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How Stable are Inflation Expectations in the Euro Area? Evidence from the Euro-Area Financial Markets*

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Abstract

We analyze evolution of inflation expectations in the euro area (EA) using a novel measure of inflation expectations implied by the French nominal and inflation-indexed bonds. Overall, we find that EA inflation expectations have been relatively well anchored in the 2004 – 2019 sample but have been somewhat sensitive to the incoming macroeconomic news and monetary policy shocks in the sample that includes the COVID-19 pandemic. Our results are robust with respect to the use of different inflation-indexed securities data, such as the EA inflation-linked swaps.

JEL Classification: D84, E31, E37, E52, E58

Keywords: *Obligations Assimilables du Trésor, OAT, French inflation-indexed bonds, nominal-indexed bond spreads, inflation swaps, inflation expectations, macroeconomic news, monetary policy shocks, euro area, inflation anchoring, stability.*

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1 Introduction

Stable prices are essential for promoting economic growth, optimal employment, and financial stability in the economy. To that end, central banks around the world have an important mandate to guarantee price stability in their economies. For example, the European Central Bank (ECB) states: "*The primary objective of the ECB's monetary policy is to maintain price stability. This means making sure that inflation – the rate at which the prices for goods and services change over time – remains low, stable and predictable.*"[1] One of the main tools that central banks employ to achieve this objective is inflation targeting rules, explicit or implicit, as part of their monetary policy framework. The academic literature has advocated for advantages of adopting inflation targeting as part of the monetary policy framework (see, e.g., Walsh, 1995; Bernanke and Mishkin, 1997; Bernanke et al., 1999; Jia and Wu, 2023, among many others). Recently, policy-makers on both sides of the Atlantic have explicitly acknowledged the importance of understanding the evolution of inflation expectations as they provide a nominal anchor in the economy for wage bargaining, consumption, and investment decisions of households, and thus, affect aggregate economic outcomes (see, e.g., Coeuré, 2019; Lagarde, 2022, 2023; Lane, 2023; Williams, 2023). As such, the question of stable prices and anchored inflation expectations has been actively studied by academic researchers and central bankers alike (see, e.g., Gürkaynak et al., 2007; Gürkaynak et al., 2010; Beechey et al., 2011; Grishchenko et al., 2019).

Despite central banks' commitment to keep prices stable and inflation low, recently prices have risen dramatically around the world, driven, in large part, by exogenous shocks, such as the COVID-19-induced supply chain imbalances and geopolitical developments. In response to these shocks, central banks around the world tightened their monetary policy stance and communicated their strong commitment to bring inflation back to their respective inflation objectives. Thus, it is a natural question whether inflation expectations have been well anchored, in general, and during the recent episode, more specifically.

While there have been evidence, to date, regarding anchoring of inflation expectations in the

[1] See https://www.ecb.europa.eu/mopo/intro/html/index.en.html.

U.S., U.K., Sweden, and several other countries (Gürkaynak et al., 2010; Beechey et al., 2011), there are surprisingly few studies that assess the anchoring of inflation expectations in the euro area (EA). Our paper fills this gap. Realized inflation in the EA skyrocketed to an unprecedented 10 percent level in February 2023. Figure 1 shows the annualized rate of change in the EA Harmonized Index of Consumer Prices (HICP, the blue line) and the French Consumer Price Index (CPI, the orange line).[2] As shown in the figure, realized inflation in the EA, in general, and in France, in particular, varied significantly since the EA onset in 1999. In February 2023, the EA-HICP-based inflation surged above 10 percent. Around the same time, the French CPI-based increased just over 6 percent, due to the so-called "bouclier tarifaire", that is, the limits imposed on energy prices in 2022 and 2023 in France. In this paper, we analyze the stability of EA inflation expectations using the French government bonds data.

Central bank economists and monetary policy-makers use various measures to monitor inflation expectations. One measure of inflation expectations is provided by the surveys of professional forecasters. However, these surveys are available at relatively low frequencies, such as monthly or quarterly frequencies, making it difficult to assess whether inflation expectations change at the time of the major economic data releases. Another widely used measure is inflation compensation —the spread between the nominal and inflation-indexed yields at comparable maturities that presents compensation for expected inflation and inflation risk. Inflation compensation hence provides a natural albeit imperfect gauge of market inflation expectations.[3] Market-based inflation expectations have been studied at length and at depth in the advanced economies— for example, related to the U.S. inflation expectations, Gürkaynak et al. (2007), Abel et al. (2016), Christensen et al. (2010), Grishchenko and Huang (2013), D'Amico et al. (2018), Chang (2019), to name a few; and related to inflation expectations in other advanced economies, such as U.K., Japan, and the EA, Barr and Campbell (1997), Evans (1998), Kita and Tortorice (2018), Moessner and Takáts (2020), to name a few. This literature is constantly growing despite its maturity, especially

[2] The term "harmonized" reflects the fact that all the countries in the EA follow the same methodology. This ensures a consistent comparison across different economies.

[3] As the authors in these papers have argued, market-based inflation expectations contain inflation risk premiums, making it challenging to interpret the movements in these measures. We leave these issues for future research.

following the latest episode of surge in inflation during the COVID-19 pandemic. Advances have been made about understanding time variation in inflation expectations around the world and driving forces behind them, but the literature about the French inflation-indexed debt is limited (see, e.g., Pericoli, 2014; Bekaert and Ermolov, 2023; Christensen and Mouabbi, 2024). Yet, the French inflation-indexed bond market has evolved substantially during the past two decades. The market launched in 1998 and the current outstanding nominal amount of French inflation-indexed debt represents about 12 percent of the U.S. Treasury Inflation-Indexed Securities, whose outstanding nominal amount has been about two trillion USD as of August 31, 2024.[4] French inflation-indexed debt market is particular in a sense that it consists of two types of debt securities that link bond cash payments to two indexes, namely, the EA HICP (OAT€i market) and the French CPI (OATi market). We are the first, to our knowledge, to consider these two branches of the French inflation-indexed bond market.

In the first part of the paper, we describe in detail the French inflation-indexed Treasury market, construct daily inflation-indexed yield curves that proxy the term structures of real interest rates, and present several stylized facts.[5] To our knowledge, we are the first to have estimated the term structure of French inflation-indexed yields. In doing so, we broadly follow the methodology used in Grishchenko et al. (GMP, 2020) who estimate the term structure of French nominal securities (OATs). We report several findings. First, we find that the the OAT€i market is more saturated in terms of the number of securities and the outstanding notional amount than the OATi market. Second, we find that the dynamics in two markets have been quite different. The OAT€i market has been growing steadily since inception in 2000, while the OATi market stopped growing around 2010. The capped growth in the OATi market likely reflects the highly domestic nature of this market whose securities are issued to finance a very limited number of domestic

[4]See the Monthly Statement of the Public Debt by the U.S. Treasury https://fiscaldata.treasury.gov/datasets/monthly-statement-public-debt/summary-of-treasury-securities-outstanding and the Monthly Bulletin of the Agence France Trésor https://www.aft.gouv.fr/en/bulletins-mensuels. Agence France Trésor (AFT) oversees the debt management operations.

[5]Inflation-indexed and real yields differ due to relative illiquidity of the inflation-indexed debt markets. We abstain from these considerations in this paper and with this caveat in mind, we use "inflation-indexed" and "real" terms to describe the yield curve, interchangeably.

banks and insurance companies, such as *Caisse d'Epargne*.[6] Because of the small and highly segmented nature of the OATi market, we do not use it in the second part of the paper where we study the stability of inflation expectations. Second, we find that the OAT-implied real rates have been declining since the Global Financial Crisis (GFC), with the average levels around or below 1 percentage point. On average, the real rates have been negative at maturities up to five years in our sample period. Third, we find that, despite the stated differences, inflation compensation measures implied by two markets are highly correlated (it is likely that OATi market quotes simply trail the OAT€i market quotes as very few trades takes place in the OATi market.

In the second part of the paper, we use daily quotes of French nominal OAT and inflation-indexed OAT€i bonds to analyze stability of the long-run EA inflation expectations. Namely, we check if the far-forward inflation compensation measures — the difference between the nominal and real rates of comparable maturities — are materially affected by surprises in major macroeconomic data releases. The extent to which inflation compensation reacts to the incoming news is indicative of stable/unstable inflation expectations. We expect that, if the equilibrium inflation rate is constant over time, communicated to all agents by the central bank, and is well understood by the agents, then the distribution of inflation expectations should be at this equilibrium level in the long run, e.g., within the 10-year period. (See, e.g. Gürkaynak et al., 2005; Gürkaynak et al., 2010; Beechey et al., 2011). To this extent, we measure the sensitivity of OAT€i forward inflation compensation measures at various horizons to major macroeconomic news releases in the EA, France, Germany, and the U.S. and to the surprises in monetary policies of the ECB and the Federal Reserve. Namely, we look at whether surprises in macroeconomic data releases and monetary policy surprises significantly affect far-ahead EA forward inflation compensation measures.

Overall, using the sample period of 2004 − 2019 (which excludes the COVID-19 period), we find that the OAT€i forward inflation compensation measures are somewhat responsive to surprises in macroeconomic news and monetary policy shocks in the EA and the US. However, we find

[6] We thank Jean Dalbard for this insight.

that the economic magnitude of this effect is rather small. This result is in line with earlier studies (e.g., Beechey et al., 2011) whose sample is rather limited (2007 − 2011 for EA inflation swaps). Thus, our results suggest that macroeconomic surprise components and monetary policy shocks do not materially change the distribution of future inflation rates in in the EA or, in other words, that EA inflation expectations are relatively well anchored. We also use EA inflation-linked swap (ILS) rates. Recently, the ILS rates have been found to provide more accurate forecasts of future inflation than, for example, surveys of professional forecasters, of future inflation (See, e.g., Diercks et al., 2023). As such, it is important to consider this source of information to see whether information contained in the EA ILS rates is sensitive to incoming macroeconomic news and monetary policy shocks. We found that, even though the reaction in the EA ILS rates and OAT€i inflation compensation rates to macroeconomic and/or MP shocks is different, both markets convey broadly the same message.

Finally, in Appendix B, we report the sensitivity analysis results that include the COVID-19 pandemic. We find that the reaction in OAT€i and ILS financial markets is a bit stronger when the COVID-19 period is included in our sample. The reason is that this special period was marked by several macroeconomic indicators releases, well outside of the range suggested by the historical distribution, by unconventional monetary policies in response to COVID-19 pandemic, and by disruptions in the financial markets' functioning. However, this episode does not materially alter our overall conclusions.

The rest of the paper is organized as follows. Section 2 describes the French inflation-indexed government debt in France, Section 3 describes the methodology for producing smoothed term structure of inflation-adjusted yields, Section 4 discusses analysis on stability of inflation expectations, and Section 5 concludes.

2 Inflation-indexed government debt in France

Issuance of the inflation-indexed debt by government has been a popular form of government financing at the time catering to market participants demands to hold such inflation-indexed securities that would hedge their exposure to inflation (See, e.g., Campbell and Shiller, 1991, for details). Most developed countries, such as the U.S., U.K., Israel, and Italy, have been issuing such government debt for several decades now. Deacon et al. (2004) provide details about different global markets. By issuing inflation-indexed debt, governments implicitly aim to keep prices stable and inflation under control. France has been issuing inflation-indexed debt for approximately as long as the U.S. has been issuing Treasury Inflation-Indexed Securities (TIPS). Yet, the French inflation-indexed market received much less attention in academic and central banking literature than the U.S. Treasury market or other markets—e.g., U.K. or Swedish markets—with the exception of a few papers (See, e.g., Pericoli, 2014; Bekaert and Ermolov, 2023; Christensen and Mouabbi, 2024). However, the importance of this market should not be underestimated since it presents a unique channel of gauging inflation expectations not only in France, but also in the EA as whole.

In September 1998, the French Treasury started issuing inflation-indexed debt securities linked to the domestic (French) CPI. In October 2001, it also started issuing inflation-indexed debt linked to the European HICP. Corresponding securities are called *Obligations Assimilables du Trésor indexées sur l'indice des prix à la consommation en France* — OATi and *Obligations Assimilables du Trésor indexées sur l'indice des prix à la consommation de la zone euro* — OAT€i. Given these two types of securities, we derive two measures of inflation expectations: OATi- and OAT€i implied measures of inflation expectations, and we call these two markets OATi and OAT€i, respectively. The two branches of the OAT inflation-indexed market exist with the obvious aim to meet the market participants' needs for hedging their liabilities against changes in either domestic or EA inflation.[7] The information from these markets presents a wealth of information that would

[7] A likely primary objective of the OATi market is to support major French retail banks in managing savings accounts exposed to inflation risk, such as the *Livret A* and the *Livret de développement durable et solidaire*. Supporting this perspective, 83 percent of OATi bonds are held by residents as of the third quarter of 2024, leaving

potentially help monetary policy makers, central banking economists, and interested researchers to assess inflation expectations and balance of risks around these expectations.

Table 1 reports the list of bonds issued since the onset of these two markets. There are 19 OAT€i bonds issued since 2001 and 13 OATi bonds issued since 1998, until the end of our sample period, February 22, 2023. Table 1 provides the International Securities Identification Number (ISIN), issue date, coupon rate, maturity of the bond, the term-to-maturity of the bond at the issuance, and the total number of available daily observations for the security. We collect the bond characteristics from the AFT, cross-check them with Bloomberg, and collect daily bid prices from Bloomberg. As table 1 shows, there was a steady issuance of both OAT€i and OATi securities, about one issue per year in the OAT€i market and about one issue every two years in the OATi market.

Figure 2 shows the OAT€i and OATi securities' maturities, on the top left and right, respectively. In general, there exist more longer-term OAT€i securities than OATi securities, even accounting for the number of outstanding securities. This figure also shows the outstanding notional amount of the OAT€i and OATi inflation-indexed debt on the bottom left and right, respectively. The OAT€i grew steadily in our sample period, between 1999 and 2023, and reached about 150 billion euros by the end of our sample. In contrast, the OATi debt grew between 1999 and 2010, and the market reached its peak of approximately 80 billion euros in outstanding notional amount. The outstanding notional amount of the OATi market since then hovered around that level with some insignificant increases and declines. A potential reason for why the OATi market reached its steady level is likely that the demand to hedge domestic inflation has been saturated, while the demand for hedging inflation in the OAT€i market has not yet been saturated.[8] That said, currently the outstanding notional amount of the OATi market represents about half of the outstanding OAT€i market. Jointly, OAT€i and OATi markets represent about 12 percent of the U.S. TIPS market.

only 17 percent available to non-residents. The market appears to be predominantly influenced by a small number of local financial institutions. We thank Jean Dalbard for this discussion.

