Drivers of Long-Term Sovereign Yields in the Euro Area

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Abstract

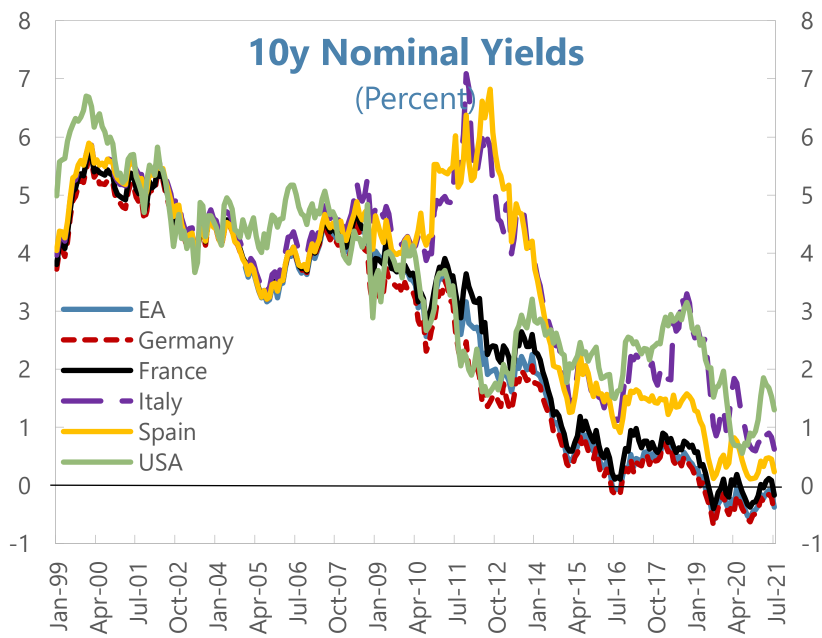
We use a joint model of macroeconomic and term structure dynamics to estimate the term premia and inflation risk premia embedded in U.S. and euro area bonds yields. We find that the fall in real risk premia has been the primary driver of declining yields, especially over the past year, given ECB assets purchases and forward guidance which lowered the uncertainty over the projected path of short-term rates. In addition, contrary to the Fed, the ECB's new strategy review has yet to lift inflation expectations with financial markets expecting inflation to remain below 2 percent. We subsequently build a model of the term premia to forecast the euro area 10-year yield curve and find that yields will likely remain depressed over the medium-term under various scenarios.

I. Introduction

The term structure of yield curves can a valuable source of information for both policymakers and investors. From the perspective of a central bank, policymakers can infer information from the yield curve term structure to gauge market expectations of future monetary policy and economic activity. Yield curves therefore play a pivotal role in testing the effectiveness of central bank communication, its credibility and assessing the transmission of monetary policy, particularly against the backdrop of COVID-19. On the other hand, investors exploit term structure information to price returns on government bonds and other market instruments.

The overall yields behavior since the financial crisis is a trend going down, and the long-term bond yields have constantly remained low. Figure 1 displays the ten-year nominal zero-coupon yields for the United States, the Euro Area overall (the yields published by ECB), and major economies in EA, i.e., Germany, France, Italy, and Spain. The yields co-movement in the United States and the EA comove was very strong before 2014, after which the divergence showed up. While the U.S. yields surged up to more than 3 percent in 2018 and then plunged, the EA yields always hovered below the level of 1 percent and turned negative in 2019. The overall EA yields published by ECB basically keeps in between of those in Germany and France. Figure 2 focuses on the Euro Area yield curve term structure, describing both the time series dynamics of the bond yields and the cross-section difference over the dimension of maturity. Our paper concentrates on the bond yields over the medium-to-long horizon, with a focus on the maturity of ten year.

The decoupling of economic performance between the United States and Europe is being reflected in yield curves. However, there remains much uncertainty over the underlying drivers of their movements. The paper aims to develop a term structure model of interest rates by decomposing benchmark euro area yield curves into their expected real, inflation rates and risk premia components, and compare it with the case of the United States.



Source: Bloomberg, IMF Staff calculations.

Figure 1. Ten-year Nominal Yields

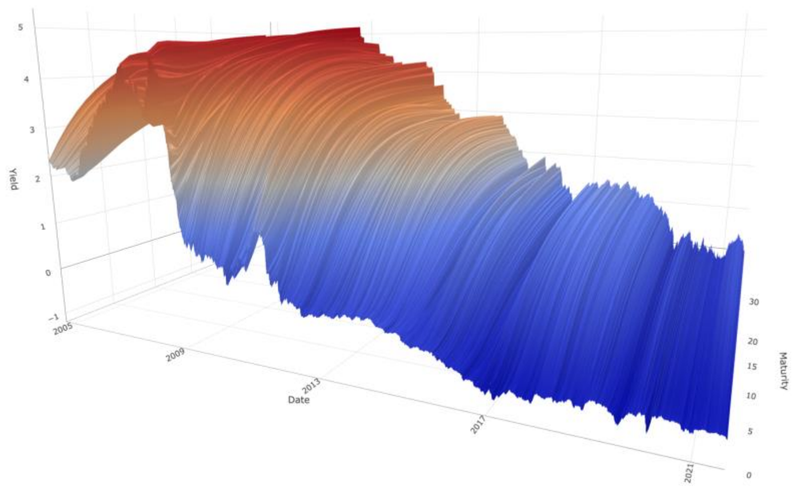


Figure 2. Euro Area Yield Curve

To well interpret the long-term bond yield curves, it requires the decomposition of the yield curves into two different parts: 1) the expected average level of future short-term interest rates, which is the expected return from rolling over a series of short bonds with a total maturity equal to that of the long bond, and 2) an extra return (a risk premium) that investors demand to compensate them for bearing the risk associated with a long-term bond (i.e., the term premium). In early works, Expectations Hypothesis has been the fundamental for modelling the yield curve term structure. According to this hypothesis, yields on a longer-maturity bond act as a predictor of future short-term interest rates and do not consider risk premia. The returns from these two assets should be the same over the lifetime of the bond. However, Fama and Bliss (1987) and Campbell and Shiller (1991), among others, found little empirical evidence supporting the Expectations Hypothesis. It then has become a widespread practice to decompose long-term yields into the expectations of future short-term interest rates and a time-varying term premium.

But the decomposition of yield curves and analysis of term premia are not straightforward, given the fact that both the expected future short-term interest rates and term premia are not directly observable or measurable. Essentially, the difficulties of estimating term premium stem from the uncertainty of investor expectations on the future short-term interest rates over the horizon of the long-term bond maturity. Therefore, certain assumptions are required to measure the term premium from the term structure.

Beyond estimating term premium, we can further extract more detailed components of the long-term bond yields. As illustrated in Figure 3 below, the long-term bond yields can be decomposed in two ways. On one hand, it can be decomposed into a real rate and a break-even inflation rate, empirically proxied by the yields on inflation-indexed government bonds and the break-even inflation rate implied by those bonds, respectively. On the other hand, it can also be decomposed into their respective expectation components and risk premium, which are expected short-term interest rates and nominal term premium. Furthermore, the real rate, and break-even inflation rate can be decomposed into their expected component and premia as well. The real rate is decomposed into the expected real rate and the real term premium (related to risk associated with variable future real interest rates), and break-even inflation rate into the expected inflation and the inflation risk premium (related to uncertain future inflation developments). As with more detailed data available and more assumptions imposed, estimating these detailed components of nominal yields become accessible in modern literature.

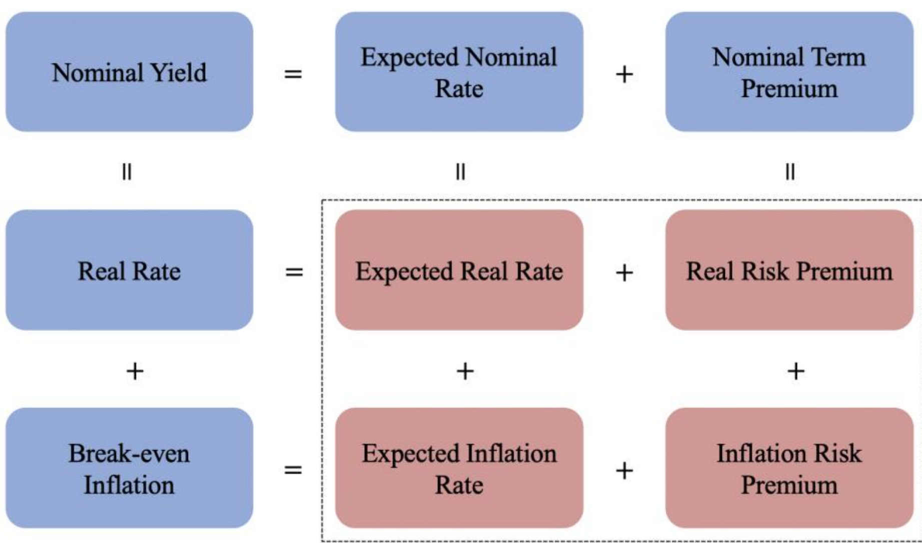


Figure 3. Decomposition of Nominal Yields

In general, methods emerged for estimating term premia can be broadly categorized into three groups: (1) survey-based estimation, (2) regression-based models, and (3) term-structure based model. This variety of methodologies to decompose movements in bond yields has been implemented and resulted in a wide range of term premium estimates.

The first approach to estimate term premium is to use financial market survey forecasts as a model-free proxy for the average expected future short rates. The term premium in this case can be simply obtained by subtracting the survey implied average expected short rate from the observed bond yield. However, there are important caveats with this approach. Survey data may not be a precise proxy of actual expectations of market participants. The expectations may be affected due to business competition or disproportionate impact of the participants. There is also issue with inferior data quality in terms of the low frequency and lack of reliability of survey data. Hence, literature often incorporate survey data to improve the estimation procedures, instead of solely using the survey forecasts to estimate term premia.

