not an observable variable. Three types of approaches are commonly deployed. The simplest one is to use the **moving average of an observable real interest rate proxy** to smooth out fluctuations. These rates can be calculated as "ex-ante rates" by computing the real rates using the expected inflation rate over the maturity horizon, or as "ex-post rates" by using the realized inflation rate. Critical

to the outcome is – irrespective of whether more sophisticated filtering approaches are used – the choice of the actual rates and the moving average window.



Source: Datastream, GIAM calculations

Second, **multivariate approaches** set up simple models to determine R-star and explicitly consider changes in inflation, output, interest rates, and other variables. These models yield R-star estimates as the realisation of a latent variable that cannot be directly observed. The most prominent and commonly used approach here by HLW, see box below.

Third, R-star can be determined by estimating a full **macroeconomic model based on microeconomic foundations of firms and households**. The major advantage of this approach is that the key drivers of R-star can be identified. However, it requires specific assumptions about frictions and various model parameters making the results very sensitive to specifications.

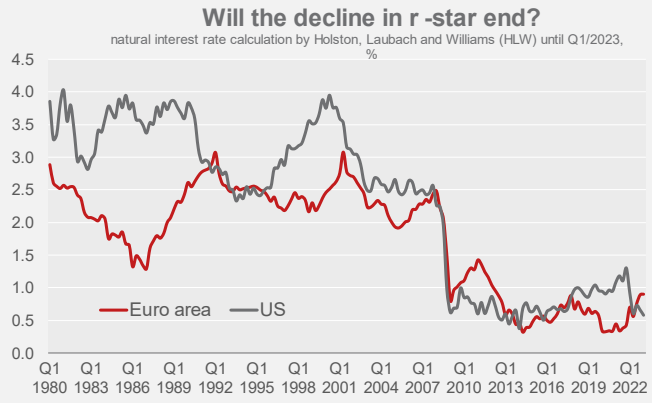
Point estimates for R-star are surrounded by huge uncertainties

The **variety of approaches yields very different point estimates of R-star**. The analysis of various models for the euro area (see this ECB paper, p. 36) yields considerable uncertainty (as measured by the 90% confidence band for R-star) within a certain approach as well as among the various methods presented. Point estimates for the euro area range from -2% to +2%. For the US this uncertainty is similarly high, ranging from 0% to 3% according to the IMF (p. 49) for the second half of 2010. This underlines that point estimates of R-star must be treated with a big grain of salt. Focusing on the change of R-star instead may alleviate these shortcomings and prove more reliable.

While the various approaches provide estimates for R-star, they say little about the importance of various factors. According to first estimates by HLW (see box) R-star rose as of Q1 2023 compared to the pre-pandemic level (Q4 2019) in

Holston, Laubach and Williams's R-star approach

Holston, Laubach and Williams (HLW) use a two-step procedure to assess R-star. The economy is modelled by the interaction of aggregate demand (depending on the output gap and the deviation of the real interest rate from its equilibrium) and inflation (depending on past inflation and past growth). First, current GDP and inflation data are used to compute forecasts for the period ahead. Then the macroeconomic model is used to obtain estimates for R-star, potential output, and trend growth. As these variables are not observable, they need to be derived indirectly. This is done using filtering (Kalman filter). Second, when new actual inflation and GDP data become available, they are compared to the predicted values.



Source: HLW, GIAM calculations

While intellectually appealing the approach has shortcomings: the resulting course of the output gap is often unrealistic and expected inflation is modelled as a moving average of preceding inflation. The results are sensitive to even minor tweaks of the technical assumptions concerning time series characteristics, the estimation method, or the choice of the dataset. Therefore, significant revisions of the computed R-star values are usual. With all these caveats in mind, R-star has trended down since the 1980s in both the US and the euro area. Very recently, the authors updated their estimates (by no longer assuming random and serially uncorrelated economic disturbances) to account for the pandemic; the changes until just before the pandemic were only small but as of Q1/2023 R-star is higher for the EA than the US. Considering the US, it is hard to understand what drives the fall in R-star, as around the turn of the year cyclical conditions were improving. According to these estimates, and assuming 2% long term expected inflation, as of Q1 2023 the gap between the Fed funds rate and nominal R-star, a proxy for the

tightness of monetary policy, stood at an unprecedentedly high level of nearly 200 bps.