[8] In accordance with the footnote 7, the ceiling on outstanding OATi debt reflects the level of domestic demand for hedging against domestic inflation.

In the early 2000s, the bonds' coupon rates were around 3 percent for both segments of this market and have been declining since then, likely reflecting declining interest rates and bonds' profitability globally, as the central banks around the world slashed interest rates to nearly zero following the aftermath of the GFC. OAT€i bonds have had coupon rates of 0.1 percent since 2016.[9] Concerning the time-to-maturity of the bond at the issuance, we have several observations. The average time-to-maturity at issuance of the OAT€i bonds is about 15.5 years, and these bonds have a wide spectrum of maturities. The shortest maturity bond (ISIN FR0108664055) with less than 4 years was issued in October 2006, and the longest maturity bond (ISIN FR0010447367) of 33.4 years was issued in March 2007. The average time-to-maturity of the OATi bonds at issuance is approximately 12 years, with time-to-maturities ranging from 5.5 years to just under of 30 years. Overall, our sample contains 40,252 and 30,877 daily bond quote observations for OAT€i and OATi securities, respectively. In the next section, we describe how we use these daily bond quotes for construction of smoothed daily yield curves of inflation-indexed debt.

3 Pricing inflation-indexed government debt

This section summarizes several key pricing concepts related to inflation-indexed securities, describes the details of the smoothing procedure that we use to obtain term structures of real rates and presents estimated real yield curves.

3.1 Pricing of nominal and inflation-indexed OATs

The time $t-$price of a *nominal* coupon bond maturing in $T-t$ years, promising $N_{c,t}$ remaining coupon payments c, and paying a principal of €F in $T-t$ years, is given by

$$P^{\mathbf{nom}}(c,t,T)=\sum_{i=1}^{N_{c,t}} c\times B(t,t_i)+F\times B(t,T), \tag{1}$$

[9]Since the end of our sample, the coupon rates have increased in the OAT€i and OATi markets (to 0.6 percent and 0.55 percent in the 24/07/2023 and 14/06/2023 issues, respectively). Naturally, these constant coupon rates inherently result in variable coupon payments that fluctuate in response to inflation.

where t_i stands for the $i-th$ coupon payment date, $t_{N_{c,t}} = T$ for the last payment date and $B(t,T)$ for the price of a nominal zero-coupon bond promising a unit face value and maturing at time T. The nominal continuously compounded zero-coupon yield is denoted by $y^{\text{nom}}(t,T)$.

The value of nominal cash-flow payments tends to be eroded by inflation over time, and this is where inflation-indexed securities come in. In inflation-indexed government bonds, the coupon payments and the principal value to pay are adjusted for inflation. The adjustment is based on a *reference index* that adjusts bond cash-flows for inflation. In the French inflation-indexed security markets, the reference indexes are the EA-HICP and the French CPI for OAT€i and OATi, respectively. In both cases, the value of the reference index at time t is calculated by interpolating the two- to three-month lagged value as a function of the current day of the month (see, for details, Deacon et al., 2004). The time-t cash flows promised by the inflation-indexed bond involve an index factor IF calculated as the ratio between the reference index associated with time t and the *base index*, which is the value of the reference index that prevailed at the time of bond's issuance. The value at time t of the index factor associated with a bond issued at time t_0 is:

$$IF_t = \frac{\text{reference index}_t}{\text{base index}_{t_0}}$$

where the base index is fixed when the bond is issued.[10]

The coupon amount payable on day t_i is calculated by Coupon amount$_{t_i} = IF_{t_i} \times$Coupon rate (in %)$\times F$ and the redemption amount to pay at bond's maturity is Redemption amount $= \max(IF_T; 1) \times F$. Hence, the final redemption amount cannot be less than the face value, and both OATi and OAT€i securities are contractually protected against deflation. This feature of OATi contracts creates a so-called deflation put, present in the TIPS as well. Of course, the level of inflation at interim coupon payments and at maturity is not known in advance, and the standard net present value pricing formula must be adapted for valuing the inflation-indexed bonds. The price of the

[10]The base index (i.e., the reference index that prevailed at the time of bond's issuance) has a reference year and that this reference year has been changing over time; It used to be 1996, then 2005, and then 2015.

inflation-indexed bond may be written:

$$\begin{aligned} P_{\text{OATi/OAT€i}}(c,t,T) &= \sum_{i=1}^{N_{c,t}} c \times \mathbb{E}_t^{\mathbb{Q}_{t_i}}\left[IF_{t_i}\right] \times B(t,t_i) + F \times \mathbb{E}_t^{\mathbb{Q}_T}[\max(IF_T;1)] \times B(t,T) \\ &\approx IF_t \times \left(\sum_{i=1}^{N_{c,t}} c \times B^{\text{IL}}(t,t_i) + F \times B^{\text{IL}}(t,T) \right) \end{aligned} \quad (2)$$

where $\mathbb{Q}_{t_i}$ represents the t_i-forward equivalent measure, $\mathbb{E}_t^{\mathbb{Q}_{t_i}}[.]$ is the conditional expectation under $\mathbb{Q}_{t_i}$, and $B^{\text{IL}}(t,T)$ is the inflation-indexed zero-coupon bond maturing at time T. The corresponding inflation-indexed continuously compounded zero-coupon yield is denoted by $y^{\text{IL}}(t,T)$. The expression in eq. (2) is very close to equality when deflation is highly unlikely and the deflation put value is insignificant. Grishchenko et al. (2016) and Christensen et al. (2016) find that the value of deflation out is nonsignificant in most of the periods. Therefore, we abstract from modeling this value.

The next subsection explains how we construct the yields.

3.2 Yield curve fitting and estimation

This section provides details of our fitting procedure of the yield curves. We broadly follow the Gürkaynak et al. (2007, 2010) and Grishchenko et al. (2020) approaches to fit implied yield curves using OAT and OATis bond prices. For inflation-adjusted bonds, we use the Nelson and Siegel (1987) (NS) functional form due to the limited number of issued securities, especially in the beginning of our sample in 2004. The NS specification for the instantaneous forward rates $f(t,m)$ m periods ahead at time t is:

$$f(t,m;\Theta) = \beta_0 + \beta_1 \exp\left[-\frac{m}{\tau_1}\right] + \beta_2 \frac{m}{\tau_1} \exp\left[-\frac{m}{\tau_1}\right], \quad (3)$$

where $\Theta = \{\beta_0,\ \beta_1,\ \beta_2,\ \tau_1\}$ are four parameters to be estimated. This methodology is quite effective at capturing the general shape of the yield curve implied, while smoothing through idiosyncratic variation in the yields of individual inflation-indexed securities. In addition, $\beta_0 + \beta_1$

and β_0 have natural interpretations as being the yields at the short and long end of the yield curve, respectively. The third term of the NS functional form locates and sizes the unique hump in the term structure of interest rates. The m-period continuously compounded zero-coupon yield at time t is obtained by integrating $f(t, m; \Theta)$ given by (3) over the interest rate horizon $[t, t+m]$:

$$y(t, t+m; \Theta) = \beta_0 + \beta_1 \frac{1 - e^{-\frac{m}{\tau_1}}}{\frac{m}{\tau_1}} + \beta_2 \left[\frac{1 - e^{-\frac{m}{\tau_1}}}{\frac{m}{\tau_1}} - e^{-\frac{m}{\tau_1}} \right] \tag{4}$$

with $\Theta = \{\beta_0, \beta_1, \beta_2, \tau_1\}$ the four parameters. The Svensson (1994) functional form has two extra parameters and allows for a second hump. We nevertheless find that the second hump presence is virtually nonexistent in the case of real yield curves. On average, Svensson fit yielded only 1 basis point gain in the mean absolute fitting error, relative to NS fit.[11] For nominal OATs, we use the Svensson (1994) functional form, because adding the possibility of a second hump is important to capture the shape of the nominal yield curve.[12] In addition, there are significantly more nominal OAT securities than inflation-indexed securities—namely, about 200 versus 18 (see table 1), as of late May 2022— so the cost of fitting an extra two parameters (for the Svensson model) is far smaller.

We collect on day t a set of N_t observed bond bid prices $\widehat{p}(c_k, t, T_k)$, $k = 1, ..., N_t$ where c_k and T_k are the coupon and maturity of the bond k. respectively, and then estimate the NS model, by minimizing the sum of squared deviations between observed bond prices and model predicted values, the deviations being weighted by the inverse modified duration of the considered bond.[13] As we will clarify later, we exclude securities with a duration shorter than one year, following Gürkaynak et al. (2007, 2010) and GMP. Excluding such securities prevents particular institutional details, unrelated to variation that reflects changes in fundamentals, to affect the fit and inference about the yield curve.[14] We do not impose any other filters in our estimation.

[11] Results are not reported but available upon request.

[12] GMP provides further details on nominal OAT yield curve fitting.

[13] Some authors use mid quotes (the average of bid and ask quotes). See, e.g., Ermolov 2017.

[14] One example is that some long-term asset (pension or insurance) managers tend to sell off shorter-duration bonds in re-balancing their portfolios.

Specifically, assume observed and model bond prices are related via:

$$\widehat{p}\left(c_k, t, T_k\right) = p\left(c_k, t, T_k; \Theta_t\right) + \varepsilon_{t,k}, \tag{5}$$

where the vector of error terms $\varepsilon' = \left(\varepsilon_{t,1}, ..., \varepsilon_{t,N_t}\right)$ has a zero mean and a diagonal covariance matrix with possibly different variances on the diagonal. Then we solve

$$\widehat{\Theta}_t = \arg\min_{\Theta_t} \sum_{k=1}^{N_t} \frac{1}{D_k} \left(\widehat{p}\left(c_k, t, T_k\right) - p(c_k, t, T_k; \Theta_t)\right)^2. \tag{6}$$

where D_k the modified duration of the bond k.[15] Hence, the set of parameters Θ_t is estimated on a daily basis by minimizing a weighted sum of squared errors whose weights are the inverses of the squared modified duration. Such a particular weighting scheme is an appropriate way to deal with the nonlinear relation between yields and prices (see Svensson 1994; GSW; Gauthier and Simonato 2012). As explained by GSW (see their footnote 4 on page 2296), this method avoids converting bond prices into yields and therefore speeds up the calibration exercise. Of course, the above optimization program applies to both nominal and inflation-indexed securities (i.e. OATi and OAT€i securities), so that we can finally get yield curves for both $y^{\text{nom}}\left(t, T\right)$ and $y^{\text{IL}}\left(t, T\right)$.[16]

We then compute, at a given time t, the mean absolute error (MAE) of the model fit for particular maturity bins. $MAE_t\left(\tau\right)$ averages the absolute differences between the observed and Nelson-Siegel predicted yield-to-maturity of the bonds within a particular maturity bin τ:

$$MAE_t\left(\tau\right) = \frac{1}{N_t\left(\tau\right)} \sum_{k=1}^{N_t(\tau)} \left| y^o\left(c_k, t, T_k\right) - y\left(c_k, t, T_k; \widehat{\Theta}_t\right) \right|, \tag{7}$$

[15]Some authors use more standard durations. E.g., Hu et al. (2013) use the Macaulay duration in estimating the curve.

[16]As a final note, unlike for the nominal curve fit case in GMP, we do not place any restrictions on the four parameters in estimation, due to two reasons: (1) a lower number of parameters to estimate for the OAT€i securities relative to the number of parameters used in curve fit for the nominal OAT securities: there are four parameters in the NS setting whereas we had 6 Svensson parameters in the case of nominal OATs; (2) a lower number of OAT€i securities relative to the number of nominal OATs. We experimented with placing constraints on the parameters and did not find any meaningful differences in statistical fit and economic interpretation relative to when we did not constrain the parameters.

where $N_t(\tau)$ is the number of bonds within a particular maturity bin τ; $y^o(c_k, t, T_k)$ and $y\left(c_k, t, T_k; \widehat{\Theta}_t\right)$ are the observed and fitted yield-to-maturity of the bond k, respectively. MAE_t represents the mean absolute error across all securities and all maturities on a particular day. Appendix A presents further details on curve fitting of OAT€i and OATi markets, discusses the quality of fit in respective markets and over our sample period, and shows the fit of OAT securities on specific days.

3.3 Estimated inflation-indexed yield curves

Table 2 reports the summary statistics of the estimated OAT€i and OATi zero-coupon yields and instantaneous forward rates at 2-, 5-, 7-, 10-, 20-, and 30-year maturities, in respective samples: November 17, 2004 to February 21, 2023 for the OAT€i sample and June 15, 2004 to February 21, 2023 for the OATi sample. In the OAT€i sample, average yields were below 1 percent, with some notable variation around those mean values. Shorter-term yields were positively skewed while longer-term yields were, in general, negatively skewed. The AR(1) coefficient is close to one, indicating a high degree of persistence in yields, at all horizons. Average yields in the OATi sample have been also below one percent in our sample, with similar standard deviation, skewness, and persistence parameters similar to the OAT€i sample. However, on average, the OATi yields were notably higher than OAT€i yields: The average OATi yields ranged from negative 37 basis points to positive 98 basis points at 2- and 30-year maturities, respectively, while average OAT€i yields have ranged between negative 68 basis points and positive 84 basis points at 2- and 30-year maturities, respectively.

Figure 3 shows time series of estimated 2-, 5-, 10-, and 30-year zero-coupon inflation-adjusted yields in the OAT€i securities.[17] According to these charts, real rates have been declining since the end of the GFC, amid notable variation in rates. At the end of the sample that includes the COVID-19 pandemic and aggressive easing policies implemented by central banks around the world, the real rates hit rock bottom at around negative 4, negative 3, negative 2, and negative 1

[17]Similar plots could be shown for the OATi market, which we omitted for space constraints.

percentage points for 2-, 5-, 10-, and 30-year maturities, respectively.

Figure 4 shows the real instantaneous forward and zero-coupon yield curves on the left hand-side and inflation compensation rates on the right-hand side on three different dates: November 28, 2007, July 27, 2016, and March 17, 2022. These graphs illustrate that the two typesof curves have had different shapes over our sample period. Most often the real forward and zero-coupon yield curves are upward sloping. Interestingly, forward inflation compensation term structures ranged from inverted upward-sloping in 2007 to upward-sloping in 2016 and then to downward-sloping in 2022, likely representing different inflation expectations regimes. For example, the downward-sloping yield curve in 2022 likely reflects the fact that the short-term expected inflation was significantly above the ECB target of 2 percent but that market participants expected inflation to gradually fall back to the target.