The second group of models is dynamic term structure models, or “no-arbitrage models”. The key “no-arbitrage” assumption states that bonds with the same risk characteristics are priced so that there are no arbitrage opportunities across all maturities. In other words, the pricing would make it impossible to form a portfolio consisting of bonds with different maturities that generates a riskless profit. The so-called Gaussian affine term structure model (GATSM) is a workhorse model among others. “Affine” implies the linear dependency of bond yields on risk factors, and “Gaussian” refers to the assumption on risk factor distributions. Both assumptions simplify the bond yield dynamics and help the specification to accommodate a variety of term structure models. For example, Krippner (2012) extracts the term premia from US yield curve data by calibrating an arbitrage-free Nelson Siegel term structure model.

Because term structure models try to capture the high persistence of yields, they have a tendency to be highly correlated over time. Some literature works have also incorporated survey interest rate data and macroeconomic factors into their models. For example, Kim and Wright (2005) include survey data on future three-month interest to estimate US term structure dynamics. In their model, the driving factors of interest rates are still derived only from interest rates data. Other models incorporate macroeconomic variables into the term structure models, in addition to, or instead of, yield factors. Hördahl and Tristani (2014) model, for instance, includes data on nominal and real (index-linked) yields, and the output gap as well as survey data on future short-term interest rates and future inflation rates. Within these models, macroeconomic variables are motivated by what investors pay attention to when pricing and investing in bonds. Inflation and some measures of economic activity are common choice of these variables. Another example is the term structure model used by the Bank de France based on Monfort et al (2017). They embed survey data and build a class of affine term structure models that can accommodate the recent experience with policy rates stuck at the zero lower bound (ZLB) or, in some cases, below zero.

The last group of models for estimating term premia is regression-based models. Based on expectations hypothesis and rational expectations, the difference between the forward short rate and the realized short rate should not be forecastable with ex-ante variables, which are the variables available when the expectations were formed. The idea of this family of models is that if one regresses the difference between the forward rate and the realized short-term rate on explanatory variables, the predictable component of the rate difference resulting from the regression can act as a proxy of the term premium. The most popular model within this group is the term premium model proposed by Adrian, Crump and Moench (2013, henceforth ACM). Their approach uses principal components of bond yields as pricing factors, and the model represents the factor dynamics with classical vector autoregressions. The ACM model parameters of the term structure model are then obtained using standard OLS regressions.

In this paper, we follow the methodology of Hördahl and Tristani (2014), whose distinctive features are threefold. First, it is a joint model of output, inflation, monetary policy, and term structure dynamics, providing the relationship between risk premia and the macroeconomic variables. Second, the model includes a broad information set with macro variables, nominal and index-linked yields, and survey information on expectations of future inflation and future policy interest rates. Last, the model features the correction of liquidity premium in the inflation-linked bond yields, which may distort our estimation due to liquidity factors.

We document that the pandemic has kept euro area yields at historical lows. Long-maturity euro area government bond yields have experienced a secular decline since the early 2000s. In particular, average AAA euro area sovereign yields have been negative since mid-2019, hovering around -0.3 percent. Even high-debt countries, such as Spain and Italy, have experienced relative yield stability during this period, in contrast to the US which has witnessed a sharp rise in long term yields.

The decomposition of nominal yield shows that the secular decline in yields before 2014 was a combination of a fall in the term premia and the expectations of short-term rates. After 2014, it's mostly the compression of the term premia that contributed to the fall in yields. While the downward trend of the term premia is persistent, the short-term rates expectation in the euro are compressed sharply after the GFC and further during the European sovereign debt crisis, and have remained stable ever since until the turbulence when the COVID-19 pandemic hit in early 2020.

Concerning the relationship with the macroeconomy, we relate the dynamics of our estimated term premia to the developments in the macroeconomic variables including yield volatility, output gap, inflation expectations, risk aversion measure, and ECB's asset-purchase program (APP), captured through the excess liquidity or total size of ECB balance sheet. We document the general countercyclicality of the term premia and its strong co-movement with the inflation expectations rather than realized inflation. Finally, we present a linear model to explain how the ten-year term premium relates to key macroeconomic and financial variables. While we observe the post-GFC downward trend in the term premium coincided with a sharp rise in the ECB's balance sheet, the quantitative results highlight the estimated impact of the ECB's balance sheet expansion ranges from 1% to 2.9% from one specification to another. This result is in line with the notion that demand pressures from these sources on sovereign bonds helped to push down yields. The model of the term premium also forecasts the euro area 10-year yield curve and finds that yields will likely remain depressed over the medium-term under various scenarios.

The estimated model-implied inflation risk premium features the divergences on across the two sides of the Atlantic. The euro area has seen the overall downward trend of the inflation premium, which has remained negative since 2012. In contrast, the inflation premium in the United States surged temporarily after 2012 and fell to near-zero levels and then stabilized. The divergence in the dynamics of inflation premium suggests that financial market participants appear to price the inflation risk in the United States and in the euro area differently. The market seems more confident about the Federal Reserve's capability to deliver a stable inflation rate over the medium-to-long run, compared to that of the ECB. More recently, the inflation risk premia in both areas showed a strong rebound since the COVID-19 pandemic along with the economic recovery. But while the it rebounded well above zero in the U.S., the inflation risk premium still remains negative for the euro area.

Given the model-implied inflation risk premium, we can tease out the premium-adjusted inflation expectation by stripping out the inflation risk premia component from the break-even inflation rates, hence resulting in a more accurate and cleaner measure of expectations on future inflation over the lifetime of the bonds. The premium-adjusted long-term inflation expectation have remained remarkably stable both in the euro area and in the United States, even over the peak of the GFC. In contrary to the Fed, the ECB's new strategy review has yet to lift inflation expectations with financial markets expecting inflation to remain below 2 percent.

The rest of this paper is organized as follows. The next section describes our model and the econometric methodology. Section III describes the data and the correction in liquidity premium. The empirical results are presented in section IV, where we show our estimates for term premia and inflation risk premia. In this section, we also relate the term premia to macroeconomic determinants and calculate premium-adjusted break-even inflation rates. Section V concludes.

II. The Model

We closely follow Hördahl and Tristani (2014, henceforth HT) model, which is a joint model of macroeconomic and term structure dynamics, to estimate inflation risk premium and inflation expectations in the euro area, as well as the United States for comparison. The main distinctive feature of applying this model is that it uses an information set of macro variables and survey data, including output gap, inflation, survey information on expectations of inflation and policy interest rates at various future horizons, together with nominal and index-linked yields.

The first module of the model is specified at the aggregate level relying the New Keynesian tradition. The specification of the model includes two equations describing the evolution of inflation π_t and the output gap x_t:

$$\pi_t = \frac{\mu_\pi}{12} \sum_{i=1}^{12} E_t\left[\pi_{t+i}\right] + (1-\mu_\pi) \sum_{i=1}^{3} \delta_{\pi,i}\pi_{t-i} + \delta_x x_t + \varepsilon_t^\pi, \qquad (1)$$

$$x_t = \frac{\mu_x}{12} \sum_{i=1}^{12} E_t\left[x_{t+i}\right] + (1-\mu_x) \sum_{i=1}^{3} \zeta_{x,i} x_{t-i} - \zeta_r\left(r_t - E_t\left[\pi_{t+1}\right]\right) + \varepsilon_t^x, \qquad (2)$$

r_t is the one-month nominal interest rate (deviation from its mean $\bar{r}$), and inflation is the year-on-year change in the log-price level. Inflation can be either due to the demand shocks ε^x_t, or to cost-push shocks ε^π_t, which have an impact on output gap or prices, respectively. Monetary policy enters into effect by influencing real rate $r_t - E_t[\pi_{t+1}]$ or expectations. Monthly data is used for the estimations.

Based on Taylor (1993), central bank is assumed to set the nominal short rate according to a forward-looking rule

$$r_t = (1-\rho)\left\{\beta\left(E_t\left[\pi_{t+11}\right] - \pi_t^*\right) + \gamma x_t\right\} + \rho r_{t-1} + \eta_t, \qquad (3)$$

where π_t^* is the perceived inflation target and η_t is a monetary policy shock. We further assume the inflation target to follow an AR(1) process

$$\pi_t^* = \left(1-\phi_{\pi^*}\right)\bar{\pi} + \phi_{\pi^*}\pi_{t-1}^* + u_{\pi^*,t}, \qquad (4)$$

$u_{\pi^*,t}$ is a normal disturbance with constant variance uncorrelated with other shocks.

The Taylor rule in equation (3) does not consider the case of negative interest rates, so it cannot accommodate the situation of zero lower bound (ZLB). Ignoring ZLB may lead to incorrect expected policy rates and term premia dynamics. In order to mitigate this, our model discipline model-implied interest rate forecasts by including survey on future short-term interest rates.