However, estimates very recently published by the NY Fed, and derived from a (Dynamic General Equilibrium Model) model with the same logic as HLW, but a more detailed and sophisticated description of the economy shows that R-star has instead increased in the last quarter, from a level much below those derived with the HLW model. This highlights the difficulty of using an estimate of the neutral rate as a safe gauge for the assessment of the monetary policy stance and again highlights the uncertainty surrounding R-star estimates.

the euro area (by 33 bps) but fell in the US (by -38 bps). To us, this underlines the need to look at the underlying drivers more thoroughly and to identify the ultimate drivers as we doubt that a divergence in the transatlantic R-star will be sustainable. We **regress the HLW estimates for R-star on selected fundamentals** and extract the statistically significant drivers under various specifications. For the US as well as the euro area, the classical driver related to the real economy – potential growth – was always significant (see Annex 1). But this exercise also showed that measures of global capital flows, monetary policy, and inflation expectations also help to explain the historical development of R-star. We see this **as an indication that solely focusing on variables related to the real economy is not appropriate: thus the financial cycle hypothesis stresses an important point**. We shed additional light on this issue in the R** section. However, we first examine the other two most important new dimensions: climate change and inflation (Chap. 4 and 5).

4. Green transition: limited impact on R-star

The impact of different climate policies may affect R-star positively or negatively. There are at least three fundamental channels that will impact[1] the natural interest rate and for the sake of clarity, we discuss them ceteris paribus:

- Almost all climate policies build on a substantial increase in CO2 emission costs, a **carbon tax**. The goal is to change relative prices to the disadvantage of fossil fuels, but this unavoidably raises energy prices (at least for some time). This negative price shock raises production costs and/or reduces the return on investment. Consequently, this works in the direction of a **lower R-star**.
- However, typically, the **governments'** collected carbon taxes are supposed to be re-channelled, financing or **subsidising low carbon investment or mitigating energy expenses via transfers** for specific income groups. "*Public Investment in green infrastructure and subsidies to renewable energy positively affect investment,* ***pushing up R-star***" (IMF WEO 2023, Chapter 2). Also, governments are not confined to a budget-neutral approach. They may resort to deficit spending, calibrating their expansionary fiscal packages to make low-carbon energy cheaper and more readily available.[2] Moreover, the global savings glut (while receding) suggests that a pool of excess savings may be used to finance investments (IMF data suggest excess savings of 0.3% of global GDP in 2023). All in all, the **resulting increase in aggregate demand may have only limited crowding out effects**.
- In the longer run, the effect on supply and the production capabilities of the economy is key. If it is not enhanced, higher investment will only lead to higher inflation (Nixon, Hannon 2021). Just replacing the energy source from carbon- to non-carbon does not improve efficiency. A widespread switch to more efficient technologies is needed to sustain/complement expansionary policies. Or put differently, it is necessary that the "demand stimulus, […] sustained over many decades, can facilitate the necessary innovation, essentially making aggregate supply endogenous to aggregate demand." (Nixon, Hannon 2021) Only in this case, R-star will rise.

Hence, it takes a general equilibrium model and scenario analysis to consolidate the diverging effects. The **IMF has developed a growth and distribution-friendly scenario** using the G-Cubed global macroeconomic model (WEO 10/2020), and a modified version in WEO 04/2023. The latter assumes:

- Carbon taxes — aimed at achieving net-zero emissions by 2050 — starting (country-specific) at between $6 and $20 a metric ton of CO2 and ending between $40 and $150 a ton in 2050 (actual emission prices have risen quite above these assumptions of late).
- A budget-neutral fiscal package with 25% of tax income recycled toward social transfers, up to 70 percent for green public infrastructure investment, and the rest as subsidies to renewable energy sectors.

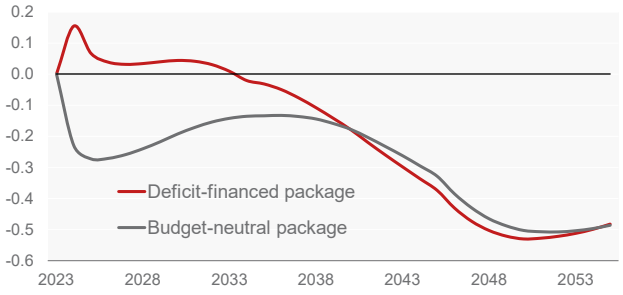
[1] For a more elaborate discussion of policy tools, see WEO 10/2020.

[2] For a discussion of fiscal expenditure needs for greening the economy, see "How to reconcile fiscal consolidation, greening and equality?".

- Given the large uncertainty surrounding the impact of green public investment on output, the simulations take a conservative approach and do not assume any direct productivity gains from green public investment.

The Global Natural Rate of Interest and the Green Transisition

Global average, deviation against baseline in pp



Source: IMF World Economic Outlook 04/2023, GIAM

As could be expected, the budget-neutral policy package depresses R-star along the entire transition path due to the contracting impact of the carbon tax. Relaxing the budget neutrality (also intended to provide a post-Covid boost – see WEO 10/2020) for an **initial demand push has instead a temporarily positive impact on R-star**, even though this effect largely owes to the Covid-induced capacity underutilisation prevalent in 2020.