Our results are consistent with Ermolov (2017) who documented the unconditional upward-sloping real term structure that prevailed in several countries in the world including France, are in contrast to Ang et al. (2007) who documented the nearly flat real term structure of interest rates in the U.S.[18] In the OAT€i the inflation-indexed yields range from negative 67 basis points to negative 14 basis points to 35 basis points to 84 basis points at the 2-, 5-, 10-, and 30-year horizons, in the OAT€i market. In the OATi market, the inflation-indexed yields from negative 37 to negative 8 basis points to 38 basis points to 98 basis points at the 2-, 5-, 10-, and 30-year horizons. Bekaert and Ermolov (2023) estimate the 5-year inflation-indexed yield to be, on average, 11 basis points in their 2004 - 2019 sample. It is not clear whether the authors used OAT€i or OATi markets, or both, so our results do not appear directly comparable. However, the difference between our results and the latter study could potentially be due to our more extended sample period that includes the COVID-19 period when interest rates declined to zero-lower bound in 2020-2021 caused by the aggressive easing policies at the beginning of the COVID-19 period.

[18]The latter authors did not use the TIPS market yet in their results as this market was at the very onset during the time of their study.

3.4 Market-implied inflation expectations

Inflation compensation is defined as the difference between nominal and inflation-indexed yields of comparable maturities:

$$IC_{t,n} = y_{t,n}^{\text{nom}} - y_{t,n}^{\text{IL}}. \tag{8}$$

Figure 5 shows the time series of five-year inflation compensation along with five-year zero-coupon nominal and real rates, in the OAT€i market. Between 2004 and 2008, five-year average inflation compensation hovered around 2 percent, roughly consistent with the ECB objective. From 2012 until 2020, inflation compensation declined, on net, and reached its lowest point in early 2020, around the onset of the COVID-19 pandemic. From 2020 until the end of our sample in February 2023, five-year inflation compensation has surged swiftly to levels of around 3 percent — well above the ECB's inflation target of 2 percent.[19]

The next section investigates whether surprises in macroeconomic data releases impact EA inflation expectations.

4 Response of inflation expectation to macroeconomic news releases

In this section, we analyze stability of EA inflation expectations in light of the inflation target explicitly communicated to the public by the ECB. First, the ECB introduced an inflation targeting rule of below, but close to 2 percent in the medium term (see, e.g., Łyziak and Paloviita, 2016; Paloviita et al., 2017).[20] Subsequently, the ECB revisited this rule and adopted an explicit 2-percent inflation target in 2021.[21] Thus, it is a natural question whether financial market par-

[19]Realized inflation at the peak of the COVID-19 crisis exceeded 6 percent in the EA, yet inflation compensation increased by considerably less, corroborating the ECB's commitment to the inflation target.

[20]Explicit inflation targeting was first introduced in New Zealand in 1990, then in Canada in 1991, followed by the U.K. in 1992. For example, Japan, the U.S., and some other countries have inflation rate target of 2 percent. The Federal Reserve targets 2 percent inflation in the long term, according to the Statement on Longer-Run Goals and Monetary Policy Strategy (see FOMC (2018)).

[21]See the ECB's website at https://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.fr.html.

ticipants understand central bank's commitment to keep prices stable at the 2-percent objective because of the role played by financial markets in the transmission of capital to the real sectors of the economy. To understand to what extent inflation expectations are stable, or, well anchored, we run a series of event studies, the goal of which is to measure the sensitivity of changes in forward measures of inflation compensation, or so-called breakeven inflation rates, to surprises in major macroeconomic announcements in the EA and the U.S. The sample period is from November 2004 to December 2019.

We compute the one-year n-year-ahead forward inflation compensation rate obtained from zero-coupon inflation compensation rates $IC_{t,n}$ as follows:

$$f^{IC}_{n,n+1,t} = \frac{(1 + IC_{t,n+1})^{n+1}}{(1 + IC_{t,n})^{n}}. \tag{9}$$

We then regress one-day changes in one-year forward inflation compensation rates $f^{IC}_{n,n+1,t}$ on the set of either EA or U.S. standardized macroeconomic surprises and monetary policy shocks on the release days of the macroeconomic data:

$$f^{IC}_{n-1,n,t} - f^{IC}_{n-1,n,t-1} = \alpha + \beta S_t + \epsilon_t, \tag{10}$$

where S_t is a standardized surprise measure, computed as the standardized difference between the released and expected values of a macroeconomic variable X, following methodology of Beechey et al. (2011). Median forecasts of professional analysts serve as an empirical proxy for the expected value of the macroeconomic variable of interest. Formally, $S_t = \frac{\widehat{X}_t - \mathbf{med}^{\mathbb{P}}_{t-\Delta t}[X_t]}{\sigma_S}$, with $\hat{X}_t$ the actual released value of news X_t, $\mathbf{med}^{\mathbb{P}}_{t-\Delta t}[X_t]$ the median forecast at time $(t - \Delta)$ of the news disclosed at time t, $\mathbb{P}$ the real measure, and σ_S the standard deviation of $\widehat{X}_t - \mathbf{E}^{\mathbb{P}}_{t-\Delta t}[X_t]$. In this section we report our results based only on the OAT€i forward inflation compensation and ILS forward inflation rates.

For the EA, France, and Germany macroeconomic announcements, we use the gross domestic product (GDP), consumer price index (EA HICP or domestic CPI), and producer price index

(EA or domestic PPI) announcements. We collected macroeconomic announcements and median forecast data from Bloomberg L.P. The median forecast data is obtained from the Bloomberg survey of analysts, which is based on a selection of professional economists who submit their forecasts to Bloomberg on Friday before the data release. The forecast values are median forecasts come from the Money Market Services (MMS) conducted by the Action Economics survey.

In addition, we include in our regressions the monetary policy (MP) surprises. For the EA, we use the MP surprises from the Altavilla et al. (2019) database, based on the one-month overnight index swap (OIS) rates. For the U.S. macroeconomic announcements, we use the purchasing managers index (PMI), the nonfarm payroll report (NFP), the unemployment rate, initial jobless claims (IJC), GDP Advance, retail sales, consumer price index excluding food and energy components (Core CPI), personal consumption expenditures (PCE).[22] For the U.S. MP shocks, we use the monetary policy shocks by Bauer and Swanson (2023), which are orthogonalized shocks with respect to major U.S. macroeconomic series. Bauer and Swanson (2023) find that this procedure helps eliminate any attenuation bias and, consequently, such shocks provide better estimates of monetary policy's effects on macroeconomic variables. Table 3 summarizes information about the set of the macroeconomic announcements for which we computed the surprises and which we use in estimating the effect of these macro surprises on the forward inflation compensation rates.

The results reported in the next two subsections, for EA and U.S. macroeconomic surprises, respectively, are based on the sample that excludes COVID from November 2004 (start of the OAT€i inflation compensation rates) until December 2019 (the last full month of data before the breakout of the COVID-19 pandemic). The COVID period was a special period marked by very unusual values of several macroeconomic indicators, well outside of the range suggested by the historical distribution of those values, by unconventional monetary policies very different from a "normal" monetary policy regime in response to the COVID-19 pandemic, and by disruptions in

[22] We investigated the sensitivity of inflation compensation to several other macroeconomic news releases, such as factory orders, durable goods orders,hourly earnings, industrial production, new homes built, CPI, Michigan Consumer Sentiment Index, and Consumer Confidence Index. We did not find sensitivity of inflation compensation to these news releases and, therefore, we do not report results related to these macroeconomic announcements' for space constraints. The results are available upon request.

the financial markets functioning, in general, and, OAT markets, in particular. These factors, considered together, could potentially lead to very different results and conclusions relative to pre-pandemic period. Appendix B reports the results with the COVID-19 pandemic included in our event study analysis.

4.1 EA macroeconomic announcements

Table 4 reports ordinary least squares (OLS) regression (10) results for OAT€i forward inflation compensation rates, for the one-year forward rates, three-year- to nine-year-ahead.[23] Panels A, B, and C report estimated regression coefficients and standard errors for the EA, French, and German surprises in macroeconomic releases of the CPI (HICP in the case of the EA), PPI, and GDP, as well the ECB MP shock, based on the one-month OIS rate, computed in Altavilla et al. (2019) and provided by the ECB.[24] Overall, we find a mild response in forward breakeven rates to macroeconomic news. According to Panel A, OAT€i breakeven rates are fairly mute both to the EA macroeconomic news and MP surprises, across the entire term structure of forward rates. While this result might be welcome news, it is worth noting that it could be driven by the fact that aggregated EA indicators are released after the country-specific indicators are released and therefore, most of the information is already known to financial market participants. In particular, the EA HICP is released after the country-specific CPIs are released. It is released on the third Wednesday of the month, and country-specific CPIs are released around mid-month. Far-forward breakeven rates are not affected by the major macroeconomic announcements and do not appear to respond to MP shocks. An MP shock is not significant at any horizon, and the magnitude of the MP coefficient (between -0.04 to -0.19) is broadly consistent with previous literature (See, e.g., Gürkaynak et al., 2010; Beechey et al., 2011). We next look at the effect of the French and

[23]We did not report the results for the relatively short-horizon forward rates (one-year one- and two-year ahead forward rates) because these rates are known to be affected by a number of technical issues — e.g., indexation effect etc. — that may hinder the fitting performance of the Nelson-Siegel methodology especially when only longer-term securities are available for a fitting procedure.

[24]See `https://www.ecb.europa.eu/pub/pdf/annex/Dataset_EA-MPD.xlsx` for the ECB MP shocks database. The shocks are based on the OIS rates movements in the monetary policy event window, for which the MP shock computed as the change in the median quote from the window 13:25-13:35 before the press release of the Governing Council Statement to the median quote in the window 15:40-15:50 after the press conference by the ECB president.

German macroeconomic news on the OAT€i forward inflation compensation, shown in Panels B and C, respectively.

According to Panel B, the OAT€i forward breakeven rates appear to be reacting to surprises in the French PPI releases at six to nine-year horizons, the corresponding regression coefficients are significant at the 5 percent level. In addition, the one-year eight-year ahead breakeven rate is mildly sensitive to the French GDP release, at the 10 percent level. Yet, the effect seems to be economically contained: One-standard-deviation positive shock results in a less than 1 basis point response at those horizons. Looking at the results on the macroeconomic releases in Germany, reported in Panel C, we find that one-year forward breakeven rates across medium to long-term horizons (from five to nine years ahead) strongly react to the release of the German CPI (coefficients are significant at 5 to 1 percent levels), yet with a relatively small economic effect; One-standard-deviation positive shock results in approximately only half a basis point increase. However, neither German GDP nor PPI are significant, in contrast with the results in Panel B.

Table 5 reports the sensitivity of the ILS forward rates, at the same horizons of those reported in Table 4. With respect to macro news, the results are broadly similar to those based on the OAT€i market. The EA surprises do not appear to affect the ILS forward rates, but the French PPI and German CPI do, at the medium and long horizons, with some solid statistical significance, yet mild economic significance. With respect to the MP shocks, the response in the ILS one-year forward rates is significant at the 1 percent level with respect to the MP shocks in the near to mid-term horizons, up to six years ahead. Yet, at longer horizons, the response in the ILS forward rates is not significant. Thus, the two markets, OAT€i and ILS, despite their potential liquidity differences, suggest that OAT forward inflation compensation rates appear to be somewhat affected by the incoming macroeconomic news, especially those related to inflation, at longer horizons, while ILS forward rates appear to be affected by the MP shocks at the near- to mid-term horizons. Yet, the ultimate response of those forward rates is not very large economically.

4.2 U.S. macroeconomic announcements

Table 6 reports regression (10) results for OAT€i forward inflation compensation regarding the U.S. macro news. In general, the OAT€i breakeven rates appear to be relatively mute to them, with the exception of the GDP advance news, to which the forward breakeven rates respond strongly, at the 1 percent significance level. One-standard-deviation positive shock in the GDP advance release results in about a 2.5 basis point increase in the forward rates, a relatively mild response. In addition, we find some small responses in one-year-forward rates four- and five-years ahead to news in the IJC, a broad measure of labor market conditions, released weekly.[25] Lastly, the NFP news (which is the so-called king of the news in the U.S., is an indicator of overall labor market conditions, and is released the first Friday of the month at 8:30 a.m. Eastern Time) affects the OAT€i forward inflation compensation rates at the five-year horizon: one-standard deviation shock results in about a 6 basis point increase in these rates. Finally, we use the MP shocks constructed by Bauer and Swanson (2023), in our event study. These shocks are the orthogonalized shocks with respect to macroeconomic variables.[26] We find that the response of OAT€i forward inflation compensation is relatively mute to these shocks.

Table 7 reports the results of the EA ILS forward rates and broadly confirms the results of table 6. On balance, the far-ahead forward ILS rates appear to be relatively mute to the U.S. news in the 2004 - 2019 sample.

The lack of response of OAT€i forward inflation compensation and ILS forward rates is consistent with earlier findings in the literature. Beechey et al. (2011), Grishchenko et al. (2019), and Moessner and Takáts (2020) find that EA inflation expectations are relatively well anchored, apparently due to the ECB's emphasis on the price stability goal with the relatively well defined definition of the medium-term inflation target. Other reasons may explain this result as well.

[25]The IJC measure provides a more frequent picture of the labor conditions and thus could provide advance insights of the labor conditions than that of the unemployment statistics released monthly with the nonfarm payrolls report.

[26]The shocks are computed as the residuals from regressing the standard Gürkaynak et al. (2005) shocks on some macro and financial variables. The shocks are available at the Federal Reserve Bank of San Francisco at https://www.frbsf.org/research-and-insights/data-and-indicators/monetary-policy-surprises/. For more details, see Bauer and Swanson (2023).

First, we carry our estimation with daily data, so the news that arrive from the U.S. after the trading hours in Europe may affect identification of the response of the OAT€i forward breakeven rates. Second, OAT inflation-indexed markets are likely to be affected by some technical factors, such as liquidity premiums in them, which, of course, could be a broader issue and applies to the interpretation of our results.[27]

Overall, the results in tables 4 to 7 suggest that EA inflation expectation, measured either by the OAT€i forward inflation compensation or by the ILS forward rates, is reasonably well anchored in the November 2004 - December 2019 sample. Appendix B reports sensitivity results in the sample, from November 2004 to February 2023, which includes the COVID-19 period in its later part. We find a bit higher sensitivity of forward breakeven rates and ILS rates to the incoming news when the COVID period is included. See Appendix B for more details.