In order to solve the model numerically, we can write the model in state-space form, see details in appendix of Hördahl and Tristani (2014). The resulting matrix **M** determines the law of motion of the predetermined variables $\mathbf{X_{1,t}} = [x_{t-1}, x_{t-2}, x_{t-3}, \pi_{t-1}, \pi_{t-2}, \pi_{t-3}, \pi_t^*, \eta_t, \varepsilon^\pi_t, \varepsilon^x_t, r_{t-1}]'$, and **C** describes the dependency of the non-predetermined variables $\mathbf{X_{2,t}} = [E_t x_{t+11}, \ldots, E_t x_{t+1}, x_t, E_t\pi_{t+11}, \ldots, E_t\pi_{t+1}, \pi_t]'$ on $\mathbf{X_{1,t}}$. We can obtain

$$\mathbf{X}_{1,t} = \mathbf{M}\mathbf{X}_{1,t-1} + \Sigma\xi_{1,t}, \qquad (5)$$
$$\mathbf{X}_{2,t} = \mathbf{C}\mathbf{X}_{1,t}, \qquad (6)$$

where ξ_1 is the independent, normally distributed shocks vector, and the equilibrium short-term interest rate in terms of the state variables is given by $r_t = \boldsymbol{\Delta}'\mathbf{X}_{1,t}$.

Then for the term structure module of the model, the state variables follow a first-order Gaussian VAR and the short-term interest rate is expressed as a linear function of the state vector, so we impose the no-arbitrage assumption and specify a process for the pricing kernel. Following Duffee (2002), we assume the market prices of risk are affine functions of states. the transformed state vector $\mathbf{Z_t} \equiv [x_{t-1}, x_{t-2}, x_{t-3}, \pi_{t-1}, \pi_{t-2}, \pi_{t-3}, \pi_t^*, r_t, \pi_t, x_t, r_{t-1}]'$ is obtained as $\mathbf{Z_t} = \widehat{\boldsymbol{D}}\mathbf{X_{1,t}}$. The following equation describes that the market prices of risk λ_t is linearly dependent on state vectors, and the risk premium associated with shocks also depend on the state variables.

$$\lambda_t = \lambda_0 + \lambda_1 \mathbf{Z}_t, \qquad (7)$$

Following this setup, the continuously compounded nominal yield of a zero-coupon bond with maturity n is equal to

$$y_t^n = A_n + B_n' \mathbf{Z}_t, \qquad (8)$$

Where A_n and B_n can be derived from recursive relations. Hence, the yields vector $\mathbf{Y_t}$ can be written as $\mathbf{Y_t = A + BZ_t}$, or equivalently, $\mathbf{Y} = \mathbf{A}+\widetilde{\boldsymbol{B}}\mathbf{X}_{1,t}$. Similarly for real bond yields,

$$y_t^{*n} = A_n^* + B_n'^* \mathbf{Z}_t, \qquad (9)$$

and $\mathbf{Y^*} = \mathbf{A^*}+\widetilde{\boldsymbol{B}}^*\mathbf{X}_{1,t}$. With the solutions for real and nominal bonds, we can then follow Hördahl and Tristani (2012) to derive the inflation risk premium as the difference between historical and risk-adjusted expectations of future inflation rates.

III. Data

The data used to estimate the model includes nominal and real zero-coupon bond yields, inflation, output gap, survey data on short-term interest rate and inflation, all data is in monthly frequency. We apply the model to euro area, as well as U.S. for comparison. Due to the availability of euro area yield curves data published by ECB, the sample period for euro-area is limited to September 2004 - October 2021. For the United States, we have more historical data dated back to January 1998.

3.1 Euro Area Data

The euro area nominal yields are zero-coupon yields sourced from European Central Bank. The ECB estimates zero-coupon yield curves based on AAA bonds issued in euro by euro area central government. Seven maturities of nominal bonds ranging from one month to ten years are used in the estimation. For the real yields, we estimate zero-coupon rates using Nelson-Siegel-Svensson (NSS) method, based on prices of French government bonds linked to the euro-area HICP, and we include four maturities from three to ten years. We exclude bonds issued by other countries to avoid the problem of mixed credit ratings. Furthermore, French Treasury firstly issued HICP-linked government bond in November 2001. And the inflation-indexed bonds issued by French government make the largest share of the market in the euro area, which provides relatively good liquidity.

The inflation measure is the monthly year-on-year (YoY) HICP log-differences. For the measure of output gap, we adopt the estimation from European Commission based on D'Auria et al. (2010).

The survey data in our estimation consists of inflation forecast from ECB's quarterly Survey of Professional Forecasters (SPF) and monthly 3-month interest rate forecast from Consensus Economics. The inflation forecast includes HICP expectation of 1, 2, and 5 years ahead. The interest rate forecasts refer to those 3 and 12 months ahead. Previous literature (e.g. Kim and Orphanides (2012)) argued that determining the dynamics of the bond yields and state variables is challenging due to the high persistence of interest rates, but survey data can provide some additional useful information to pin down the dynamics.

3.2 U.S. Data

The U.S. real and nominal term structure data is the zero-coupon yields data based on NSS method directly obtained from Federal Reserve Board. We use the same maturities as in the euro area case for the nominal and real zero-coupon yields.

The inflation data is the monthly YoY seasonally adjusted CPI log-differences. The output gap is measured by the quarterly log-difference of real GDP and the Congressional Budget Office's estimate of potential real GDP. To match the monthly frequency of the model estimation, we fit an ARMA(1,1) model to the quarterly output gap, forecast the gap one quarter ahead, and compute one- and two-month-ahead values by linear interpolation.

The U.S. survey data for inflation and the 3-month interest rate is obtained from the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters (SPF). We include survey on expected 3-month interest rate two quarters ahead, four quarters ahead, and for the coming ten years, and the expected CPI inflation for the same horizons. The ten-year forecast of the three-month interest rate is reported annually, while other forecasts are all at a quarterly frequency. So these survey data only enter the measurement equation in months that they are reported.

3.3 Liquidity Premia Correction

Literature has documented that the liquidity problem affects both U.S. Treasury Inflation-Protected Securities (TIPS) and the euro-area index-linked bonds, their yields are distorted during the early years when these markets were initially launched and the 2008 financial crisis. D'Amico, Kim, and Wei (2018) argue that there were severe distortions in TIPS yields in the early years resulting from the illiquidity of the TIPS market. Gürkaynak, Sack, and Wright (2010) and Pflueger and Viceira (2011) estimate the liquidity premia during the financial crisis.

Due to these problems, we use the real yields in the estimation after correcting for liquidity premia. For the cases of the United States and euro area respectively, we find the proxies for market liquidity. We regress the break-even inflation rates on these proxies and take the regression fitted value as the time variation in liquidity premia on index-linked bonds. Specifically, the proxy for the liquidity premium in the euro area is the spread between Kreditanstalt für Wiederaufbau (KfW) bonds and German bunds. KfW bonds are explicitly guaranteed from the Federal Republic of Germany. According to Ejsing, Grothe, and Grothe (2012), this spread can be a reliable and timely measure of the liquidity premia in the euro area. The two proxies for the U.S. are borrowed from Gürkaynak, Sack, and Wright (2010). The first proxy is the trading volume in TIPS as a share of total Treasury trading volume, among primary dealers. The second one is the yield spread between Resolution Funding Corporation (Refcorp) strips and Treasury strips. Bonds issued by Refcorp are guaranteed by the U.S. Treasury, but less liquid than Treasure bonds. Therefore, the spreads between the two bonds can capture the market liquidity premium, which is a proxy for the TIPS liquidity premium.

Follow Gürkaynak, Sack, and Wright (2010), we normalize the U.S. and euro area premium to be zero in April 2005 and then compute the liquidity premium based on the estimated time variation. We use these liquidity premia to correct the inflation-linked bond yield, and estimate the model using the liquidity-adjusted real yield data.

IV. Empirical Results

4.1 Term Premia and Risk-Neutral Rate

The dynamics of our estimated 10-year nominal term premia for the euro area and the United States and Japan are displayed in Figure 4, with a focus on 10-year maturity. We also include the estimated term premia based on nominal yields data from the major four economies in the euro area – Germany, France, Italy, and Spain – for comparison. In spite of the different evolution of the term premia, similar downward trends are shared for all countries after the spike around the Global Financial Crisis. Specifically in the euro area, the estimation result shows that the 10-year term premium remained in the range of 0-200bp until early 2014, after which it dropped sharply below zero and remains in the negative territory ever since. In Figure 4, one can see that the euro area term premia comove closely with German and French ones all the time. While the term premia in Italy and Spain follow others before the GFC, they hiked up drastically to a higher level and the persistent high term premia coincided with the European sovereign debt crisis. They dropped rapidly afterwards but remained relatively higher down the road. The term premia in the United States are less volatile than the euro area, it fluctuates around zero and turned negative in late 2014 but remained relatively stable and close to zero, until dropped sharply in late 2018 and spiked up since the onset of the COVID-19 pandemic in early 2020.