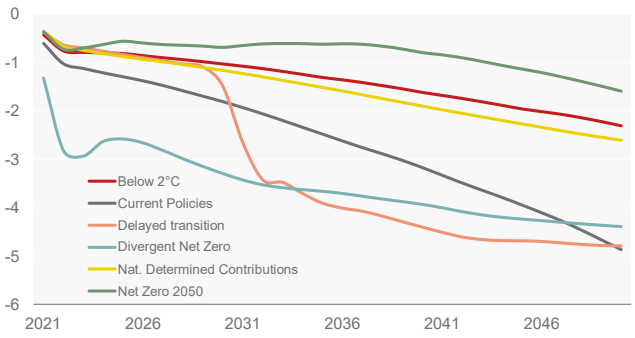
> *All in all, a minor positive effect from the green transition on R-star is more likely*

This approach has its limits as general equilibrium models tend to treat climate mitigation as a "zero-sum outcome" Increasing investment macroeconomically crowds out consumption. Without productivity-enhancing technologies, rising energy prices necessarily remain a negative supply shock until the carbon based-production capital of the economy has been fully replaced. Accordingly, GDP growth suffers relative to the baseline. This is also true for the NGFS scenarios and the IMF G-Cubed analysed scenario. That said**, quantitatively the effects are not large**. After 15 years, GDP is lower by about 1pp relative to the baseline, which assumes a 120% cumulative global GDP growth over the next 30 years (see WEO 10/2020).

In an alternative approach, researchers at *Oxford Economics* built a scenario incorporating larger innovation effects that lead to a small boost to world GDP levels by 2050. The scenario relies on external benefits to R&D investment, which in turn lowers the optimal carbon pricing trajectory, and thus the negative impact on R-star relative to the original "Net Zero scenario".

World GDP in NGFS scenarios

% deviation from baseline



Source: IIASA NGFS scenario explorer, Nigem model, GIAM

In sum, general equilibrium models give no clear hint about the impact of climate change on R-star but are skewed towards a small negative impact (see also ECB study, Nov. 2022). The rise in energy prices will cause a deterioration, but the diminishing effect will become smaller the larger the fiscal impulse and the higher the elasticity of supply. Modelling R&D effects on supply more positively leads to a **positive but minor increase in R-star, which we judge – all in all – slightly more likely.**

5. From deflation worries to inflation and QT

A key feature of the 2010s was **stubbornly low inflation amid deflationary risks**. As discussed above, this can be interpreted as a result of a permanent positive output gap, which is associated with a reduction in R-star. A closely related hypothesis is the global savings glut (GSG). The term was coined by former Fed Governor Bernanke (for a review see Chicago Fed, Barsky, Easton 2021), who saw international causes, i.e. Asian countries (not only China), oil-exporting counties, and selected Northern African countries as the source of excess global savings, which resulted in large capital inflows and current account deficits in many Western countries (e.g. the US).

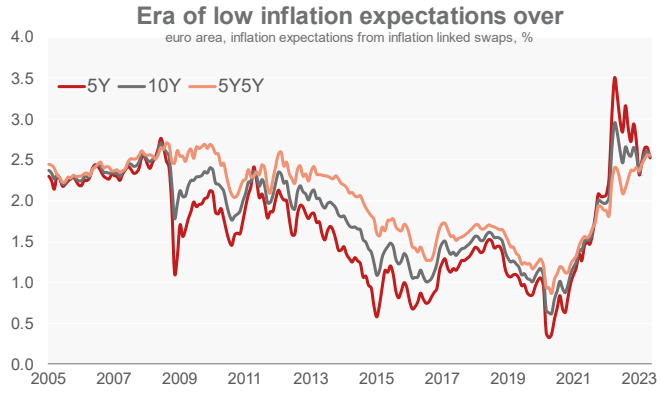
The downward pressure on the equilibrium natural rate forced central banks to lower key rates. Once – due to the (roughly) zero-lower bound in interest rates – monetary authorities could no longer only rely on key rates as instruments, they switched to unconventional policy measures like quantitative easing (QE) to stimulate activity. The purchase of government bonds on a large-scale significantly boosted demand for (safe) assets. Likewise, the low inflation environment was perceived as persistent, leading to low nominal interest rates and QE.

The fall in the **term premium as well as of the inflation risk premium also contributed to lower real rates and R-star,**

especially in the US and the euro area. According to our estimates the sharp fall of long-term euro area long-term (5Y5Y) inflation expectations lowered R-star in the 2014 to 2019 period by on average 30 bps while in the US various measures for inflation expectations remained stable.