5 Conclusion

We study the evolution of the relatively recent French OAT inflation-indexed markets and their implied inflation-indexed yields. Our contribution to the literature of international sovereign bonds is two-fold. First, we have constructed inflation-indexed yield curves using the Nelson and Siegel (1987) model implied by OAT€i and OATi markets and documented several empirical facts about these markets. Interestingly, the average level of the OAT€i yields is about 5 basis points lower than the one implied by the OATi yields in the middle of the yield curve and about 15 basis points for longer-term maturities, potentially indicating that the OAT€i securities are more liquid relative to their domestic counterparts. Notably, we observe that, for the most of our sample period, outside of perhaps the COVID-19 episode, real yields have been declining since around 2010 and hoovered in the negative territory. A related open question is whether this somewhat prolonged period of negative real interest rates reflects expectations of future high inflation and therefore market participants demand OAT inflation-protected bonds, or it reflects growth to flight-to-safety concerns in the EA.

[27] We leave liquidity considerations for future research.

Second, we analyzed a response of OAT forward inflation compensation measures and ILS forward inflation rates to major incoming news in the EA and U.S. via series of event studies. We found some mild response of inflation expectation measures to these news. On balance, however, EA inflation expectations appear to be well anchored, in our sample.

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Table 1: **Summary of OAT€i and OATi securities**

N	ISIN	Issue Date	Coupon	Maturity	Term	Obs
Panel A: OAT€ i securities						
1	FR0000188013	10/31/2001	3.00	07/25/2012	10.73	2793
2	FR0000188799	10/31/2002	3.15	07/25/2032	29.73	5295
3	FR0010050559	01/22/2004	2.25	07/25/2020	16.51	4310
4	FR0010135525	11/23/2004	1.60	07/25/2015	10.67	2787
5	FR0108664055	10/04/2006	1.25	07/25/2010	3.81	1111
6	FR0010447367	03/14/2007	1.80	07/25/2040	33.37	4159
7	FR0010899765	05/25/2010	1.10	07/25/2022	12.17	3178
8	FR0011008705	02/16/2011	1.85	07/25/2027	16.44	3138
9	FR0011237643	07/25/2011	0.25	07/25/2018	7.00	1636
10	FR0011427848	02/26/2013	0.25	07/25/2024	11.41	2611
11	FR0011982776	06/18/2014	0.70	07/25/2030	16.10	2268
12	FR0013140035	03/21/2016	0.10	03/01/2021	4.94	1293
13	FR0013209871	10/05/2016	0.10	07/25/2047	30.80	1668
14	FR0013327491	04/06/2018	0.10	07/25/2036	18.30	1278
15	FR0013410552	03/25/2019	0.10	03/01/2029	9.94	1022
16	FR0013519253	06/22/2020	0.10	03/01/2026	5.69	697
17	FR0014001N38	01/25/2021	0.10	07/25/2031	10.49	542
18	FR0014008181	02/01/2022	0.10	07/25/2053	31.48	276
19	FR001400AQH0	01/06/2022	0.10	25/07/2038	16.15	190
Panel B: OATi securities						
1	FR0000571424	09/29/1998	3.00	07/25/2009	10.82	2736
2	FR0000186413	10/01/1999	3.40	07/25/2029	29.82	5736
3	FR0000188955	02/11/2003	2.50	07/25/2013	10.45	2733
4	FR0010094375	06/22/2004	1.60	07/25/2011	7.09	1854
5	FR0010235176	09/20/2005	1.00	07/25/2017	11.84	3096
6	FR0010585901	02/20/2008	2.10	07/25/2023	15.43	3715
7	FR0010850032	01/26/2010	1.30	07/25/2019	9.49	2479
8	FR0119105791	01/25/2011	0.45	07/25/2016	5.50	1436
9	FR0011347046	10/23/2012	0.10	07/25/2021	8.75	2287
10	FR0012558310	02/23/2015	0.10	03/01/2025	10.02	2090
11	FR0013238268	02/20/2017	0.10	03/01/2028	11.03	1571
12	FR0013524014	07/15/2020	0.10	03/01/2036	15.63	684
13	FR0014003N51	05/24/2021	0.10	03/01/2032	10.77	460

Notes: Panel A of the table reports descriptive characteristics of Obligation Assimilables du Trésor (OAT)€i securities whose cashflows indexed to the Harmonized Index of Consumer Prices, issued between October 31, 2001, and February 22, 2023. Panel B reports the same information for OATi securities whose cashflows are indexed to the French Consumer Price Index, issued between September 29, 1998, and February 22, 2023. *Source:* Agence France Trésor and Bloomberg.

Table 2: Summary statistics of OAT€i and OATi fitted yields

	2yr	5yr	7yr	10yr	20yr	30yr
Panel A: Zero-coupon rates for OAT€i sample						
Mean	-0.6785	-0.1421	0.1069	0.3491	0.7071	0.8426
Max	2.6496	2.7301	2.8592	2.9259	2.9064	2.9330
Min	-4.4121	-3.2383	-2.8177	-2.3300	-1.4617	-1.1589
Std. Dev.	1.3445	1.2290	1.2154	1.1855	1.0956	1.0417
Skewness	0.5063	0.2666	0.1183	-0.0141	-0.1474	-0.1439
Kurtosis	-0.0058	-0.9724	-1.2014	-1.2935	-1.3178	-1.3610
AR(1) coeff	0.9965	0.9992	0.9993	0.9993	0.9992	0.9990
Panel B: Forward rates for OAT€i sample						
Mean	-0.4075	0.6055	0.8272	0.9800	1.1060	1.1155
Max	3.5209	3.1794	3.1613	2.9882	3.4323	3.7962
Min	-3.4269	-2.0900	-1.6632	-1.3730	-0.8347	-0.5912
Std. Dev.	1.3971	1.3045	1.2183	1.1186	0.9667	0.9299
Skewness	0.4385	-0.1312	-0.2896	-0.3621	-0.2104	-0.0735
Kurtosis	-0.8725	-1.4689	-1.3257	-1.1956	-1.3071	-1.4787
AR(1) coeff	0.9868	0.9990	0.9991	0.9989	0.9983	0.9963
Panel C: Zero-coupon rates for OATi sample						
Mean	-0.3699	-0.0789	0.1440	0.3828	0.7841	0.9841
Max	3.0858	2.6491	2.7402	2.8108	2.8934	3.4014
Min	-4.1714	-2.9331	-2.3990	-1.8437	-1.3322	-1.0657
Std. Dev.	1.3336	1.1953	1.1765	1.1625	1.1014	1.0447
Skewness	0.3886	0.4155	0.2489	0.0777	-0.0808	-0.1031
Kurtosis	-0.2650	-0.9407	-1.2040	-1.3399	-1.4142	-1.3689
AR(1) coeff	0.9984	0.9992	0.9993	0.9993	0.9990	0.9976
Panel D: Forward rates for OATi sample						
Mean	-0.4486	0.5450	0.8254	1.0296	1.2993	1.4632
Max	3.4257	2.9561	2.9739	2.9759	4.1568	7.2404
Min	-3.2809	-1.8547	-1.6787	-1.2596	-1.0975	-0.8638
Std. Dev.	1.3105	1.2239	1.2227	1.1676	1.0180	1.1488
Skewness	0.5210	-0.0564	-0.2374	-0.3037	-0.1811	0.4751
Kurtosis	-0.4125	-1.4266	-1.3355	-1.2737	-1.1663	0.9322
AR(1) coeff	0.9930	0.9989	0.9991	0.9990	0.9948	0.9868

Notes: Panels A and B report summary statistics of the fitted Obligation Assimilables du Trésor (OAT)€i zero-coupon yields and instantaneous forward rates, respectively. Panels C and D report summary statistics of the fitted OATi zero-coupon yields and instantaneous forward rates, respectively. All statistics are reported in the annualized percent. The OAT€i sample is from November 17, 2004, to February 21, 2023. The OATi sample is from June 15, 2004, to February 21, 2023. The frequency is daily. The yield curves are fitted following Nelson and Siegel (1987) methodology.
Source: Bloomberg and authors' calculations.

Table 3: Macroeconomic announcements

Data release	Source	Frequency	Units
Panel A: Eurozone			
GDP	Eurostat	Quarterly	Percent change YoY
HICP	Eurostat	Monthly	Percent change YoY
PPI	Eurostat	Monthly	Percent change YoY
MP Shock	Altavilla et al. (2019)	ECB MP meetings	Basis point
Panel B: France			
GDP	INSEE	Quarterly	Percent change YoY
CPI	INSEE	Monthly	Percent change YoY
PPI	INSEE	Monthly	Percent change YoY
MP Shock	Altavilla et al. (2019)	ECB MP meetings	Basis point
Panel C: Germany			
GDP	DeStatis	Quarterly	Percent change YoY
CPI	DeStatis	Monthly	Percent change YoY
PPI	DeStatis	Monthly	Percent change YoY
MP Shock	Altavilla et al. (2019)	ECB MP meetings	Basis point
Panel D: United States			
PMI	Institute for Supply Management	Monthly	Index
Nonfarm Payrolls	Bureau of Labor Statistics	Monthly	Thousands
Unemployment	Bureau of Labor Statistics	Monthly	Percent YoY
Initial Jobless Claims	U.S. Department of Labor	Weekly	Thousands
Core CPI	Bureau of Labor Statistics	Monthly	Percent change MoM
PCE	Bureau of Labor Statistics	Monthly	Percent change MoM
FOMC	Federal Reserve Board	8 times per year	Basis points
GDP (advance)	Bureau of Economic Analysis	Quarterly	Percent change QoQ, ar
Retail Sales	Bureau of the Census	Monthly	Percent change MoM
MP Shock	Bauer and Swanson (2023)	FOMC meetings	Basis point

Notes: In this table, for data releases, GDP is gross domestic product; HICP is Harmonized Index of Consumer Prices; PPI is producer price index; CPI is consumer price index; PMI is purchasing managers index; PCE is personal consumption expenditures; ECB is European Central Bank; FOMC is Federal Open Market Committee MP is monetary policy; for sources: INSEE is French National Institute for Statistics and Economic Studies; DeStatis is Federal Statistical Office of Germany; and for units: MoM is month-over-month, QoQ is quarter-over-quarter, ar is annualized rate.

Table 4: Euro-area OAT inflation compensation and euro-area macroeconomic news, 2004-2019

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
Panel: EU News							
GDP EA	4.63*	2.22	0.50	-0.78	-0.96	-1.05	-0.87
	(2.50)	(1.51)	(1.23)	(1.14)	(1.12)	(1.09)	(1.09)
HICP EA	0.40	-0.05	-0.12	-0.24	-0.21	-0.21	-0.24
	(0.61)	(0.37)	(0.30)	(0.28)	(0.27)	(0.27)	(0.27)
PPI EA	-1.11	-0.82	-0.52	-0.28	-0.07	-0.11	-0.01
	(1.30)	(0.78)	(0.64)	(0.60)	(0.58)	(0.57)	(0.57)
MP shock	-0.19	-0.14	-0.08	-0.04	-0.10	-0.05	-0.14
	(0.28)	(0.17)	(0.14)	(0.13)	(0.12)	(0.12)	(0.12)
Panel: FR News							
GDP FR	3.58	1.02	-0.59	-1.89	-1.90	-2.07*	-2.02
	(2.42)	(1.59)	(1.29)	(1.22)	(1.25)	(1.22)	(1.23)
CPI FR	-0.71	-0.35	0.03	0.12	0.31	0.39	0.41
	(0.56)	(0.37)	(0.30)	(0.28)	(0.29)	(0.28)	(0.28)
PPI FR	0.13	0.43	0.48	0.70**	0.70**	0.88***	0.76**
	(0.70)	(0.46)	(0.37)	(0.35)	(0.36)	(0.35)	(0.35)
MP shock	-0.19	-0.13	-0.07	-0.02	-0.09	-0.04	-0.13
	(0.25)	(0.17)	(0.14)	(0.13)	(0.13)	(0.13)	(0.13)
Panel: DE News							
GDP DE	0.53	0.19	-0.25	-0.39	-0.56	-0.51	-0.30
	(1.42)	(0.83)	(0.57)	(0.50)	(0.51)	(0.51)	(0.51)
CPI DE	0.42	0.49	0.50**	0.50***	0.54***	0.57***	0.53***
	(0.63)	(0.37)	(0.25)	(0.22)	(0.23)	(0.22)	(0.23)
PPI DE	0.38	0.07	0.49	0.60	0.84	0.92	0.58
	(2.24)	(1.31)	(0.90)	(0.79)	(0.80)	(0.80)	(0.81)
MP shock	-0.18	-0.14	-0.08	-0.04	-0.10	-0.05	-0.14
	(0.33)	(0.20)	(0.13)	(0.12)	(0.12)	(0.12)	(0.12)

Notes: This table reports the sensitivity results of one-year Obligations Assimilables du Trésor euro-area (EA) Harmonized Index of Consumer Prices (HICP)-linked (OAT€i) forward inflation compensation rates three- to nine-year-ahead to surprises in the macroeconomic announcements in the EA, France (FR), and Germany (DE). GDP is gross domestic product; CPI is consumer price index; PPI is producers price index; MP shock is monetary policy shock. The MP shock is the Altavilla et al. (2019) monetary policy shock based on the one-month overnight index swap rate. Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP shocks are in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The ordinary least squares standard errors are reported in parentheses. The *, **, and *** denote the 10-, 5-, and 1-percent significance levels, respectively. The sample period is from November 2004, to December 2019.
Source: Bloomberg, Eurostat, French National Institute of Statistics and Economic Studies, German Federal Statistical Office, European Central Bank, and authors' calculations.