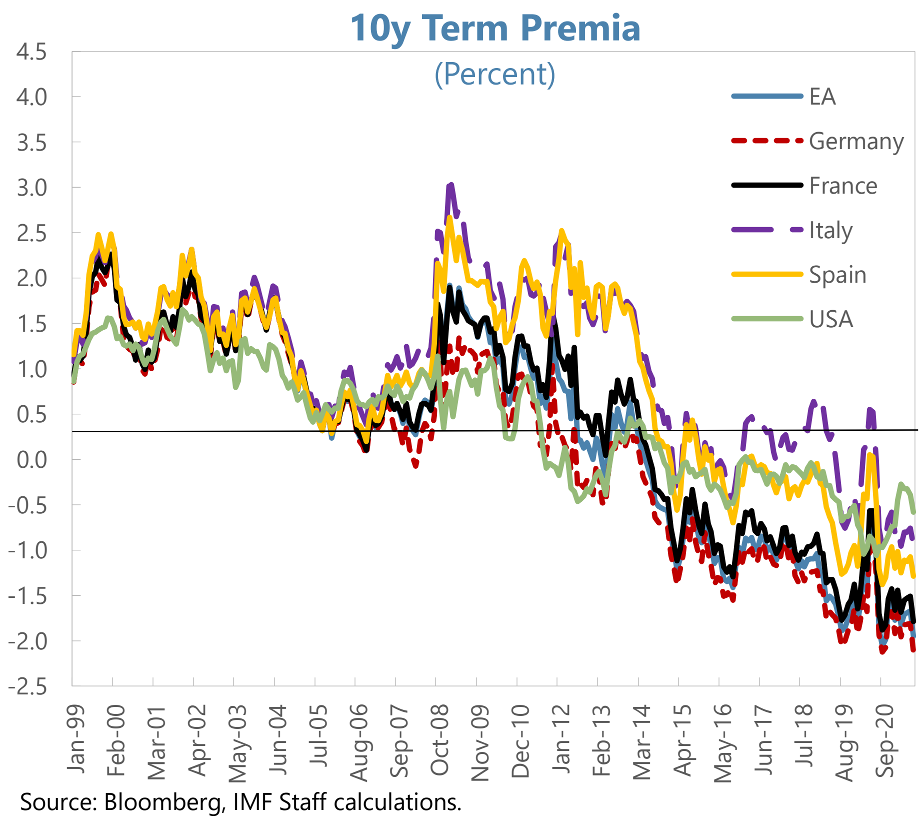


Figure 4. Ten-year Term Premia

The general downward trend of the term premia in the past decade since the GFC have been related to the insurance-like properties of the bonds. After the GFC, investors raised their awareness of the tail risks and kept concerned about any sign of setbacks in the economic recovery. As a result, there were stronger incentives for investors to insure against these risks using bonds. The resulting "flight to safety" boosted the demand for safe assets like sovereign bonds. Therefore, the aftermath of the GFC saw the falling of the bond yields in response to the strong willing among investors to hold bonds, even if the term premia fell towards or below zero level.

The 10-year risk-neutral rates in the euro are compressed sharply after the GFC and dropped again in 2012, and have remained very stable since then until the trough during the COVID-19 pandemic. But the quick recovery has been seen in recent months. Compared with other EA countries, risk neutral rate is very stable for all EA countries except a bout for Italy, and has been fluctuating since 2014 around 1.5 percent. Furthermore, risk-neutral yields have remained in positive territory, indicating that investors regard negative policy rates as temporary. The United States shows a different dynamic where the risk neutral rate increased first and shot over 3% in 2019, then dropped since then.

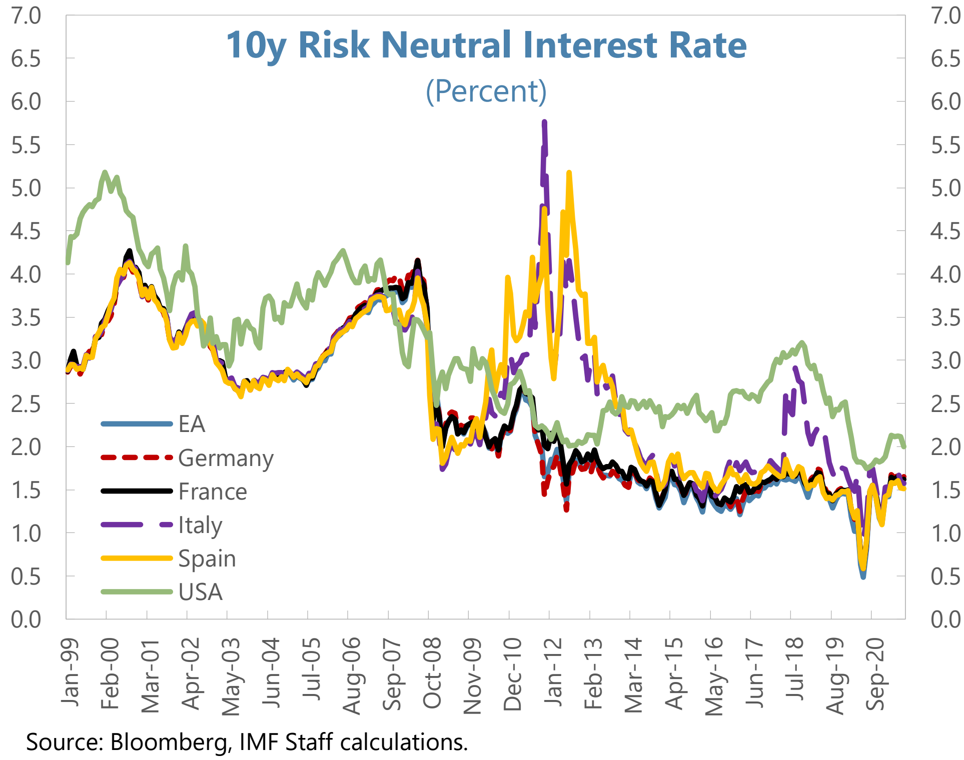


Figure 5. Ten-year Risk Neutral Interest Rate

Combining the two decomposed components of nominal yields, what drove yields down before 2014 was a combination of a fall in the term premia and the risk neutral interest rate. After 2014, it's mostly the compression of the term premia that contributed to the fall in yields.

4.2 Term Premia and Macroeconomic Variables

In this section, we take a closer look at the relationship between term premium in the euro area and macroeconomic developments. In essentially affine models, movements in risk premia are related to changes in the state variables. We relate the dynamics of our estimated term premia to the developments in the macroeconomic variables including yield volatility, output gap, inflation expectations, risk aversion measure, and ECB's asset-purchase program (APP), which is captured through the excess liquidity or total size of ECB balance sheet.

We expect the term premium to be positively related to yield volatility, since investors will require more to be compensated for the risk borne. We compute yield volatility as the annualized standard deviation of monthly changes in 10-year nominal yields, over a rolling one-year window. The following empirical plot confirms the positive relationship between these two variables.

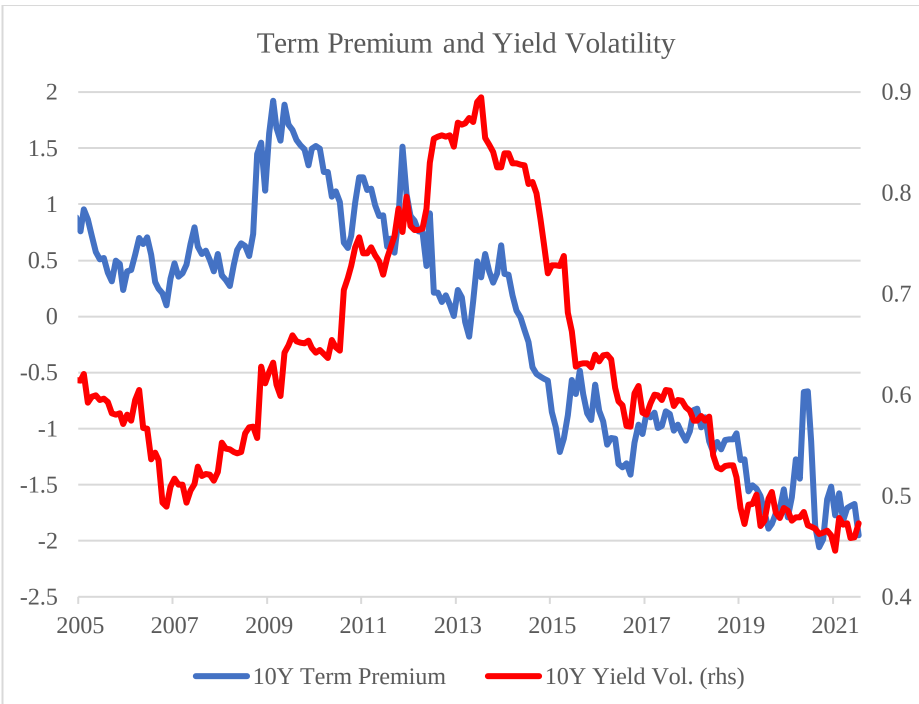
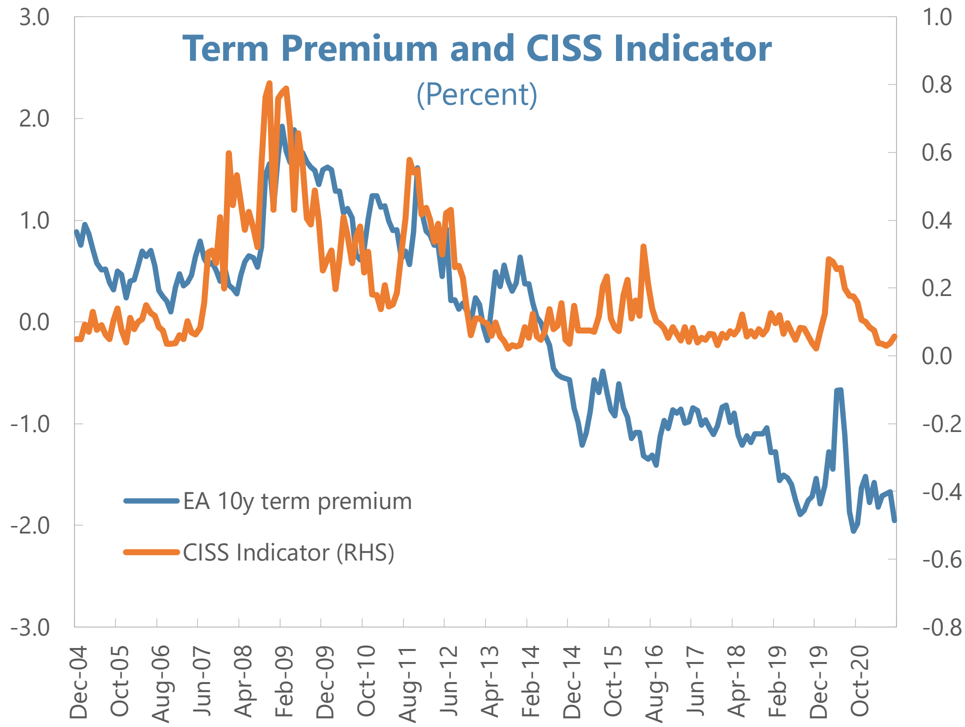


Figure 6. Term Premia and Yield Volatility

In addition, the term premium comoves with the aggregate volatility or risk aversion. We use the Composite Indicator of Systemic Stress (CISS) which is computed for the Euro Area by the ECB (see Hollo et al. (2012)). It includes 15 raw, market-based financial stress measures that are split equally into five categories: the financial intermediaries sector, money markets, equity markets, bond markets and foreign exchange markets.