> *Rise of inflation expectations above normal levels lifted R-star in the euro area already*

We think that the low inflation environment is over for the following reasons: The combination of post-pandemic recovery, rising energy prices, and persistently tighter labour markets have increased inflation pressure in the advanced economies considerably. It has been spilling over to core inflation and wage negotiations, causing a considerable increase in inflation expectations. While there is some room for overshooting in the short term, we expect them to again hover around their historical mean in the medium and longer term and to hence stabilise above the pre-pandemic average (but slightly below current ones). The rapid move from low inflation to above-target inflation triggered a sharp turnaround in policy rates and the **turn from QE to quantitative tightening (QT)**. Looking ahead, higher inflation expectations compared to post-GFC period, geopolitical tensions leading to some de-globalisation, as well as the inflation impact of the greening of economies make us think that we will not return to the "low-flation" environment, seen before the crisis.



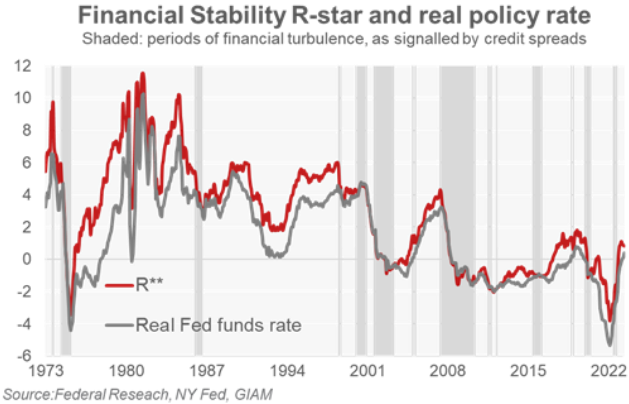
Source: Datastream, GIAM

6. R-Star and financial stability

The outlined approaches to deriving R-star commonly focus on the interaction of basically just three variables: output, inflation, and the short-term rate. There is no role for financial markets and intermediaries. Yet R-star is used as a benchmark or reference for the monetary policy stance, and financial conditions do matter for policy transmission. Therefore, ignoring financial markets may lead to suboptimal results. An **equilibrium on the market for goods and services may not be compatible with stable financial markets**. For example, due to slow growth and strong demand for safe assets, the equilibrium level of the short-term rate used as a benchmark by the central bank may be very low. This forces investors to take up more risk, which can create bubbles with destabilising effects. Ongoing research by the New York Fed shows that **higher bank leverage reduces the neutral rate compatible with financial stability** (the so-called R**), due to more fragile balance sheets. In normal times – according to the model presented in the paper – R** lies above the natural real rate, but when financial imbalances widen the opposite happens.

> *Financial stability considerations complicate the use of R-star for monetary policy further*

Therefore, a policy rate that tracks the natural real interest rate or is set above it to tame inflation may lead to financial instability. Moreover, a prolonged period of low real interest rates leads eventually to an increase in leverage of the banking sector and/or, as in the case of the Silicon Valley Bank or the First Republic Bank, excessive asset duration or too much risk-taking. This further lowers the level of R**. Low for long real interest rates then tend to reduce the policy space as the gap between the natural rate and R** shrinks and financial instability may follow. The recent US regional bank sector turmoil, related to the Fed tightening, may also be seen as reflecting worries about the incompatibility between the level of rates the economy can tolerate and the one the financial system can absorb without damage.



Source:Federal Reseach, NY Fed, GIAM

Empirically, **R** appears even more difficult to estimate with precision than R* and this increases the uncertainty** about the level of any equilibrium rate. The NY Fed provides

estimates of R** up to December 2022. We replicated its model to extend the projections to April: Rate hikes and QT reduced the amount of reserves (safe assets from a bank's point of view) and generated potential unrealized losses in long-term Treasuries. This has raised vulnerabilities, and consequently, the rise in R** has reversed. In reaction to the banking turmoil the Fed provided more liquidity to the sector, and this moderated the drop in R**.

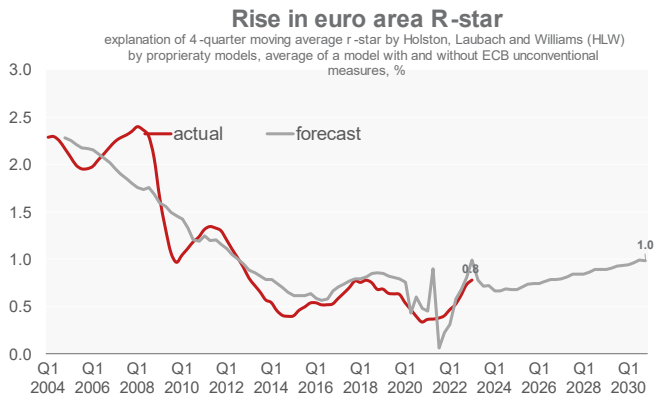
7.Upward pressure on R-star in the US and EA

From an investor perspective, the decisive question is the direction of R-star over the next years. Compared to the latest HLW estimates **we see R-star rising** when accounting for partly opposing factors, first of all **in the US but to a lower degree also in the euro area**.