Table 5: Euro-area inflation swap rates and euro-area macroeconomic news, 2004-2019

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
Panel: EU News							
GDP EA	1.21	1.95	4.83	1.19	2.63	-4.61	-5.85
	(2.14)	(2.34)	(2.73)	(2.84)	(2.59)	(2.81)	(3.79)
HICP EA	-0.06	0.22	-0.57	0.16	0.39	0.76	-0.65
	(0.52)	(0.58)	(0.68)	(0.70)	(0.63)	(0.69)	(0.93)
PPI EA	1.16	-2.39**	0.04	-1.47	1.00	-0.08	-0.91
	(1.11)	(1.22)	(1.42)	(1.48)	(1.36)	(1.47)	(1.97)
MP shock	-0.68***	0.77***	-0.82***	0.97***	0.32	-0.23	0.16
	(0.24)	(0.26)	(0.31)	(0.32)	(0.29)	(0.32)	(0.42)
Panel: FR News							
GDP FR	1.62	0.71	5.38	-4.62	4.94	4.50*	-4.35
	(2.18)	(2.67)	(3.22)	(2.72)	(2.98)	(2.67)	(3.54)
CPI FR	-0.09	0.69	0.47	-1.44***	0.86	1.31**	-1.07
	(0.50)	(0.62)	(0.74)	(0.63)	(0.68)	(0.61)	(0.81)
PPI FR	0.11	0.92	0.46	0.40	-0.73	0.65	-0.70
	(0.63)	(0.77)	(0.93)	(0.78)	(0.86)	(0.77)	(1.02)
MP shock	-0.69***	0.73***	-0.89***	1.06***	0.26	-0.34	0.24
	(0.23)	(0.28)	(0.34)	(0.29)	(0.32)	(0.28)	(0.37)
Panel: DE News							
GDP DE	0.59	0.86	-1.19	1.53	0.78	-1.35	-1.43
	(0.86)	(0.99)	(1.31)	(1.41)	(1.26)	(1.30)	(1.52)
CPI DE	0.71	-0.27	1.76***	-0.90	0.42	0.30	1.10
	(0.38)	(0.44)	(0.58)	(0.63)	(0.56)	(0.58)	(0.68)
PPI DE	1.18	-1.48	0.95	-2.45	6.22***	-6.20***	2.69
	(1.35)	(1.56)	(2.06)	(2.22)	(1.98)	(2.05)	(2.40)
MP shock	-0.67***	0.76***	-0.82***	0.96***	0.33	-0.24	0.16
	(0.20)	(0.23)	(0.31)	(0.33)	(0.30)	(0.31)	(0.36)

Notes: This table reports the sensitivity results of one-year euro-area (EA) Harmonized Index of Consumer Prices (HICP) inflation-linked forward swap rates three- to nine-year-ahead to surprises in the macroeconomic announcements in the EA, France (FR), and Germany (DE). GDP is gross domestic product; CPI is consumer price index, PPI is producers price index; MP shock is monetary policy shock. The MP shock is the Altavilla et al. (2019) monetary policy shock based on the one-month overnight index swap rate. Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP shocks are in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The ordinary least squares standard errors are reported in parentheses. The *, **, and *** denote the 10-, 5-, and 1-percent significance levels, respectively. The sample period is from November 2004, to December 2019.
Source: Bloomberg, Eurostat, French National Institute of Statistics and Economic Studies, German Federal Statistical Office, European Central Bank, and authors' calculations.

Table 6: Euro-area OAT inflation compensation and U.S. macroeconomic news, 2004-2019

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
PMI	-0.05	0.13	0.14	0.08	0.11	0.00	0.06
	(0.63)	(0.37)	(0.28)	(0.27)	(0.28)	(0.28)	(0.28)
NFP	-4.37	2.36	4.54	5.54*	4.52	4.69	3.52
	(6.93)	(4.01)	(3.08)	(2.96)	(3.05)	(3.03)	(3.03)
UNEMP	1.16	0.25	-0.44	-0.57	-0.27	-0.23	0.37
	(2.20)	(1.27)	(0.98)	(0.94)	(0.97)	(0.96)	(0.96)
IJC	-1.48	-1.53*	-1.44**	-1.00	-0.60	-0.73	-0.62
	(1.58)	(0.92)	(0.70)	(0.68)	(0.70)	(0.69)	(0.69)
GDP Advance	1.34	2.07***	2.47***	2.43***	2.63***	2.33***	2.15***
	(1.36)	(0.79)	(0.60)	(0.58)	(0.60)	(0.59)	(0.59)
Retail Sales	0.75	1.25	1.06*	0.93	0.48	0.56	0.26
	(1.38)	(0.80)	(0.61)	(0.59)	(0.61)	(0.60)	(0.60)
Core CPI	0.62	0.04	-0.12	-0.23	-0.10	-0.10	0.01
	(0.80)	(0.46)	(0.36)	(0.34)	(0.35)	(0.35)	(0.35)
PCE	1.95**	0.71	0.11	-0.22	-0.28	-0.31	-0.26
	(0.91)	(0.53)	(0.41)	(0.39)	(0.40)	(0.40)	(0.40)
MP shock	-0.07	-0.13	-0.12	-0.04	-0.01	0.02	0.05
	(0.17)	(0.10)	(0.08)	(0.07)	(0.08)	(0.08)	(0.08)

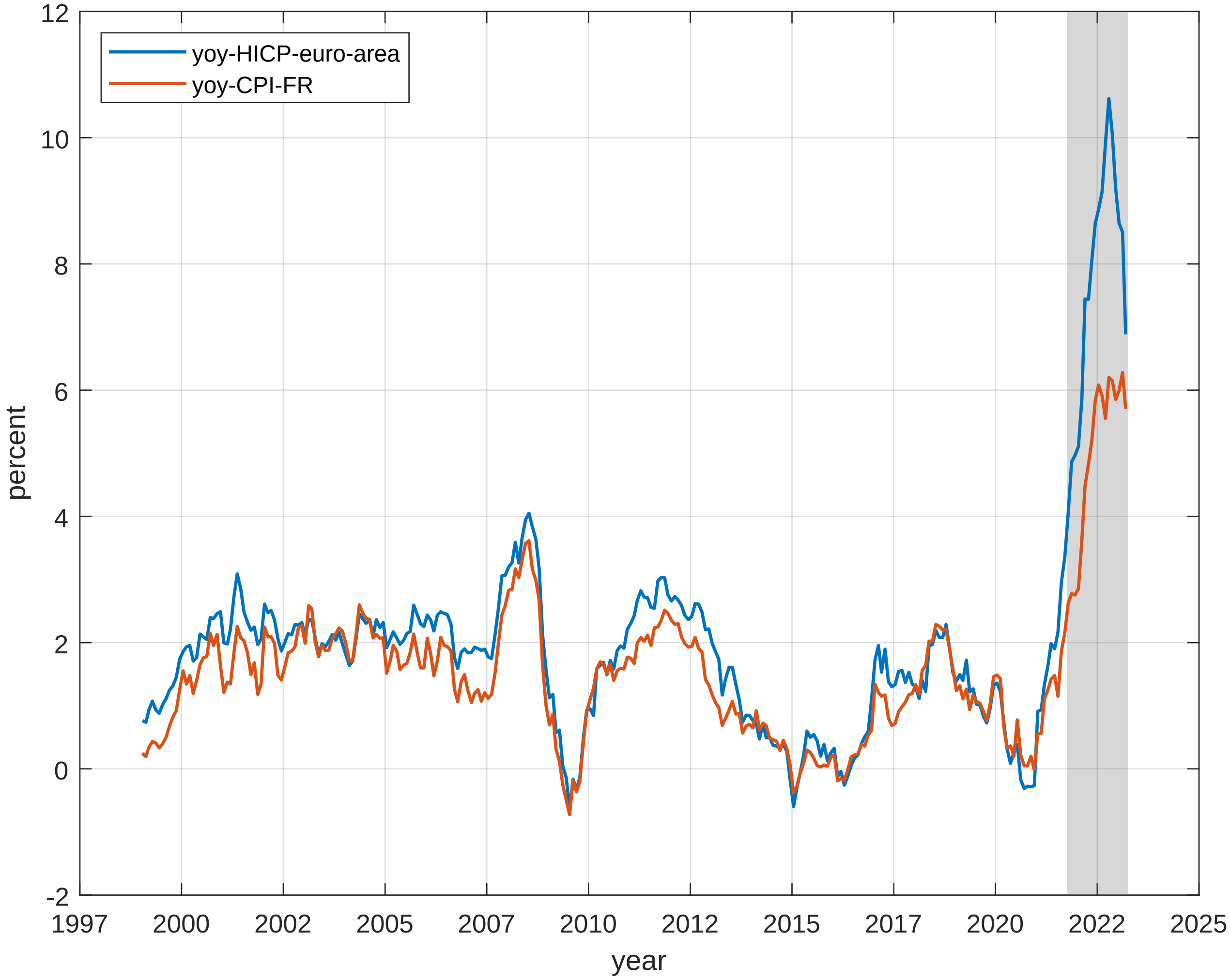
Notes: This table reports the sensitivity results of one-year *Obligations Assimilables du Trésor* euro-area (EA) Harmonized Index of Consumer Prices (HICP)-linked (OAT€i) forward inflation compensation rates three- to nine-year-ahead to surprises in the macroeconomic announcements in the United States. PMI is purchasing managers index; NFP is nonfarm payrolls; UNEMP is unemployment rate; IJC is initial jobless claims; GDP is gross domestic product; CPI is consumer price index; PCE is personal consumption expenditures; MP shock is monetary policy shock. The MP shock is the Federal Reserve monetary policy shock constructed by Bauer and Swanson (2023). Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP shock is in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The sample for OAT€i securities is from June 2004, to February 2023. The ordinary least squares standard errors are reported in parentheses below the estimates. The *, **, and *** denote the 10-, 5-, and 1-percent significance levels, respectively. The ample period is from November 2004 to December 2019. *Source:* Bloomberg, Action Economics, Federal Reserve Bank of San Francisco, and authors' calculations.

Table 7: Euro-area inflation swap rates and U.S. macroeconomic news, 2004-2019

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
PMI	0.82	0.18	0.75	-0.23	0.63	0.32	0.70
	(0.51)	(0.53)	(0.62)	(0.76)	(0.66)	(0.69)	(0.90)
NFP	6.85	-4.12	6.70	6.62	-6.89	0.11	-12.60
	(5.34)	(5.49)	(6.49)	(7.89)	(6.87)	(7.26)	(9.43)
UNEMP	1.89	-3.06*	1.81	0.33	2.23	-0.02	0.61
	(1.78)	(1.83)	(2.17)	(2.64)	(2.33)	(2.46)	(3.13)
IJC	-1.24	-1.18	1.44	-2.21	0.69	-4.63***	-1.59
	(1.27)	(1.31)	(1.55)	(1.88)	(1.63)	(1.72)	(2.23)
GDP Advance	-6.92	0.81	1.60	-3.74***	1.33	5.91***	-4.30**
	(1.08)	(1.11)	(1.32)	(1.60)	(1.38)	(1.52)	(1.98)
Retail Sales	0.96	-0.38	3.27***	-1.27	1.19	-1.36	0.71
	(1.11)	(1.14)	(1.35)	(1.63)	(1.48)	(1.57)	(1.95)
Core CPI	0.50	-0.56	-0.53	2.43***	1.00	-0.22	-1.80
	(0.64)	(0.66)	(0.78)	(0.94)	(0.82)	(0.87)	(1.13)
PCE	-0.56	0.63	0.16	-1.03	1.48	0.85	0.34
	(0.70)	(0.72)	(0.85)	(1.04)	(0.90)	(0.95)	(1.23)
MP shock	0.10	-0.04	0.11	0.36*	0.15	0.13	0.28
	(0.14)	(0.14)	(0.17)	(0.21)	(0.18)	(0.19)	(0.24)

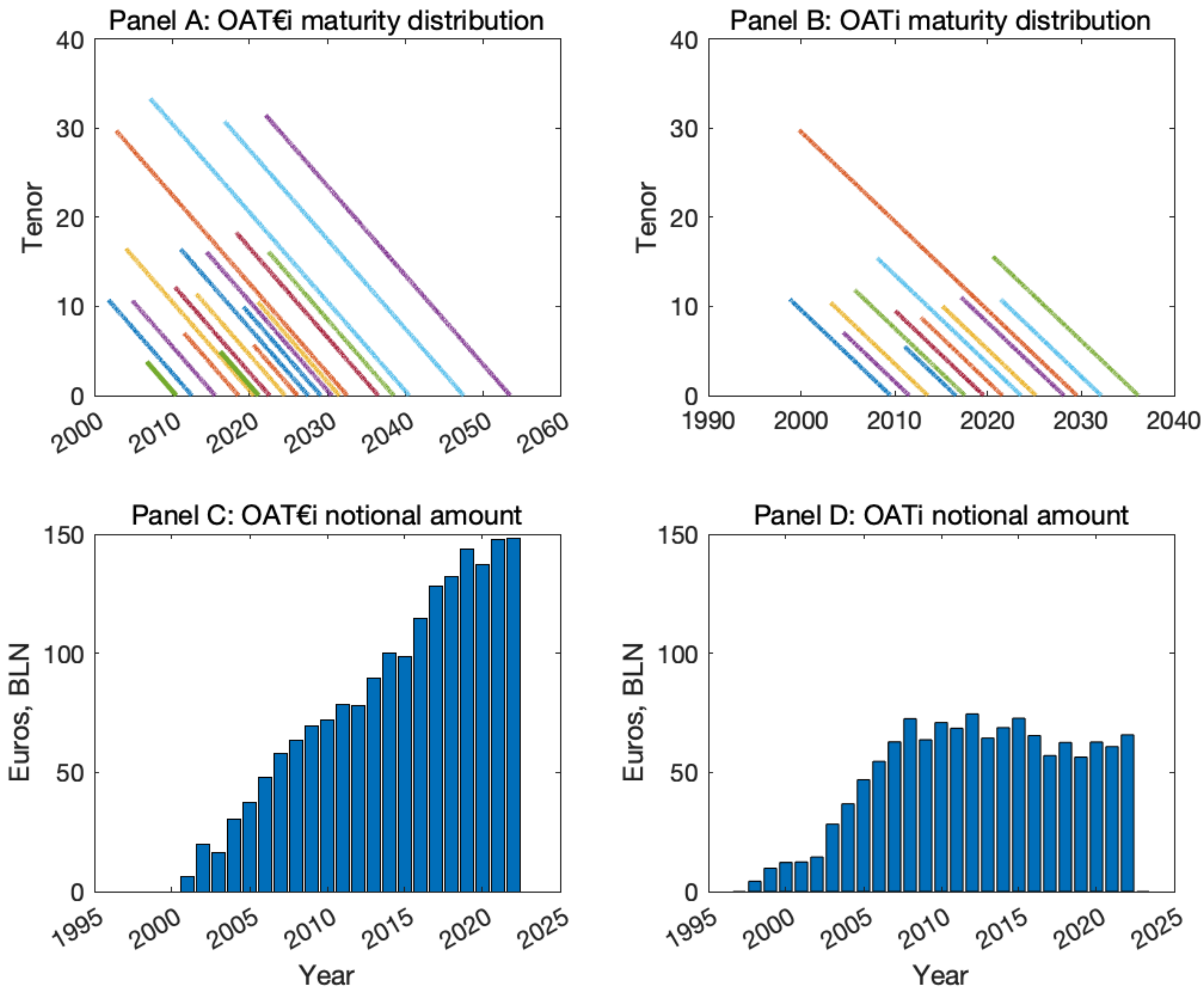
Notes: This table reports the sensitivity results of one-year euro-area (EA) Harmonized Index of Consumer Prices (HICP) inflation-linked forward swap rates three- to nine-year-ahead to surprises in the macroeconomic announcements in the United States. PMI is purchasing managers index; NFP is Nonfarm Payrolls; UNEMP is unemployment rate; IJC is initial jobless claims; GDP is gross domestic product; CPI is consumer price index; PCE is personal consumption expenditures; MP shock is monetary policy shock. The MP shock is the Federal Reserve monetary policy shock constructed by Bauer and Swanson (2023). Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP shock is in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The ordinary least squares standard errors are reported in parentheses below the estimates. The *, **, and *** denote the 10-, 5- and 1-percent significance levels, respectively. The sample period is from November 2004, to December 2019. *Source:* Bloomberg, Action Economics, Federal Reserve Bank of San Francisco, and authors' calculations.