Source: Bloomberg, IMF Staff calculations.

Figure 7. Term Premia and CISS

From a descriptive perspective, we find that term premia are in general counter-cyclical. In other words, they tend to rise when output is below potential or the economy is in recession, as investors seek higher compensation for being exposed to interest rate risk in bad times. In particular, term premia increase during the GFC, when output and inflation contracts at the end of 2008. The downtrend in term premia during the recovery after the GFC represents a return to this pattern. The recent spike of term premia also coincided with sharp fall in output gap when the COVID-19 pandemic hit at the beginning of 2020. This result is consistent with the countercyclicality of term premia documented in literature (e.g., Stambaugh 1988; Hördahl, Tristani, and Vestin 2006).

Empirically, term premium is more closely related to inflation expectations rather than realized inflation. From the figure below, one can see it is the deterioration in inflation expectations rather than realized inflation that has contributed more to the decline in the term premium.

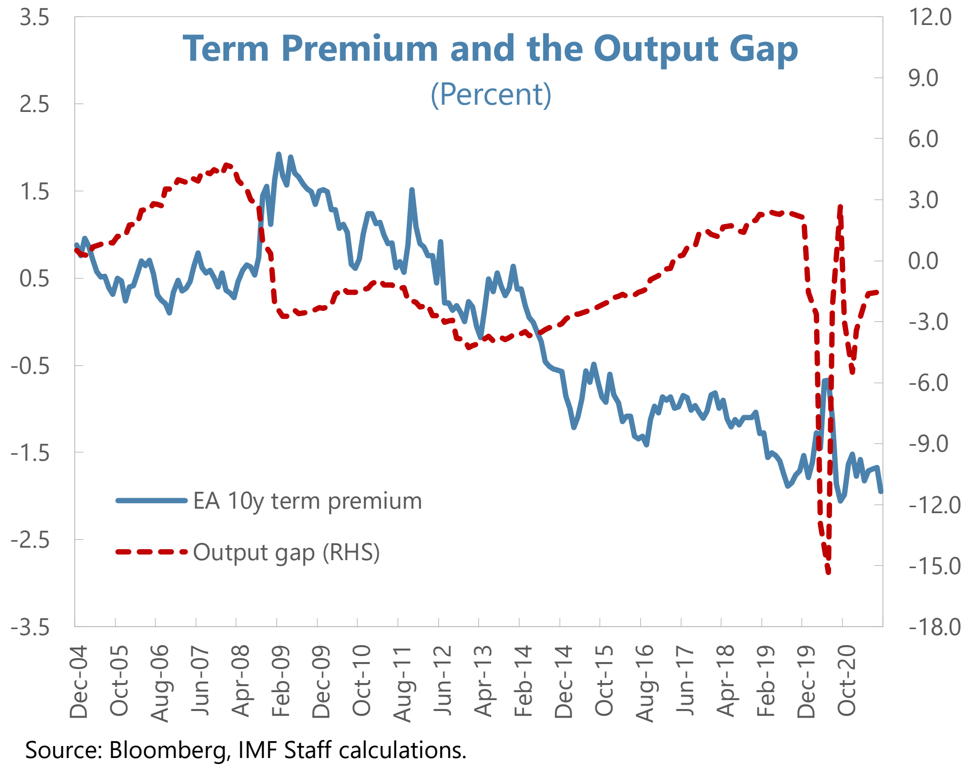


Figure 8. Term Premia and Output Gap

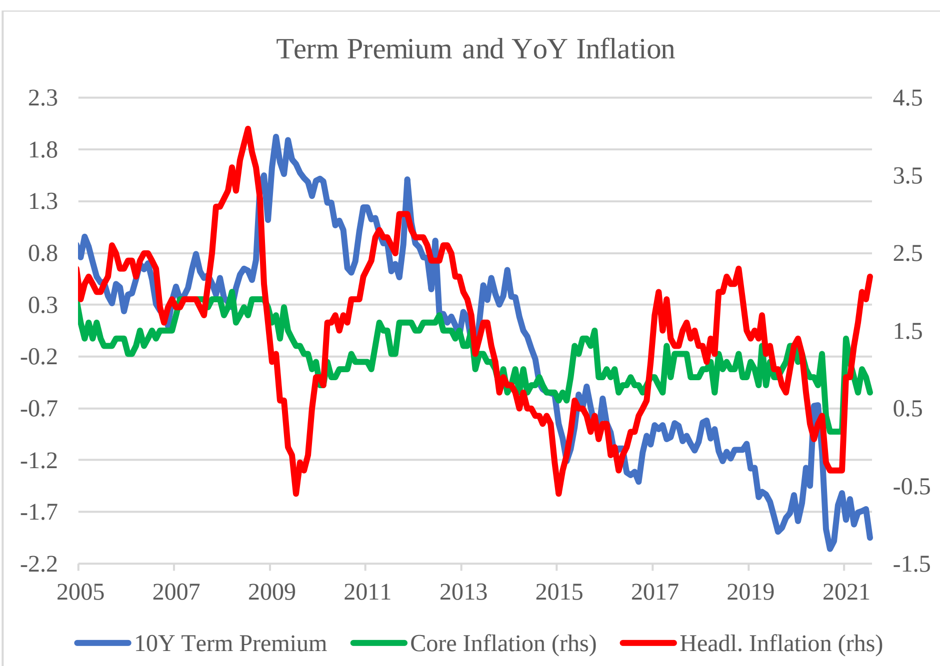
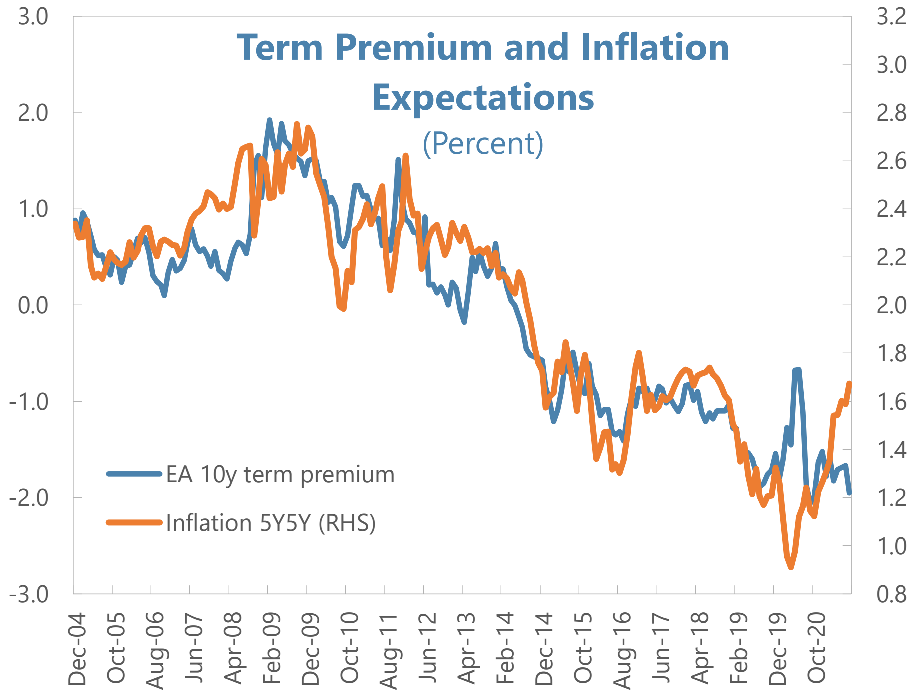


Figure 9. Term Premia and Inflation

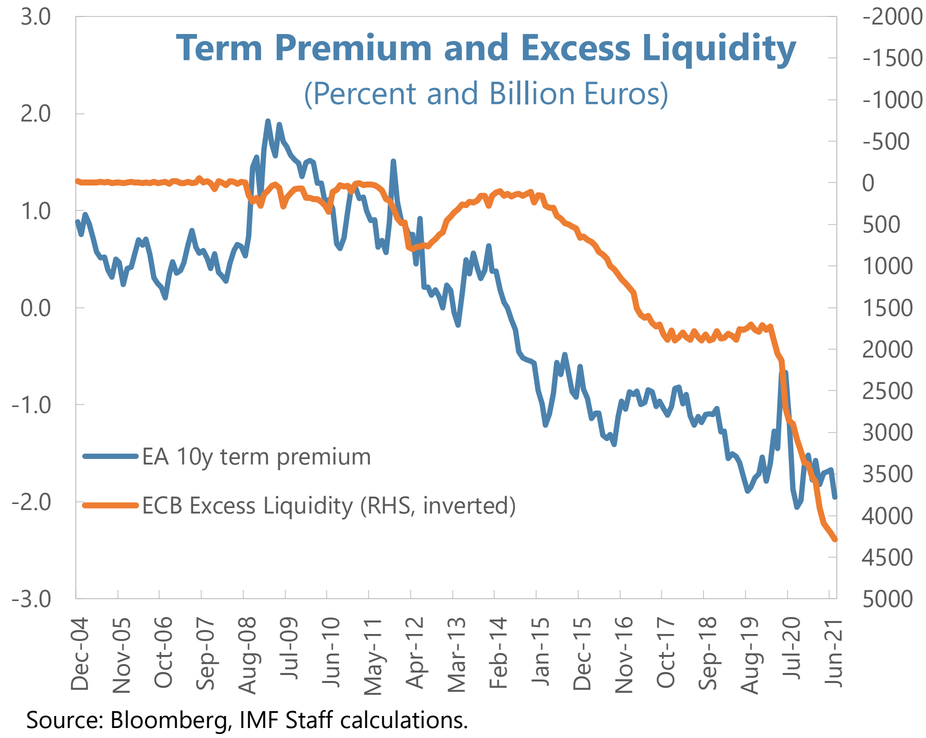


Source: Bloomberg, IMF Staff calculations.