From the discussion it becomes clear that the growth potential captures the original idea of the concept. Essential to the classical concept is the savings and investment balance. An open economy environment is proxied by the current account balance while green spending needs impact the government budget and hence the overall economic savings rate. The **development of real rates in the past decade also suggests that monetary policy has a role to play**. It works directly (via key rates and quantitative policy) and indirectly via for instance inflation expectations. Given the high degree of global financial market integration, we also find it appropriate to incorporate variables proxying global monetary policy. To do so we chose global foreign exchange reserves or a proxy for unconventional policy measures (e.g. QE plus LTROs in the case of the ECB, see also Annex 1 for details).

We are aware of the shortcomings underlying the quantification of R-star in the **HLW** approach. Still, we deem it useful to analyse the **evolution** of such an estimate of R-star **using the identified domestic, global, and monetary policy-related factors key factors**.

These factors explain the past evolution of R-star relatively well (see chart). Regarding the euro area, we chose two approaches with one explicitly accounting for the ECB's unconventional measures (asset purchases plus LTROs) in the period since 2015. What is striking in all approaches is that with Covid having appeared the mentioned factors had difficulties to explain the evolution of R-star. During the pandemic the output gap became strongly negative, excess savings rose and inflation expectations remained depressed at the outset but sharply soared later on. Also potential growth, a key driver of R-star, was on a roller coaster. Since mid-2021 a dummy variable is needed to account for this structural break. Depending on the model specification Covid has decreased R-star between 25 and 85 bps in the euro area and by about 40 to 50 in the US. The yet undecided question is whether this break will stay or not. We expect it to slowly ease.



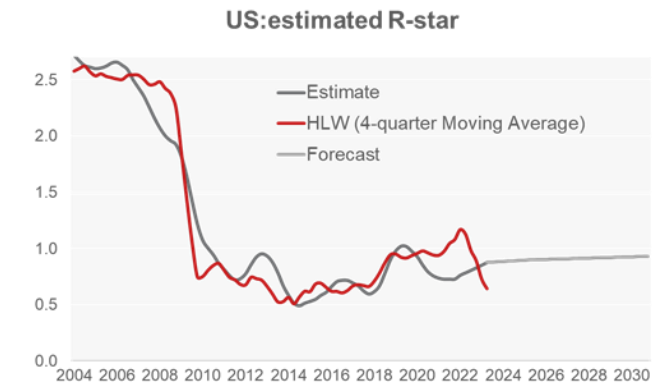
Source: HLW, Datastream, GIAM calculations,

That said, we then apply the estimated coefficient to our medium-term macro scenario to derive a projection for R-star until 2030 and find that R-star is likely to rise. In the medium term the expected, demography-driven **slowdown in trend growth** pushes down the equilibrium rate. As discussed before, it seems unrealistic to expect climate change-related innovations amid implied higher investment demand to fully compensate for that. Focusing only on potential growth there is reason to expect R-star to recede. Our calculations suggest a magnitude of about 10 bps in the euro area. In the US better demographics and higher productivity growth let us expect only an even smaller negative effect of about 5 bps. But in both regions, the **drag from lower trend growth will be more than offset by** policy-related factors, namely the **reduction in central banks' balance sheets** and the size of global FX reserves.

QT to dominate slowdown in trend growth and to drive R-star higher

Following another pandemic-induced push, the Fed and the ECB have started to unwind their balance sheets. Here, passive QT (not investing maturing bonds) is the key factor contributing to the medium-term balance sheet reduction. The Fed and the ECB started in spring 2022. In our projections, we forecast the Fed to reduce its asset holding from the current 29% of GDP to around 23% by 2030. This will reduce the Fed footprint on the Treasuries market from roughly 1/3 to below 20%. The ECB is set to reduce its stock of QE from 36% of GDP to just 10% by 2030. Global FX reserves had according to *Oxford Economics* soared to a peak of slightly above 15% of GDP by 2015 mainly due to EM central banks. A key motive was to build up insurance against financial crisis

when opening up their economies. Following projections from *Oxford Economics* we expect global FX reserves to normalise (China to further move to flexible exchange rates) to about 10% of GDP by 2030.