Figure 1: Realized inflation series



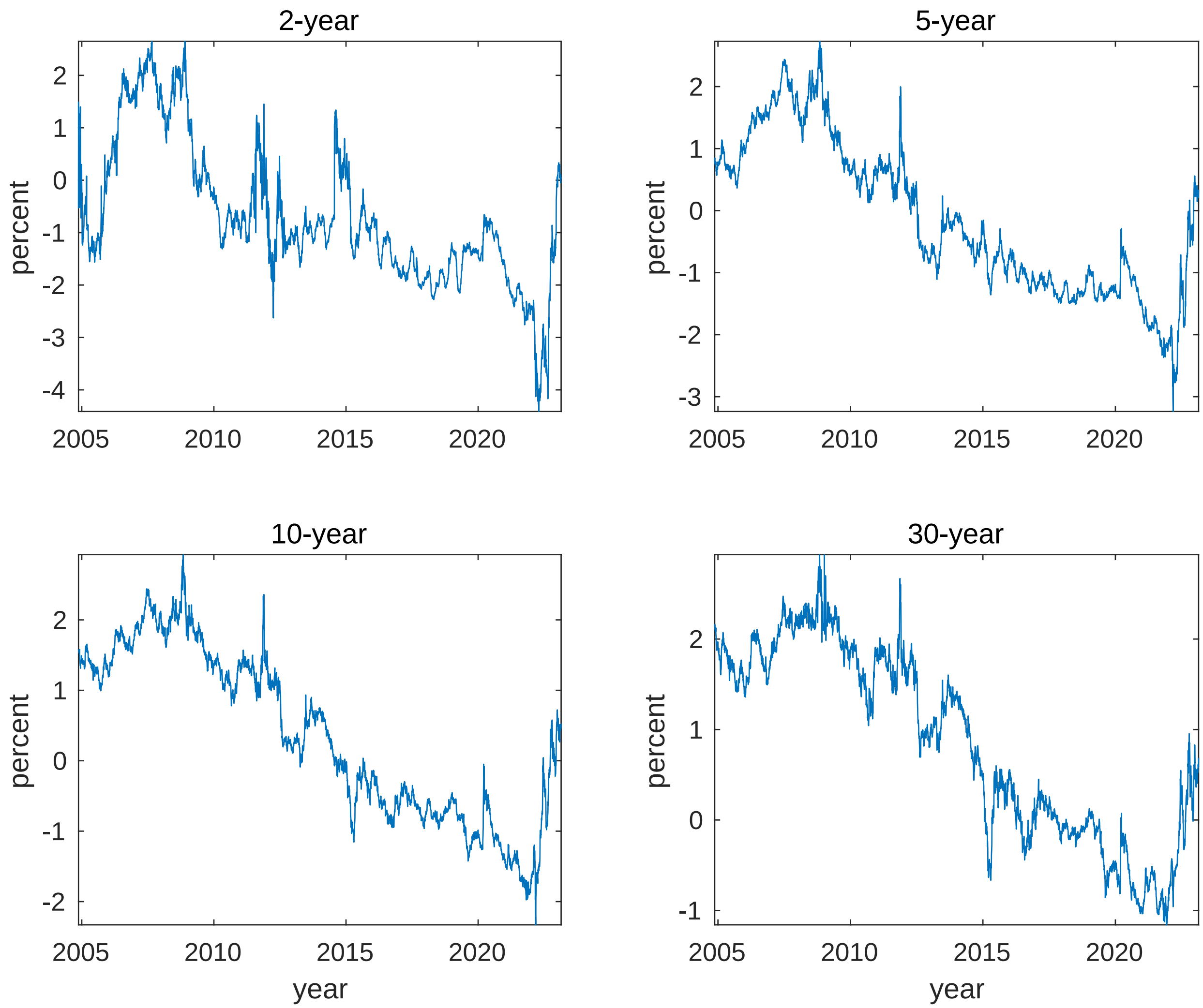
Notes: This figure shows the realized inflation according to the euro-area Harmonized Inflation for Consumer Prices (HICP, blue line) and the French Consumer Price Index (CPI, red line) from January 1999 to March 2023. The shaded area indicates the implementation of the "bouclier tarifaire" regime, from October 2021, to March 2023.
Source: Eurostat.

Figure 2: French sovereign inflation-indexed debt



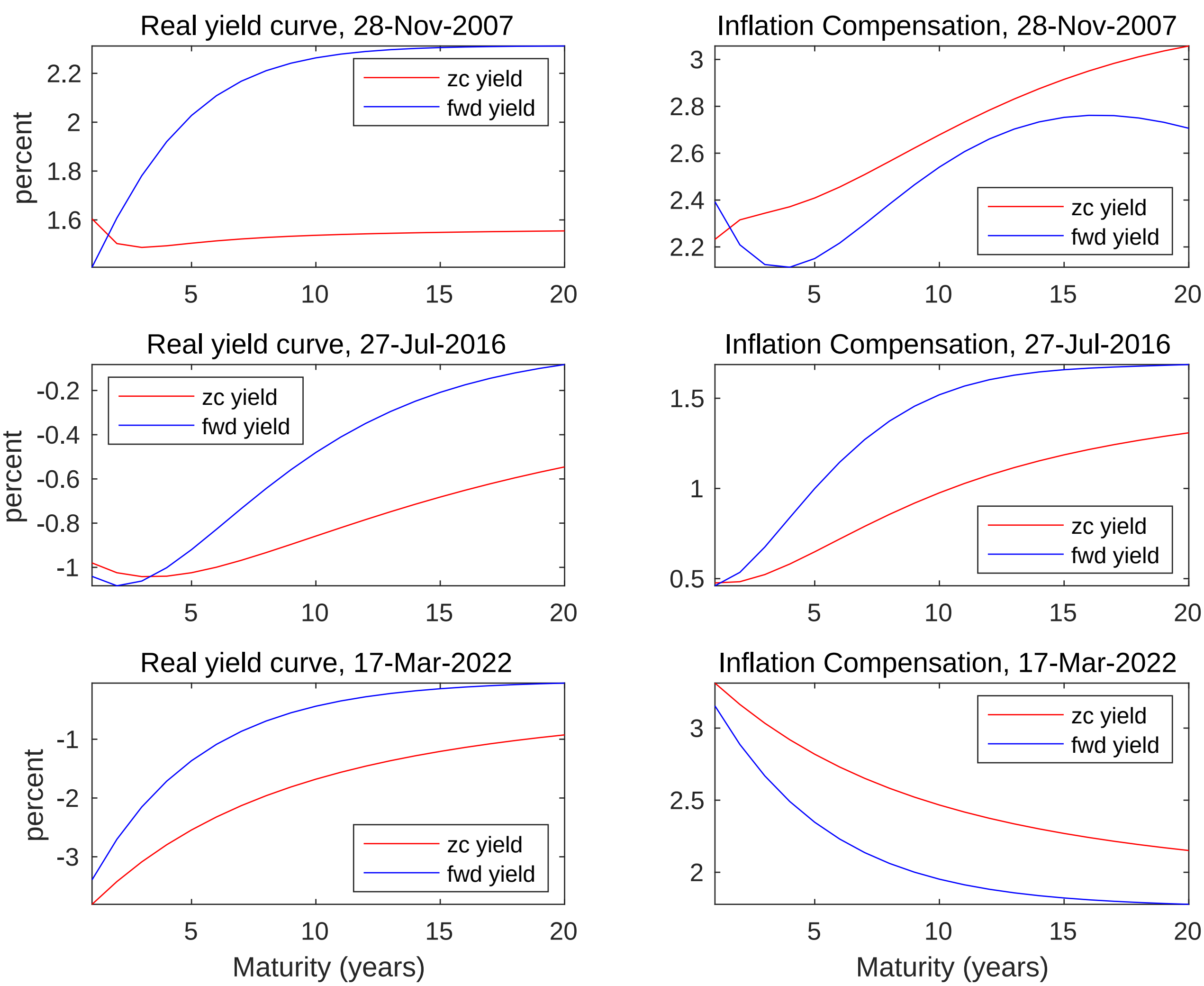
Notes: The top-left and top-right panels of the figure indicate the maturity structure of the OAT€i market and OATi markets,respectively. Each line represents one security. The date is shown on the horizontal axis and the remaining time-to-maturity, measured in years, is shown on the vertical axis. The upper-left and lower-right ends of each line (in the top panels) correspond to the issue date and to the bond expiration date, respectively. The bottom-left and bottom-right panels show the outstanding nominal notional amount of the OAT€i debt issued from October 31, 2001, to February 22, 2023, and the OATi debt issued from September 29, 1998, to February 22, 2023.
Source: Agence France Trésor, Bloomberg.

Figure 3: Time series of zero-coupon OAT€i yields



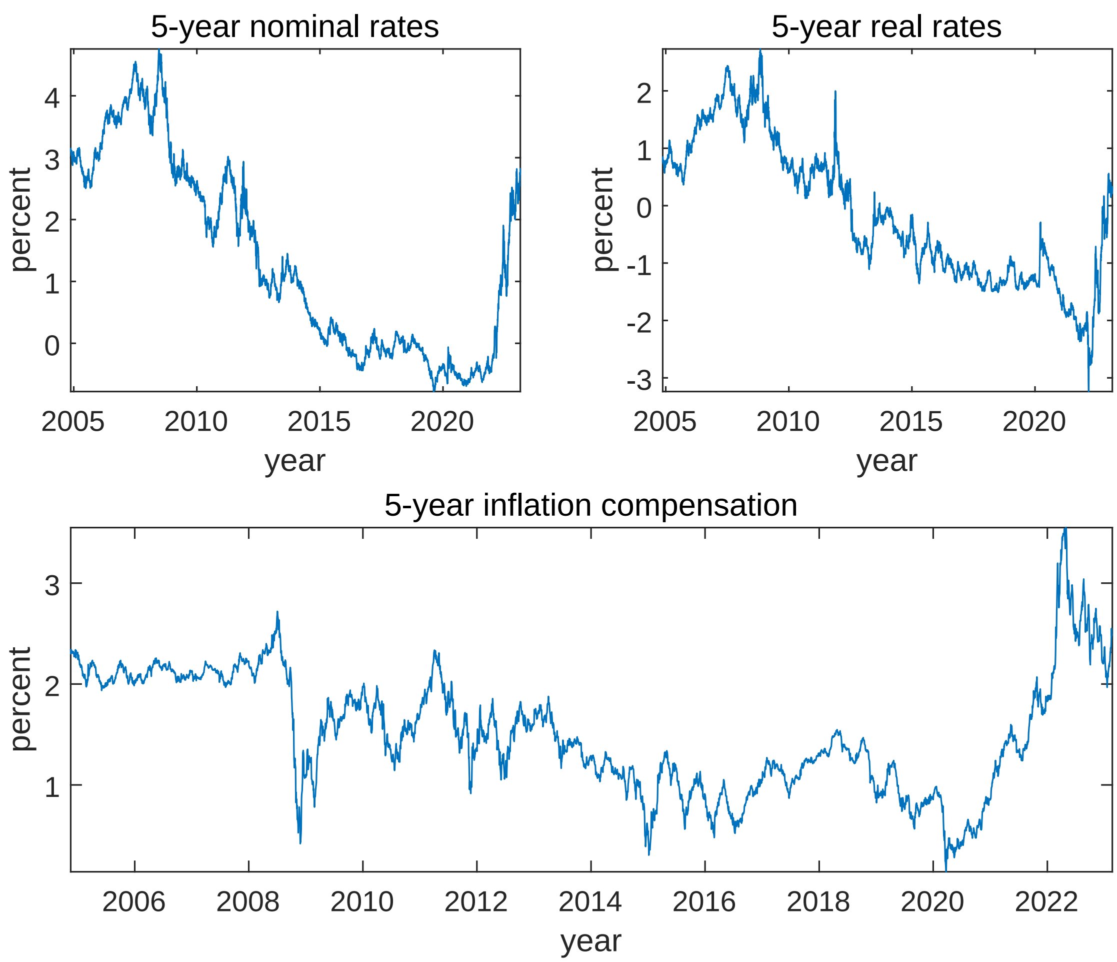
Notes: This figure shows the time series of the Nelson and Siegel (1987) fitted 2-, 5-, 10-, and 30-year zero-coupon inflation-indexed yields implied by the price quotes of OAT€i securities. The sample period is from November 17, 2004, to February 21, 2023. The frequency is daily.
Source: Bloomberg and authors' calculations.

Figure 4: Zero-coupon and forward rates in the OAT€i sample



Notes: Term structures of zero-coupon and forward OAT€i rates are shown in the left-hand-side panels. Term structures of inflation compensation defined as the difference between the nominal and OAT€i yields of comparable maturities are shown in the right-hand-side panels. Term structures are shown on November 28, 2007, July 27, 2016, and March 17, 2022. The fitted OAT€i yields and inflation compensation are reported in annualized percent.
Source: Bloomberg and authors' calculations.

Figure 5: Time series of five-year nominal and OAT€i rates and inflation compensation



Notes: The top-left and top-right panels show the time series of the Svensson (1994) and Nelson and Siegel (1987) fitted five-year zero-coupon nominal and OAT€i yields, respectively. The bottom panel in the figure shows the time series of inflation compensation, defined as the difference between the five-year nominal and OAT€i yields. The sample period is from November 17, 2004, to February 21, 2023. The frequency is daily.
Source: Bloomberg and authors' calculations.

A The fit of the OAT inflation-indexed yield curves

In this appendix, we discuss the details and accuracy of the smoothing procedure of the OAT inflation-linked yield curves.

Table A1 reports fitting errors for our smoothing procedure described in Section 3.2. Panels A and B report descriptive statistic for OAT€i and OATi yield fitting errors, respectively. In our sample, OAT€i-related fitting errors appear somewhat higher than OATi-specific errors. In the OATi sample, there is no "30-50 year" bin due to absence of such maturity bonds.