Figure 10. Term Premia and Inflation Expectations

Next, we relate the term premium with the ECB balance sheet policy, which is captured by the excess liquidity or ECB total balance sheet size. We can see from the following figure that the term premium has tightened substantially in 2013-2010, as well as in 2020, when the asset purchase program (APP) was initially launched and when the net purchase pace increased dramatically since the pandemic. The interpretation of this relationship is not very straightforward. For example, the term premium falls sharply in 2019 despite the ECB balance sheet remaining stable in this period due to the end of QE. But in general, the post-GFC downward trend in the term premium coincided with a sharp rise in the ECB's balance sheet, in line with the notion that demand pressures from these sources helped to push down yields.

To conclude this part, we present a set of linear models to explain how the ten-year term premium in the euro area relates to key macroeconomic and financial variables. The variables used to explain the term premium are output gap, CISS, ECB's balance sheet policy (alternatively, captured by excess liquidity, ECB's balance sheet size, or public sector purchase program (PSPP) holding), inflation, inflation expectation, and inflation volatility.



Source: Bloomberg, IMF Staff calculations.

Figure 11. Term Premia and Excess Liquidity

Table 1 shows the results of all the model specifications. Most of the estimated coefficients have the expected sign. Except model (1), the coefficient of output gap is always negative and that of Systemic Stress Indicator is always positive, they are mostly statistically significant and confirm the countercyclicality of the term premia. In model (2) and (3) when we add excess liquidity and 5Y5Y inflation into the model, respectively, the R-square increases significantly from to 73% and then 90%, indicating the strong explanatory power of ECB's balance sheet policy and inflation expectation on the term premia. While the coefficient of 5Y5Y inflation expectation remains positive and stable, the realized inflation (headline inflation or core inflation) is not significantly correlated with the term premia. The effect of ECB's balance sheet policy remains significant and stable when we use the alternative measure total balance sheet size or total PSPP holding.

As the last line of the table highlights, the estimated impact of APP is calculated by multiplying the model coefficient by the change in ECB excess liquidity from September 2005 to July 2021. The estimates of the impact of the ECB's balance sheet expansion vary from one specification to another, ranging from 1% to 2.9%. We have used the log of excess liquidity, which implies expansion has a marginally decreasing effect. A linear specification would result in a stronger impact of the ECB action. For reference, the ECB has calculated that a 10-year term premium compression of around 50 bps was associated with the initial APP announcement in January 2015. With the expansion of the program, the yield curve impact has become more marked and is estimated to be around 95 bps in June 2018 (see Eser et al. 2019). Given the again drastic increase in excess liquidity since 2020 due to the resumption of QE, we would see the term premium to move further away from zero.

Table-1 Linear Model Results

	Dependent variable: Euro Area 10Y Term Premia							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Const.	-0.72***	0.02	-3.24***	-3.34***	-3.32***	-3.34***	-2.83***	-2.52***
	(0.09)	(0.07)	(0.17)	(0.17)	(0.18)	(0.19)	(0.22)	(0.43)
Output Gap	0.02	-0.02	-0.04***	-0.03***	-0.03***	-0.03***	-0.04***	-0.04***
	(0.02)	(0.01)	(0.008)	(0.009)	(0.009)	(0.01)	(0.009)	(0.01)
Systemic Stress Indicator	3.43***	2.18***	1.08***	0.91***	0.90***	0.89***	0.95***	1.42*
	(0.34)	(0.23)	(0.15)	(0.16)	(0.17)	(0.17)	(0.17)	(0.57)
Excess Liq.		-0.68***	-0.24***	-0.24***	-0.25***	-0.24***		
		(0.04)	(0.03)	(0.03)	(0.03)	(0.03)		
Balance Sheet Size							-0.18***	
							(0.02)	
PSPP Holding								-0.21***
								(0.05)
5Y5Y Inflation			1.57***	1.54***	1.52***	1.52***	1.42***	0.87***
			(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.18)
5Y5Y Inflation Vol.				0.65**	0.67**	0.66***	0.73**	-0.12
				(0.24)	(0.24)	(0.24)	(0.23)	(0.39)
Headl. Inflation					0.01	0.01	0.03	0.10
					(0.03)	(0.03)	(0.03)	(0.07)
Core Inflation						0.02	-0.02	0.13
						(0.09)	(0.09)	(0.12)
R-squared	33%	73%	90%	91%	91%	91%	92%	72%
Estimated Impact of APP (%)	/	-2.90	-1.02	-1.02	-1.07	-1.02	-1.28	-0.76

Standard errors in parentheses.

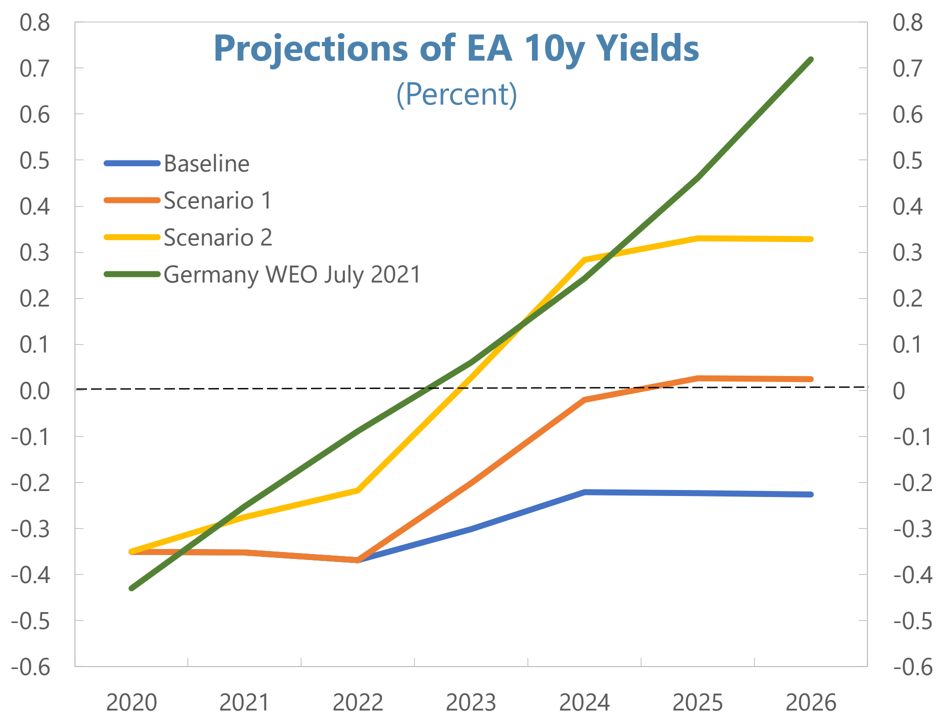
*** p<0.001, ** p<0.01, * p<0.05

4.3 Nominal Yield Projections in the Euro Area

We make forward projections of the 10-year nominal yields under different scenarios by combining the expected short-term rate and the estimated term premia, which is based on model (6) in Table 1. Figure 12 below plots the baseline projection and two alternatives, together with the German bund yield projection from WEO Update published in July 2021 for reference. While they show different dynamics of the bond yield recovery, our results suggest that term premia and yields are likely to remain compressed under our assumptions in all scenarios.

- **Baseline Projection**

Our baseline projection assumes the smooth convergence of all non-policy variables in our linear model to their past five-year average level by the year of 2024, when the output gap closes. Further, we assume ECB uses full Pandemic Emergency Purchase Program (PEPP) envelope by 2022 and then half of the PEPP amount until 2024. The baseline result shows that long-term nominal bond yield will remain compressed in the negative territory by 2026, around the level of -0.20 percent.



Source: Bloomberg, IMF Staff calculations.

Figure 12. Yield Projections in the Euro Area

- **Alternative Scenario 1**

In addition to the baseline projection, we assume that financial markets expect an ECB liftoff of interest rates starting in 2023. Specifically, the expected risk neutral rate is assumed to increase by 10bps in 2023, then by 20bps and 25 bps in the following two years. With the assumption of risk neutral interest rate liftoff, bond yields would recover quickly since 2023, and will come back to zero level in 2024 and turn positive after 2025.