Source:NY Fed, GIAM

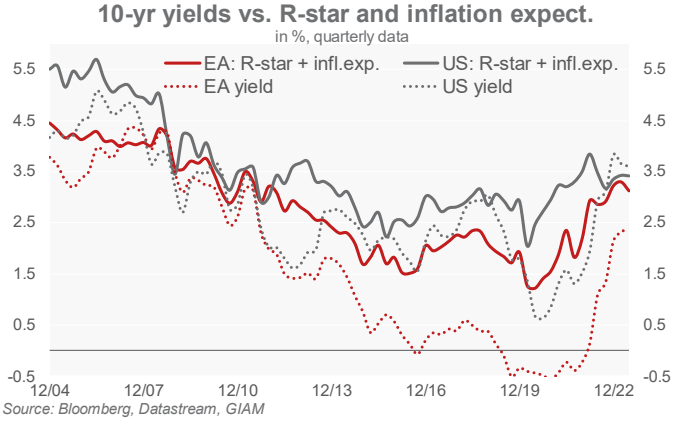
As we expect the **lowflation environment to be over**, we also look for inflation expectations to not return to the subdued levels of the 2010s. Just before the pandemic investors had expected an average euro area annual inflation rate of just below 1% over five years. In the aftermath of the pandemic, they soared to a quarterly average of up to 2.9% yoy. Medium term we see it hovering around the pre-GFC average of 2.2%. Given the still elevated current reading (of 2.6% as of Q3/23 so far) this implies a slight downward effect on R-star going forward. In the US we do not expect any contribution from long-term expected inflation as our measure (based on several surveys) shows that they have remained anchored around equilibrium levels.

In sum, as of Q1/2023, we expect that the post-pandemic rebound of R-star has largely taken its toll in the euro area. By the end of the decade, we only look for a very slight increase of about 10 bps to 1%. In the US, the rather strong upward pressure comes from changes in the policy stance. Persistent government deficits will tilt unfavourably the saving/ investment balance and the shrinking of both the Fed balance sheet and the stock of FX reserves will have a comparably slightly higher effect than for the euro area R-star. We see monetary policy factors like the reduction in global reserve and Fed's bond holdings playing a big role, offsetting the decrease in R-star due to the slowdown in trend growth. Our tentative estimate is around 0.9% by the end of the decade, from 0.6% in Q1/23.

A key message from our analysis is that rates in both regions will be the key factor lifted due to the unwinding of monetary policy accommodation. **R-star will settle clearly above pre-pandemic levels**. Moreover, our estimation results suggest that by 2030 R-star in the US and the euro area will not diverge too much from each other.

8. Core government bond market implications

To which extent will R-star influence long-term government bond yields?[3] As laid out above, R-star is an important reference point for monetary policy decisions of central banks. Adding corresponding inflation expectations (precisely, inflation swaps) to R-star (to get to a nominal dimension) gives the equilibrium key rate, from which the actual rate can deviate for cyclical reasons.[4] Not surprisingly, **10-year yields are highly correlated with the sum of (short-term) R-star and 10-year inflation expectations**. From Q4/2004 to Q1/2020, the sum of R-star and inflation expectations fell by 320 bps in the euro area (EA) and 350 bps in the US (see chart). In the same period, yields of 10-year government bonds fell by 420 bps (EA) and 280 bps (US) showing a high correlation. Hence, the secular decline in core government bond yields in recent decades can to a large extent be explained by falling R-star and retreating inflation expectations.



Source: Bloomberg, Datastream, GIAM

According to the above analysis (ch. 7), R-star developed heterogeneously across countries since the beginning of 2020. However, both EA and US market-based inflation expectations have risen rapidly. Inflation expectations are therefore the main driver of the past rise in yields (which is explained by the fall of R-star. On the contrary, the rise in real yields since the beginning of 2022 can only be attributed to R-star to a limited extent.

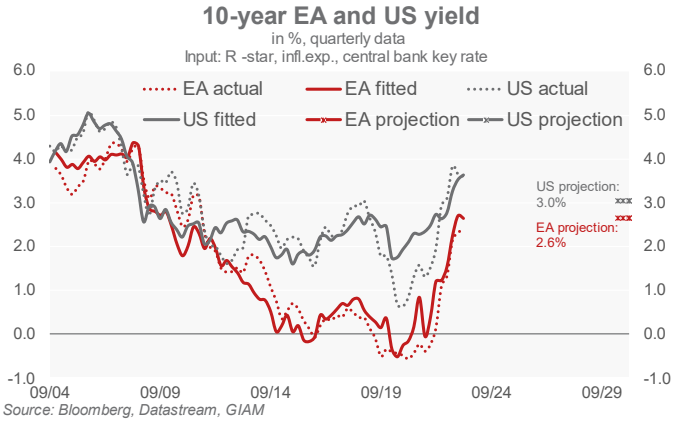
[3] To work out the main effect, we will concentrate in the following on the analysis of 10-year sovereign bond yields of Germany and the US.

[4] To present the results most concisely we limit ourselves here to the analysis of nominal yields. However, a regression of real yields on R-star shows that the development up to the beginning of the decade is well

hardly surprising, as they are a key component of bond yields). Based on the HLW estimates in Q1 2023 and applying a simple beta approach of nominal yields versus R-star (abstracting from other factors as a start), 10-year nominal yields have leeway to increase by a little more than 10 bps in the EA and by around 40 bps in the US until Q4 2030. However, these first results should be taken with a grain of salt as the models' fit (R^2) levels are rather low (around 0.7), and current model estimates are well below actual yield levels. Nevertheless, even this simple analysis shows that a **return to the very low crisis levels is not to be expected given R-star coming off its lows**.