Table A1: Summary statistics of fitting errors

Panel A: OAT€i sample							
	0-2yr	2-5yr	5-10yr	10-20yr	20-30yr	30-50yr	total
Mean	1.7414	3.1486	3.2739	3.5342	4.5247	2.3268	3.6728
Max	29.4906	31.5797	20.7871	16.8116	39.4719	47.8924	22.7901
Min	0.0007	0.0001	0.0015	0.0036	0.0003	0.0003	0.0064
SD	6.2433	4.1802	2.4832	2.9531	4.9641	7.3301	2.5643
Panel B: OATi sample							
	0-2yr	2-5yr	5-10yr	10-20yr	20-30yr	30-50yr	total
Mean	0.7651	2.3560	2.7868	2.2333	0.1843		2.4365
Max	25.8620	42.3968	14.1008	32.5260	10.8578		21.1847
Min	0.0001	0.0002	0.0011	0.0009	0.0001		0.0006
SD	3.5686	4.8365	1.8488	3.4308	1.4249		2.4462

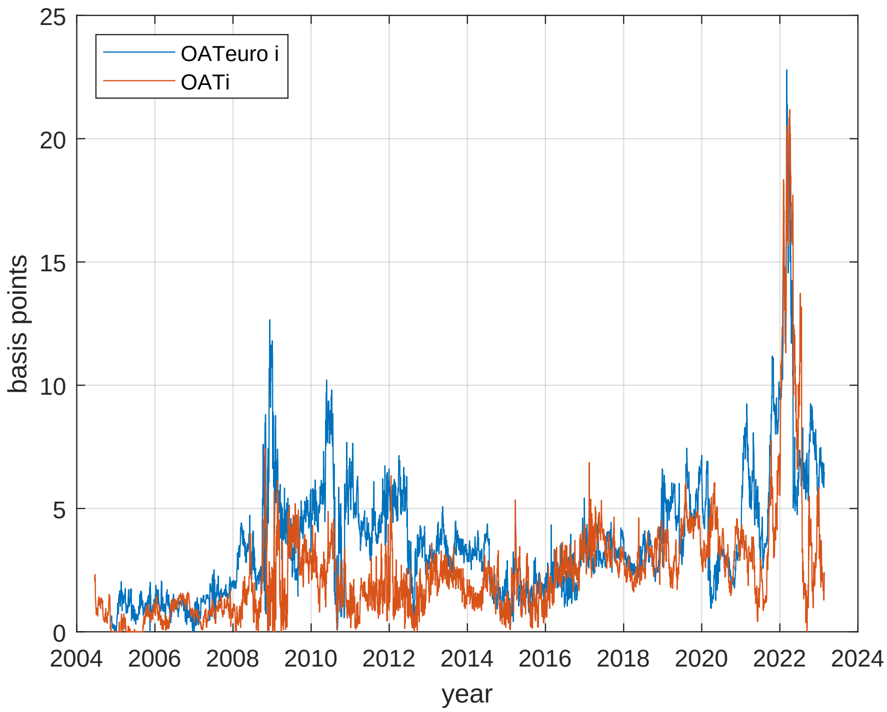
Notes: Panels A and B report descriptive statistics of the daily fitting errors for OAT€i and OATi securities in the indicated maturity bins, respectively. The fitting errors are defined as the mean absolute errors between observed and predicted yields according to Nelson and Siegel (1987) model. The sample period for the OAT€i market is from November 17, 2004, to February 21, 2023. The sample period for the OATi market is from June 15, 2004, to February 21, 2023. The errors are reported in basis points.
Source: Bloomberg and authors' calculations.

Figure A1 plots the daily time series of the mean absolute error MAE_t computed as defined in eq. (7) across all available securities each day. The time series extends from November 17, 2004–the first day when we had at least four securities traded to be able to estimate 4 NS parameters–until May 12, 2022 (the last day in our sample). Overall, the fit measure exhibits quite a bit of variation, with errors ranging from under 2 basis points to above 12 basis points during the time of the GFC. The OAT€i fit worsened significantly in time leading to the GFC in the early period of 2008, improved by the end of 2010 and was fluctuating around 3 to 5 basis points since then. The fit again worsened noticeably at the beginning of the COVID-19 pandemic, with a short period of improvement thereafter, and deteriorated again in 2022 at the end of our sample. Generally, the deterioration in fit happens in times of general strained market functioning and scarce liquidity as Hu et al. (2013) argue. They proxy the market illiquidity with the so-called *noise measure*, which is the square root of the average difference between predicted and observed yields on the market. They argue that when the trading capital is scarce, it is more difficult to smooth out the arbitrage trades leading to observed yields away from their potential equilibrium values. The noise measure is closely related to the MAE measure shown in figure A1. GMP computed both the MAE and noise measures for the nominal OAT securities in figures 3 and 16 in their paper. These nominal OAT fit measures are highly correlated with the OAT€i MAE measure presented in figure A1, indicating that both nominal and inflation-adjusted debt markets in France experienced strained conditions in similar periods. Section 2 discussed fairly contained and specific nature of the OATi market, mostly used for financing of domestic enterprises. Therefore, for the rest of this section, we do not report results related to the OATi markets. Of note, these results are fairly similar to their OAT€i counterparts.

Figure A2 shows MAE for six separate maturity brackets that represent the curve fit across the following maturity bins for OAT€i securities: 0-to-2 years, 2-to-5 years, 5-to-10 years, 10-to-20 years, 20-to-30 years, and 30-to-50-years. As indicated by this figure, the curve fit has been worse nearly uniformly across maturities during the GFC. However, the deterioration in fit during the sovereign bond crisis in 2011-2012 was led primarily by the longer-term securities, the 10-to-20- and 20-to-30-year segments (middle right and lower panels, respectively. Most of the recent deterioration in the fit is accounted for by the short-term securities (2-to-5-years, top right panel), with a smaller contribution to deterioration accounted for by the longer-term securities (5-to-10-year, middle left panel, 10-to-20-year, middle right panel, and 10-to-20-year, lower left panel). Of note, 0-to-2-year securities' fit has been the worst around 2018 when the fitting error reached about 20 basis points.

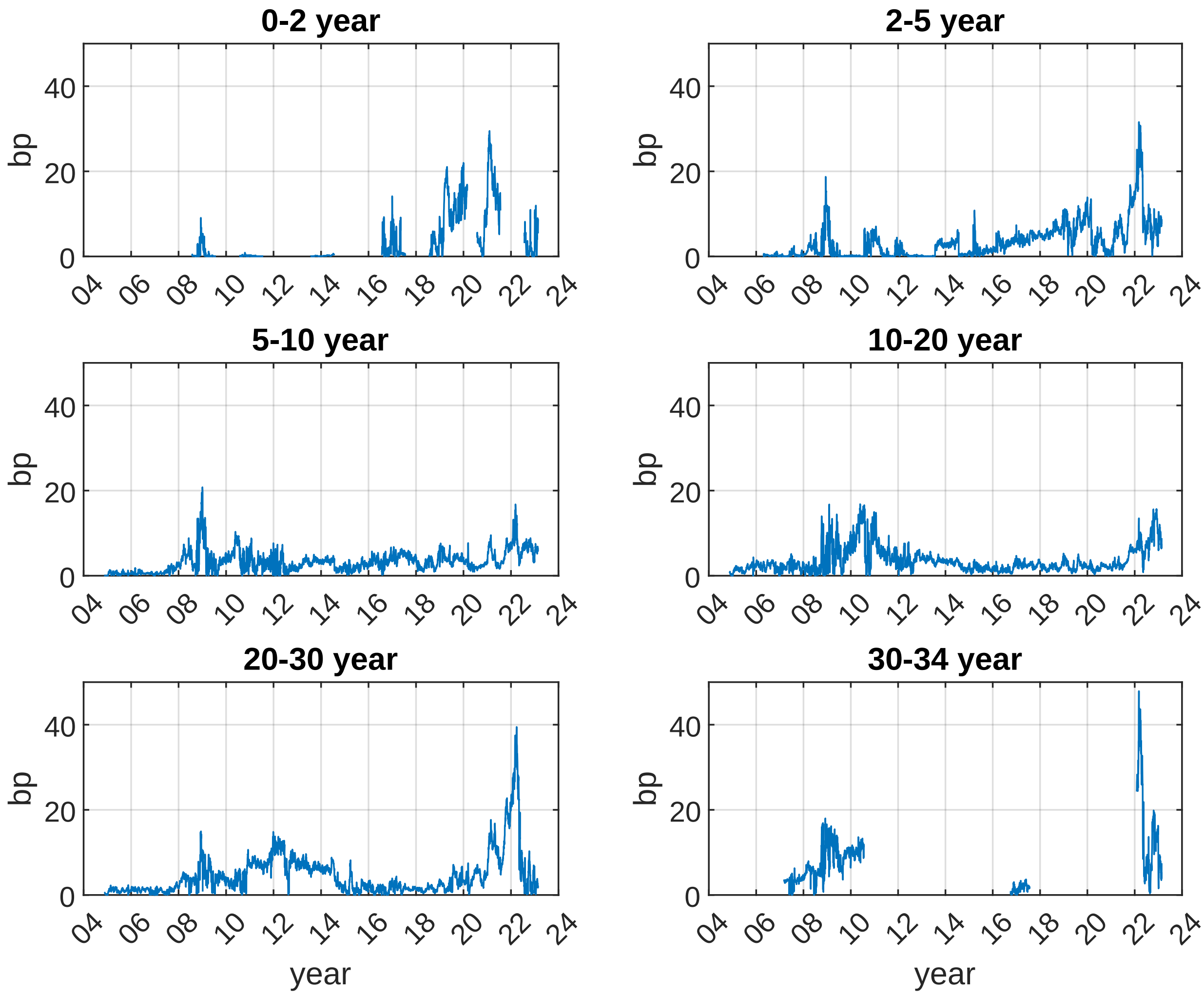
Figure A3 shows the estimated Nelson-Siegel real par yield curve implied by OAT€i securities on three different dates: January 2, 2009, February 18, 2020, and May 12, 2022. The left-hand side of these figures shows the model-implied par yield curve along with observed (blue round circles) and predicted (red crosses) continuously compounded yields. The predicted yields are computed using parameters that are estimated using bond quotes on the indicated day. The right-hand side of these figures shows security-specific fitting errors computed as differences between observed and predicted yield-to-maturity. According to the figure, the model fit has improved from 2009 to 2020 as more securities have been added by the AFT to the inflation-indexed debt market and market participants likely became more familiar with it.

Figure A1: Fitting errors for OAT€i and OATi sample



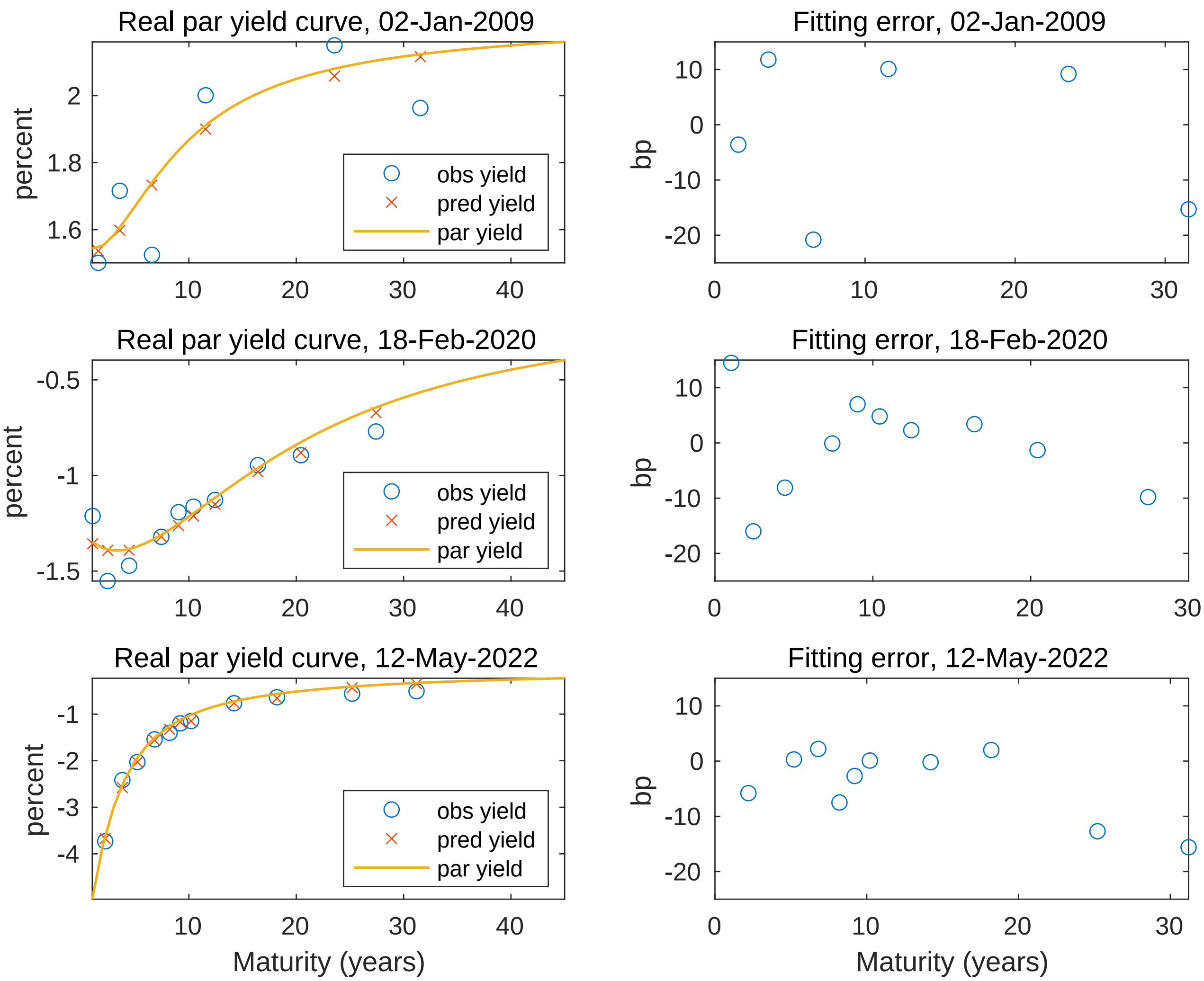
Notes: This figure shows the total fitting error of quotes of the individual OAT€i (blue line) and OATi (red line) securities implied by the Nelson and Siegel (1987) model. The fitting error is computed as the mean absolute error between the predicted and the observed yields across all available OAT€i securities and OATi securities, respectively, on a particular day. The fitting errors are shown in basis points. The sample period for OAT€i is from November 17, 2004, to February 21, 2023. The sample period for OATi is from June 15, 2004, to February 21, 2023. The frequency is daily.
Source: Bloomberg and authors' calculations.