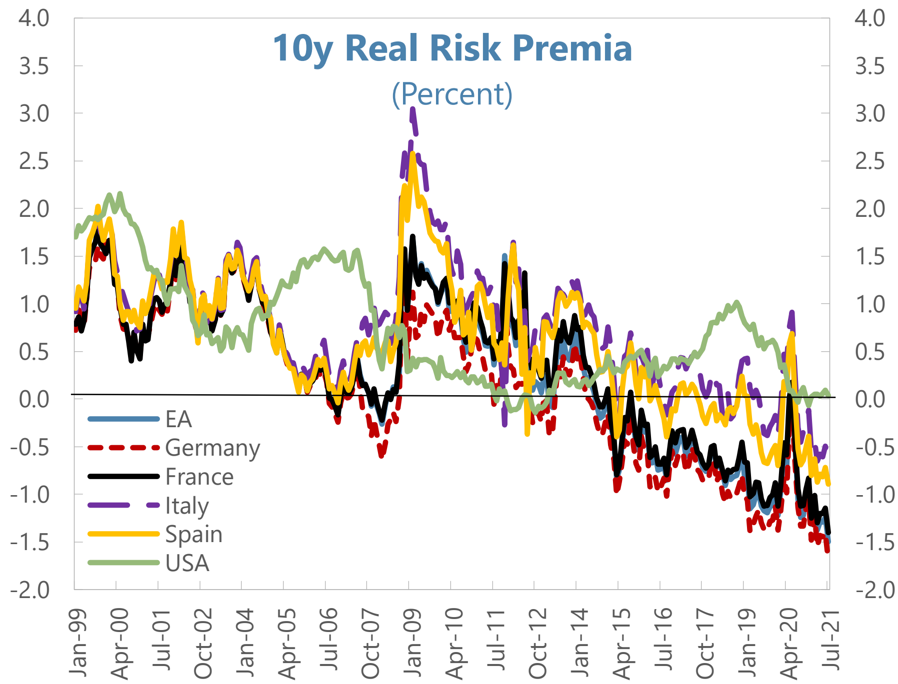
- **Alternative Scenario 2**

Based on Scenario 1 with the same trajectory of the expected risk neutral rate, we assume the inflation level will reach the 2 percent target by 2024. Given this, the bond yield in the euro area will recover more significantly and closely follow the German bund yield projection in WEO until stabilize around 0.3 percent after 2024, when the 2 percent inflation target is achieved.

4.4 Inflation and Real Risk Premia

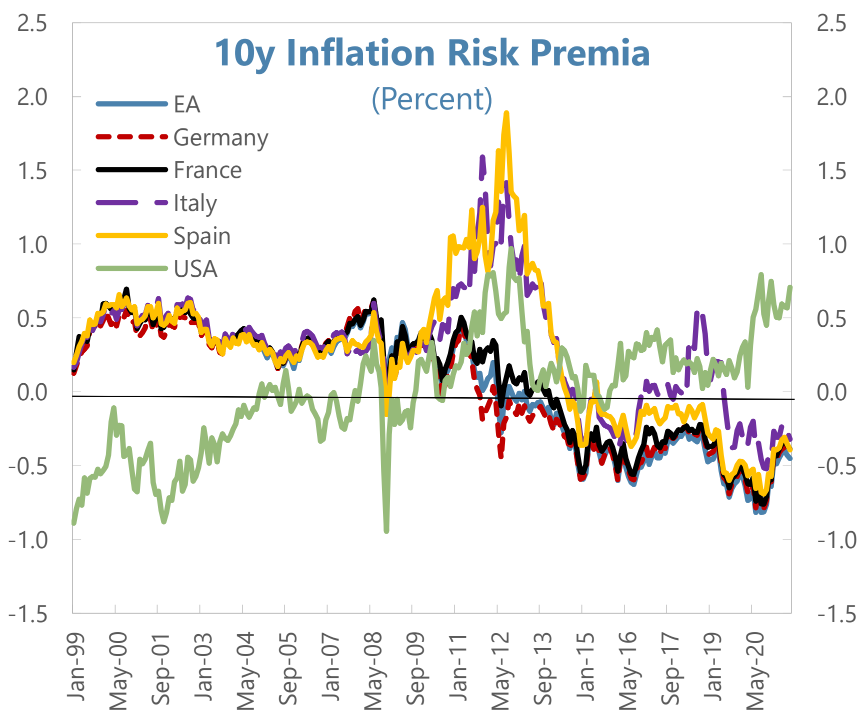
Beyond nominal term premia, with our model estimated and a specific realization of the state-variables, we can further decompose the term premia into its real and nominal part. Hence, we can compute the model-implied inflation risk premium and real risk premium. The estimated 10-year inflation risk premia and real risk premia dynamics are displayed in Figure 13 and Figure 14.

The constant fall in real risk premia has been the primary driver of declining yields, especially over the past year as demand for sovereign bonds has remained strong from ECB’s purchase, and lower uncertainty over the projected path of short-term rates given ECB’s forward guidance that rate increases were unlikely in the near term. Weak economic growth since the sovereign debt crisis has also contributed to increased preference for bonds with investors tolerating even deeper negative term premia.



Source: Bloomberg, IMF Staff calculations.

Figure 13. Ten-year Real Risk Premia



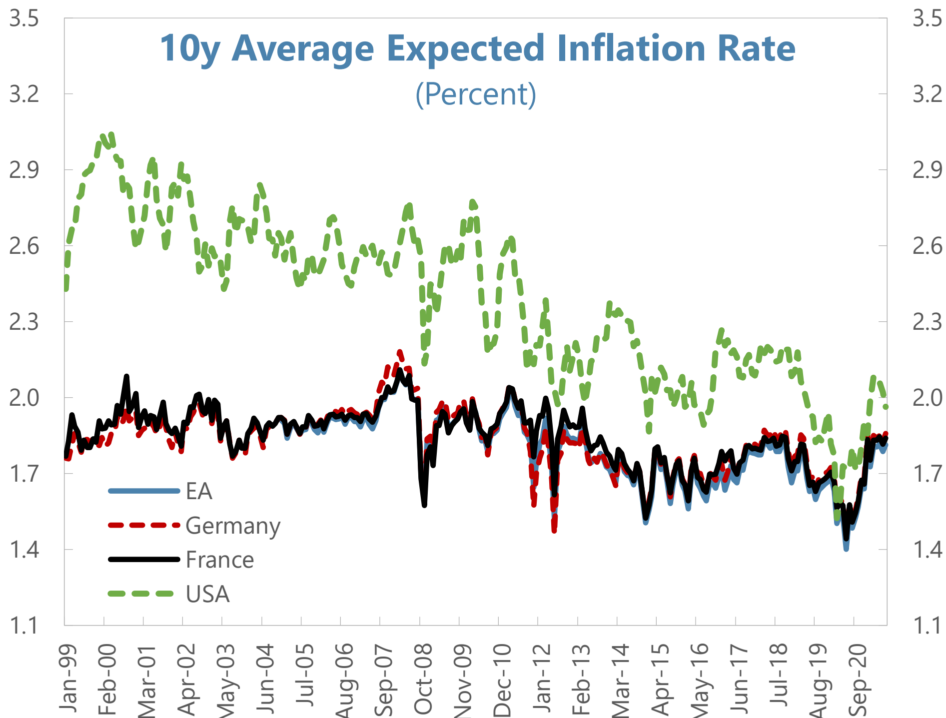
Source: Bloomberg, IMF Staff calculations.

Figure 14. Ten-year Inflation Risk Premia

For inflation risk premia, we can observe the obvious divergences across the two sides of the Atlantic. While the inflation risk premia remained stable and positive in the euro area before the GFC, the premia in the United States have long been negative. During the GFC, inflation risk premia fell sharply in both areas but more severe in the U.S. The divergence started again in 2012 and we have observed a decoupling of premia across the two areas since then: the euro area has seen the overall downward trend of the inflation premia, which has remained negative. The premia in the United States first increased temporarily and then fell to near-zero levels and stabilized. Specifically, during the years after 2012, the United States experienced an increase in the output gap and a mild increase in inflation. In contrast, the output gap and inflation rate both fell further in the euro area. The divergence in the dynamics of inflation premia suggests that financial market participants appear to price the inflation risk in the United States and in the euro area differently. The market seems more confident about the Federal Reserve's capability to deliver a stable inflation rate over the medium-to-long run, compared to that of the ECB. More recently, the inflation risk premia in both areas showed a strong rebound when the COVID-19 pandemic hit the market. The inflation risk premium in the euro area has recovered closer to zero level, though remains negative, while the real risk premium has remained stable. The U.S. also has seen an increase in the inflation risk premium since 2020. The increase in inflation risk premium likely reflecting both recent upward inflation surprises and heightened uncertainty surrounding both monetary and fiscal policies going forward.

4.5 Premium-adjusted Inflation Expectation

The market commonly used the break-even inflation rate as the timely measure of the expectations of future inflation. But recall in Figure 1 that break-even inflation rates also include the risk premia component that is to compensate investors for the inflation risk. One should be careful when interpreting the break-even inflation rates in terms of the inflation expectations. Given the model-implied inflation risk premium, we can tease out the premium-adjusted inflation expectation by removing the risk premia component from the break-even inflation rates. This results in a more accurate and cleaner measure of expectations on future inflation over the lifetime of the bonds.