R-star and inflation expectations a good proxy for bond yields

For a complete yield forecast based on R-star, we model the yield of a bond as the average expected key rate over the life of the bond (expectation hypothesis, abstracting from the term premium for the time being, see below). Hence, we extend the above model to include not just inflation expectations and R-star but also expected policy rate levels. This decomposition reflects the idea that current bond yields mirror future key rates. Accordingly, the current inverted yield curve indicates that market participants expect key rates to fall going forward.



Source: Bloomberg, Datastream, GIAM

A regression model with R-star, 10-year inflation expectations, and key rates already shows a high coefficient of determination. For US yields, we get an R^2 level of almost 0.8 and for 10-year EA the R^2 level is even 0.9 (see chart above).

The models determine a fair value of 2.65% for 10-year EA yields in Q2 2023 and 3.6% for 10-year US yields (both roughly matching the actual level in Q2, but at least in the US below the current one). Going forward, in addition to our R-star forecasts (see above) we assume that inflation expectations ease somewhat to the levels prevailing in the first decade of the century (hence, remaining above the depressed levels of the last decade). Our analysis implies a neutral nominal rate of close to 3% in both regions (adding the 2% inflation target to R-star). Given headwinds from fiscal consolidation needs and ongoing financial stability risks we expect the Fed to slightly undershoot this benchmark and the ECB to be even somewhat further below. This implies noticeable downside potential for 10-year US yields until Q4/2030 from current levels. This is mainly driven by lower key rates and somewhat decreasing inflation expectations.

Below, we extend the model again to include another important component: the **term premium**. It is the difference between the current bond yield and the market's expectations of future key rates. Alternatively, it is the excess return for holding a long-term bond versus rolling over short-term bonds. Hence, it includes all factors beyond key rates.

Yield = f(Current, exp. future key rates, term premium)

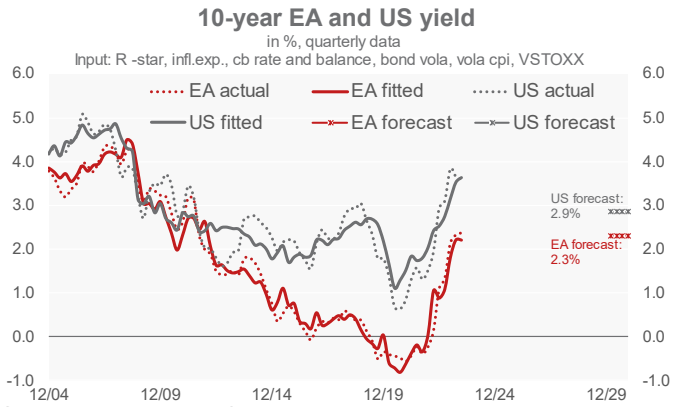
There is no single methodology to calculate the term premium and different approaches lead to different results (e.g., Fed 2005) as all models have wide standard errors and are sensitive to specifications. However, as the yield curve is *on average* upward sloping it implies that the term premium is not negligible, usually positive and increasing with maturity. Subsequently, we focus on the *changes in the term premia* as in combination with a changing key rate outlook this impacts the future yield development.

Generally, there are essentially two factors that determine the level of the **term premium: changes in *risk perception* and changes in *demand/supply***. A higher risk perception (leading to higher requested compensation for holding long-term bonds = higher term premium) can be due to on the one hand higher risk associated with a bond investment but on the other hand, it can also be triggered by a higher risk aversion on the part of investors. The most important risk for fixed income investments is inflation. The level of inflation and even more the volatility of inflation leads to a higher level of uncertainty. This link is established empirically, and we also find respective explanatory factors statistically significant. Moreover, the term premium is also dependent on changes in risk aversion. Theoretical and empirical studies show that variations are countercyclical.[5] Hence, during a recession, investors are more risk averse demanding high compensation for holding a long-term bond and vice versa.

[5] See e.g. Bauer et al (2014).

Beyond that, variations in net demand have also an impact on the term premium. Any macroeconomic or geopolitical event that leads to a sustained change in the supply or demand for bonds also influences the term premium. Accordingly, it is increased in times of great uncertainty (as can be seen from the high volatility on financial markets). QE can also be classified here. Central bank purchases reduce the net supply and thus the term premium (QT has the opposite effect).