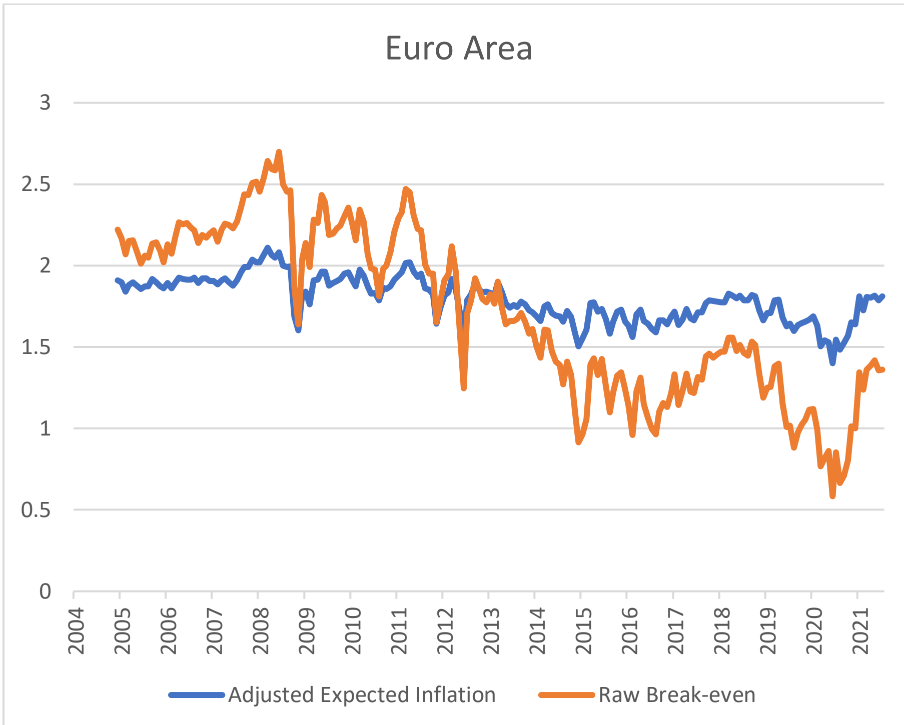
Source: Bloomberg, IMF Staff calculations.

Figure 15. Premium-adjusted Inflation Expectation

Figure 15 displays the premium-adjusted ten-year expected inflation rates in the United States and the euro area. In the euro area, the raw euro-area break-even rate remained mostly above 2 percent since 2004 and then fell significantly below 2 percent after 2012. Meanwhile, the premium-adjusted expected inflation rate has generally been fluctuating below but very close to 2 percent, indicating the long-term euro-area inflation expectations after stripping out the inflation risk premia is in line with the ECB's price stability objective. Our inflation expectation measure is more well anchored than that would be concluded based on the raw break-even rate.

In both the euro area and the United States, the premium-adjusted expected inflation rate is also less volatile than raw break-even inflation rate as presented in Figure 16. The raw U.S. break-even rate reached a minimum close to 1 percent at the end of 2008, the premium-adjusted measure has been stably hovering around 2.5 percentage points. After mid-2011, it has then fallen towards the level around 2 percent level, until the recent trough to around 1.5 percent due to COVID-19.

For the euro area, while recently during the COVID-19 turbulence the break-even inflation rate plummeted and rebounded quickly, the premium-adjusted measure remained much more stable and has recovered from the trough to the level below but very close to 2 percent.



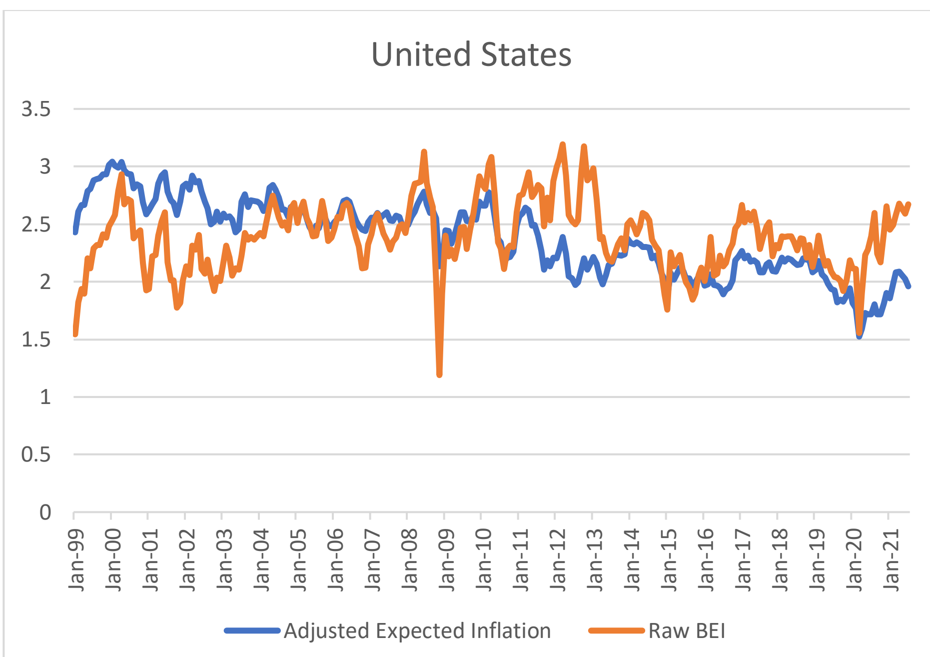
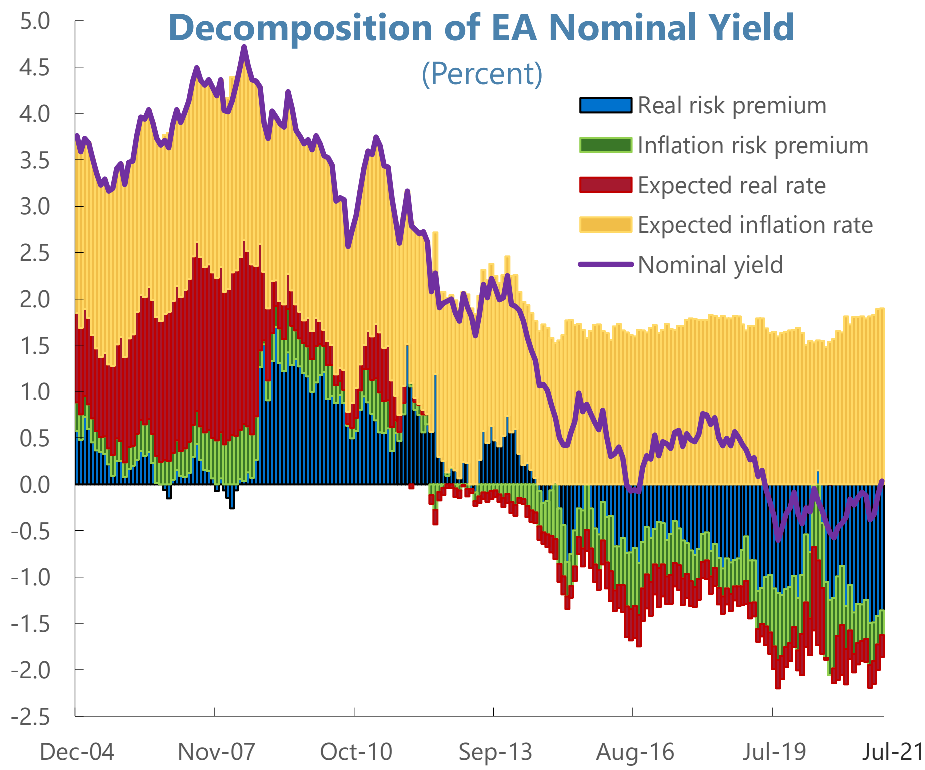


Figure 16. Raw Break-even and Premium-adjusted Inflation Expectation

To sum up, the premium-adjusted long-term inflation expectation have remained remarkably stable both in the euro area and in the United States, even over the peak of the GFC, when output gap was the largest negative and inflation rates also reached negative in both monetary areas. In addition, contrary to the Fed, the ECB’s new strategy review has yet to lift inflation expectations with financial markets expecting inflation to remain below 2 percent.

4.6 Summary of Decomposition of Nominal Yields in EA

As the pandemic has kept euro area yields at historical lows, the components embedded in the nominal yields have showed different dynamics as plotted in Figure 17. The fall in sovereign yields in the euro area has been primarily driven by a decline in the real risk premium. While expectations of short-term rates in the euro area have remained relatively stable since 2014, investors have required a smaller compensation for inflation risks since early 2019, reflecting both a fall in inflation expectations and the impact of the pandemic. More recently, inflation risk premia have started recovering as inflation volatility has increased. Nonetheless, the fall in real risk premia has been the primary driver of declining yields, especially over the past year as demand for sovereign bonds has remained strong given ECB purchases and lower uncertainty over the projected path of short-term rates following the ECB’s forward guidance that rate increases were unlikely in the near term. Weak economic growth since the sovereign debt crisis has also contributed to an increased preference for bonds with investors tolerating even deeper negative term premia. In contrast, the U.S. has seen an increase in the inflation risk premium since 2020 amid a volatile real risk premium, with the former likely reflecting both recent upward inflation surprises and heightened uncertainty surrounding both monetary and fiscal policies going forward.



Source: Bloomberg, IMF Staff calculations.

Figure 17. Decomposition of EA Nominal Yields

V. Conclusions

We jointly model the macroeconomic and term structure dynamics to estimate the term premia and inflation risk premia embedded in U.S. and euro area bonds yields. Our results suggest that while other components remain relatively stable, the fall in real risk premia has been the primary driver of declining yields, especially over the past year, given ECB's assets purchases and forward guidance which lowered the uncertainty over the projected path of short-term rates.

The financial market and policymakers often refer to break-even rates as the measure of market expectation of future inflation. But break-even rates also include inflation risk premia, which compensate investors for liquidity and inflation risks, in addition to inflation expectation. In this paper, we obtain the premium-adjusted inflation expectation by stripping out the model-implied inflation risk premia. We find that ten-year inflation expectations have remained quite stable over time both in the euro area and the United States. Contrary to the Fed, the ECB's new strategy review has yet to lift inflation expectations with the long-term inflation expectations moved very little and have been hovering slightly below 2 percent.

In addition, we investigate the macroeconomic determinants of the term premia by building a model of the term premia to forecast the euro area 10-year yield curve. The ten-year yields projection based on the model result suggests that yields in the euro area will likely remain depressed over the medium-term under various scenarios.

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