We estimate again the 10-year government bond yield for both the EA and the US. The explanatory variables include the current and the future average expected (approximated by inflation expectations and R-star) key rate. In addition, we



Source: Bloomberg, Datastream, GIAM

also consider factors that change the term premium in the long term. We limit ourselves to the variables that are statistically relevant in the analyses. Specifically, these are the development of the central banks' balance sheets, bond and equity market volatility, and fluctuations in the inflation rate. The coefficients of determination increase again compared to the previous regressions (in particular, for the EA an R^2 of 0.97 is shown). All explanatory variables are statistically significant and show the expected sign.

The chart above shows that the model estimates reflect the yield development very well. Not only is the strong yield decline over the last few decades reflected, but the sharp increase in yields since 2021 is also captured. At the current edge (Q2/2023), the actual yield levels largely correspond to the model values (the strong yield increase in Q3 lies outside the observation period and is therefore not modelled). Thus, according to the model, there is no significant over- or undervaluation.

No return to pre-crisis yield levels in the long term

To create an expectation for the future level of yields, we must also form expectations for the additional explanatory variables in addition to the expectations for R-star, key rates, and inflation expectations (see above). Assuming that central banks carry out QT as announced, the bond market volatility moves towards the long-term average, and the fluctuations in the inflation rate fall again, **EA long-term yields are like to crumble slightly over the next five to seven years** (to 2.3%). In contrast, our estimates show that there is **some more downward potential for US yields** (to 2.9% by Q4/2030). The transatlantic yield spread should therefore narrow somewhat.

9. Conclusions: handle with care

Following a decade of low-interest rates and ultra-accommodative monetary policy to push the real rate down, the coming decade will be characterised by climate change and an end of the low inflation environment amid falling potential growth. Our analysis suggests that **R-star is likely to trend higher compared to the pre-pandemic level**. Key drivers are the forecast tighter-than-before monetary policy stance and, in the case of the euro area, higher inflation expectations which more than offset the drag from falling potential growth. The effects of climate change on R-star primarily work through increased public expenditures but model simulations suggest that the net effect is rather small.

That said, R-star is a fluid concept whose interpretation changed over time from the real long-term equilibrium rate to the real short-term rate. **Depending on the operationalisation and method** to calculate R-star, **very different outcomes may emerge**. Most recently, financial stability considerations have come to the fore. Looking further ahead environmental variables might also enter the equilibrium real rate concept ultimately resulting in a R*** concept.

Against this backdrop, **any estimation of R-star should be treated with care**. While we think it is necessary to be humble regarding the level of R-star we think that statements about its change are subject to somewhat less uncertainty.

A key finding of our econometric analysis is that R-star is also dependent on monetary variables. Hence it is **not fully exogenous for monetary policymakers**. We conjecture that the concept will lose some importance for monetary policymakers in the future.

Still, it should remain an important benchmark for investors as R-star turns out to be an **empirically important ingredient to assess the development of long-term government bond yields**. In our scenario we see 10-year risk-free government bond yields at 2.3% in the euro area and 2.9% in the US by 2030.

Annex 1: The Drivers of the neutral rate: a simple econometric model

Macroeconomic theory lists a lot of possible determinants of the equilibrium interest rate owing to its multiple possible definitions. To provide a rough estimate of where R-star is headed in the medium term we build a parsimonious econometric model. The table below lists the main drivers, the expected sign, and the time series we use to proxy them

Driver	Expected sign	Variables
Trend rate of return of capital (potential growth)	(+): higher trend growth allows for a higher equilibrium rate	Potential GDP
Inflation expectations	(+): higher expected inflation requires higher real rates	Long-term expected inflation
Saving/Investment Balance	(-): Higher net savings increase the net demand for (safe) assets depressing yields	Current Account to GDP
Global demand for safe assets	(-): higher net demand reduces yields	World FX reserves to GDP
Unorthodox Monetary policy		Central banks' sovereign debt holding to GDP or total debt outstanding

As a dependent variable, we used for the US the simple average of the most popular model-based estimates of R-star: (Holston), Laubach and Williams and Lubik & Matthes. For the euro area only the HLW estimate is publicly available. The table below shows the results. The tight and sizeable correlation with trend growth is a by-product of the way the R-star is derived, what is important to notice is that, while the theoretical model underpinning the estimation assumes a closed economy with no financial intermediation, the global driver and those related to monetary policy turns out to be significant for both the US and the Euro area. This adds to the evidence that monetary and FX policies are not exogenous. The estimated coefficients show that for the euro area, the effects from monetary policy-related variables on R-star are generally much higher than for the US which is much more dominated by real activity factors.

	US	Euro area
Trend growth (%)	0.58	0.08
Inflation expectations	0.07	0.20
Current Account Balance to GDP	-0.13	-0.09
Global FX reserves	-0.01	-17.00
QE	-0.04	-0.80
All coefficients are significant at the 5% level. Standard errors corrected for non-stationarity (Fully-Modified OLS)		

Imprint

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