Figure A2: Fitting errors for OAT€i sample, per maturity baskets



Notes: This figure shows the fitting errors of the Nelson and Siegel (1987) model implied by the OAT€i securities' quotes. The fitting error is computed as the mean absolute error between the model-implied and observed quotes in a specific maturity bin. The errors are reported for 0-2-year-, 2-5-year-, 5-10-year-, 10-20-year-, 20-30-year-, and 30-34-year-maturity bins. The fitting errors are in basis points. Sample period is from November 17, 2004, to February 21, 2023. The frequency is daily.
Source: Bloomberg and authors' calculations.

Figure A3: OAT€i par yield curves



Notes: This figure shows the par yield curve and the fit of individual OAT€i securities (left-hand side charts) along with security-specific fitting errors (right-hand side charts) in three days across the sample period: January 2, 2009, February 18, 2020, and May 12, 2022. The fitted OAT€i yields are reported in annualized percent; the fitting errors are reported in basis points.
Source: Bloomberg and authors' calculations.

B Macroeconomic surprises in the full sample period, November 2004 — February 2023

This appendix reports the results of Section 4, but includes the COVID-19 period in the sample. The COVID period was a special period marked by the values of several macroeconomic indicators that were well outside of the range suggested by the historical distribution of those values. It was also a period of unconventional monetary policies conducted in response to the COVID-19 pandemic, as well as by disruptions in the financial markets functioning. These factors, considered together, could potentially lead to very different results and conclusions, relative to the pre-pandemic period.

Table B1 reports the sensitivity results of the OAT€i forward inflation compensation measures with respect to the EA macroeconomic news. French CPI inflation news become significant in affecting the OAT forward inflation compensation, in contrast to the pre-COVID sample period, reported in Table 4. As expected, the forward rates have also become sensitive to news in French PPI and German CPI. However, reaction in forward ILS rates remained fairly mute even after we added the COVID period to our sample (Table B2). Yet, the reaction in forward ILS rates to MP shocks became more pronounced with the COVID period added, and lasted longer, up to seven years ahead (with the COVID period excluded, the significance of the MP shocks extended up to sex years ahead). However, neither surprises in macroeconomic releases, nor MP surprises affect the far-ahead (one-year nine years ahead) ILS forward rates.

Table B3 reports the sensitivity results of the OAT€i forward inflation compensation to the surprises in the U.S. macroeconomic releases. The reaction of the OAT markets appears to be relatively mute except for the IJC news—that is, significant at longer horizons, from five to nine years. However, this result is entirely driven by the several-standard-deviations outlier in the IJC series in January 2020, the start of the COVID-19 period. The significance of the MP shocks is short lived; the OAT forward inflation compensation reacts to the MP shocks at the four- and five-year horizons, but not at longer horizons. Table B4 reports respective sensitivity results of the ILS forward inflation rates. In this table, the news of the GDP advance significantly affects the ILS forward rates, albeit with fairly contained economic magnitude of a less than 5 basis points across the curve.

Overall, the reaction in OAT and ILS markets appears to be relatively contained even when the COVID-19 pandemic is considered.

Table B1: Euro-area OAT inflation compensation and euro-area macroeconomic news, 2004-2023

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
Panel: EU News							
GDP EA	0.57	0.22	-0.04	-0.28	-0.36	-0.35	-0.28
	(0.90)	(0.56)	(0.46)	(0.43)	(0.43)	(0.42)	(0.42)
HICP EA	0.26	-0.11	-0.16	-0.28	-0.24	-0.27	-0.26
	(0.54)	(0.34)	(0.28)	(0.26)	(0.26)	(0.25)	(0.25)
PPI EA	-0.39	-0.12	-0.04	0.02	-0.02	-0.12	-0.05
	(0.58)	(0.36)	(0.30)	(0.28)	(0.27)	(0.27)	(0.27)
MP shock	-0.20	-0.16	-0.11	-0.09	-0.14	-0.11	-0.18
	(0.24)	(0.15)	(0.12)	(0.12)	(0.11)	(0.11)	(0.11)
Panel: FR News							
GDP FR	0.50	-0.01	-0.31	-0.57	-0.77	-0.71	-0.77
	(0.81)	(0.55)	(0.46)	(0.45)	(0.46)	(0.46)	(0.45)
CPI FR	-0.47	-0.07	0.28	0.52***	0.67***	0.79***	0.78***
	(0.41)	(0.27)	(0.23)	(0.22)	(0.23)	(0.23)	(0.23)
PPI FR	0.14	0.44	0.48	0.70*	0.71*	0.88***	0.76***
	(0.66)	(0.45)	(0.38)	(0.37)	(0.38)	(0.37)	(0.37)
MP shock	-0.16	-0.14	-0.11	-0.10	-0.15	-0.13	-0.20*
	(0.22)	(0.15)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
Panel: DE News							
GDP DE	-0.06	-0.07	-0.21	-0.11	-0.20	-0.08	0.12
	(1.15)	(0.70)	(0.51)	(0.46)	(0.47)	(0.47)	(0.47)
CPI DE	0.37	0.39	0.41**	0.49**	0.56***	0.59***	0.51***
	(0.45)	(0.27)	(0.20)	(0.18)	(0.18)	(0.18)	(0.18)
PPI DE	0.01	0.09	0.22	0.25	0.27	0.29	0.29
	(0.62)	(0.38)	(0.27)	(0.25)	(0.25)	(0.25)	(0.25)
MP shock	-0.19	-0.15	-0.11	-0.09	-0.13	-0.10	-0.18
	(0.28)	(0.17)	(0.12)	(0.11)	(0.11)	(0.12)	(0.12)

Notes: This table reports the sensitivity results of one-year three- to nine-year-ahead euro-area Harmonized Index of Consumer Prices (HICP)-linked forward swap rates to surprises in the macroeconomic announcements in the euro area (EA), France (FR), and Germany (DE): GDP is gross domestic product; CPI is consumer price index, PPI is producers price index; MP shock is monetary policy shock. The MP shock is based on the Altavilla et al. (2019) one-month overnight index swap rate. Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP shocks are in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The ordinary least squares standard errors are reported in parentheses. The *, **, and *** denote the 10-, 5-, and 1-percent significance levels, respectively. The sample period is from November 2004, to February 2023.
Source: Bloomberg, Eurostat, French National Institute of Statistics and Economic Studies, German Federal Statistical Office, European Central Bank, and authors' calculations.

Table B2: Euro-area swap inflation rates and euro-area macroeconomic news, 2004-2023

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
Panel: EU News							
GDP EA	0.23	0.13	0.55	0.43	-0.07	-0.99	-0.85
	(0.76)	(0.83)	(0.96)	(1.01)	(0.91)	(0.98)	(1.33)
HICP EA	-0.18	0.19	-0.59	0.20	0.43	0.63	-0.81
	(0.46)	(0.50)	(0.59)	(0.61)	(0.55)	(0.59)	(0.80)
PPI EA	0.35	-0.70	-0.19	-0.70	0.61	-0.11	-0.34
	(0.44)	(0.48)	(0.56)	(0.58)	(0.53)	(0.57)	(0.77)
MP shock	-0.52***	0.33*	-0.52***	0.47**	0.55***	-0.19	0.08
	(0.17)	(0.19)	(0.22)	(0.23)	(0.21)	(0.22)	(0.30)
Panel: FR News							
GDP FR	0.36	-0.04	0.45	-0.61	0.35	0.04	-0.29
	(0.77)	(0.90)	(1.07)	(0.87)	(0.96)	(0.85)	(1.12)
CPI FR	0.04	0.91**	0.07	-0.68	0.53	0.46	-0.16
	(0.38)	(0.45)	(0.52)	(0.43)	(0.47)	(0.42)	(0.55)
PPI FR	0.10	0.94	0.44	0.41	-0.73	0.63	-0.69
	(0.63)	(0.74)	(0.87)	(0.72)	(0.79)	(0.70)	(0.92)
MP shock	-0.51***	0.30	-0.51**	0.47***	0.56***	-0.21	0.09
	(0.18)	(0.20)	(0.24)	(0.20)	(0.22)	(0.19)	(0.25)
Panel: DE News							
GDP DE	0.55	0.45	-1.00	1.34	0.41	-1.07	-0.95
	(0.69)	(0.80)	(1.02)	(1.10)	(0.99)	(1.02)	(1.19)
CPI DE	0.78***	0.09	1.16***	-0.39	0.35	0.26*	0.85
	(0.27)	(0.31)	(0.40)	(0.43)	(0.39)	(0.40)	(0.47)
PPI DE	0.56	0.31	0.39	0.32	0.95*	-0.32	-0.07
	(0.37)	(0.43)	(0.55)	(0.59)	(0.53)	(0.55)	(0.64)
MP shock	-0.51***	0.33**	-0.51***	0.45**	0.55***	-0.19	0.08
	(0.14)	(0.17)	(0.21)	(0.23)	(0.21)	(0.21)	(0.25)

Notes: This table reports the sensitivity results of one-year three- to nine-year-ahead euro-area Harmonized Index of Consumer Prices (HICP)-linked forward swap rates to surprises in the macroeconomic announcements in the euro area (EA), France (FR), and Germany (DE). GDP is gross domestic product; CPI is consumer price index, PPI is producers price index; MP shock is monetary policy shock. The MP shock is based on the Altavilla et al. (2019) one-month overnight index swap rate. Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP shocks are in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The ordinary least squares standard errors are reported in parentheses. The *, **, and *** denote the 10-, 5-, and 1-percent significance levels, respectively. The sample period is from November 2004, to February 2023.
Source: Bloomberg, Eurostat, French National Institute of Statistics and Economic Studies, German Federal Statistical Office, European Central Bank, and authors' calculations.

Table B3: Euro-area OAT inflation compensation and U.S. macroeconomic news, 2004-2023

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
PMI	0.13	0.33	0.32	0.24	0.22	0.08	0.08
	(0.53)	(0.32)	(0.25)	(0.25)	(0.25)	(0.25)	(0.25)
NFP	-0.91	-0.62	-0.40	-0.03	0.29	0.59	0.94
	(1.27)	(0.77)	(0.61)	(0.59)	(0.60)	(0.60)	(0.59)
UNEMP	-0.15	-0.08	-0.14	-0.04	-0.01	0.13	0.36
	(1.27)	(0.77)	(0.61)	(0.59)	(0.60)	(0.59)	(0.59)
IJC	0.11	0.22	0.34***	0.42***	0.49***	0.48***	0.45***
	(0.26)	(0.15)	(0.12)	(0.12)	(0.12)	(0.12)	(0.12)
GDP Advance	0.44	0.71	0.81	0.58	0.53	0.47	0.36
	(0.95)	(0.58)	(0.46)	(0.44)	(0.45)	(0.45)	(0.44)
Retail Sales	0.11	0.18	0.15	0.17	0.14	0.17	0.18
	(0.52)	(0.31)	(0.25)	(0.24)	(0.25)	(0.24)	(0.24)
Core CPI	0.64	0.36	0.25	0.18	0.11	0.05	0.06
	(0.53)	(0.32)	(0.25)	(0.25)	(0.25)	(0.25)	(0.25)
PCE	0.55	0.15	0.02	-0.13	-0.13	-0.21	-0.19
	(0.55)	(0.33)	(0.26)	(0.25)	(0.26)	(0.26)	(0.25)
US MP shock	-0.10	-0.16*	-0.15**	-0.08	-0.03	-0.00	0.04
	(0.15)	(0.09)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)

Notes: This table reports the sensitivity results of one-year three- to nine-year-ahead euro-area (EA) Harmonized Index of Consumer Prices (HICP)-linked forward swap rates to surprises in the macroeconomic announcements in the EA, France (FR), and Germany (DE). PMI is purchasing managers index; NFP is nonfarm payrolls; UNEMP is unemployment rate; IJC is initial jobless claims; GDP is gross domestic product; CPI is consumer price index; PCE is personal consumption expenditures; MP shock is monetary policy shock. The MP shock is the Federal Reserve monetary policy shock constructed by Bauer and Swanson (2023). Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP shocks are in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The ordinary least squares standard errors are reported in parentheses. The *, **, and *** denote the 10-, 5-, and 1-percent significance levels, respectively. The sample period is from November 2004, to February 2023.
Source: Bloomberg, Action Economics, Federal Reserve Bank of San Francisco, and authors' calculations.

Table B4: **Euro-area swap inflation rates and U.S. macroeconomic news, 2004-2023**

	Forward Rate Horizon						
	1y3y	1y4y	1y5y	1y6y	1y7y	1y8y	1y9y
PMI	0.46	0.69	0.30	0.11	0.61	0.32	0.62
	(0.42)	(0.43)	(0.50)	(0.59)	(0.52)	(0.55)	(0.71)
NFP	0.84	-1.71	0.38	0.58	-0.35	-0.06	-0.42
	(1.01)	(1.03)	(1.19)	(1.41)	(1.25)	(1.31)	(1.68)
UNEMP	0.74	-1.86*	0.65	0.24	-0.09	-0.31	-0.45
	(1.00)	(1.03)	(1.18)	(1.40)	(1.24)	(1.31)	(1.67)
IJC	0.41**	0.07	0.31	0.09	0.31	0.07	0.16
	(0.21)	(0.21)	(0.24)	(0.29)	(0.25)	(0.27)	(0.35)
GDP Advance	-4.29***	0.08	0.25	-2.35***	0.42	2.44***	-2.47**
	(0.73)	(0.76)	(0.88)	(1.02)	(0.90)	(0.96)	(1.24)
Retail Sales	0.24	-0.13	0.51	-0.13	0.21	-0.21	0.26
	(0.42)	(0.43)	(0.49)	(0.59)	(0.52)	(0.55)	(0.70)
Core CPI	0.62	-0.16	0.08	1.41***	0.53	0.04	-0.68
	(0.42)	(0.43)	(0.50)	(0.59)	(0.51)	(0.55)	(0.71)
PCE	-0.05	0.27	0.06	-0.42	0.40	0.03	0.14
	(0.42)	(0.43)	(0.50)	(0.59)	(0.51)	(0.54)	(0.70)
US MP shock	0.02	-0.06	0.03	0.20	0.08	0.05	0.15
	(0.12)	(0.12)	(0.14)	(0.16)	(0.14)	(0.15)	(0.19)

Notes: This table reports the sensitivity results of one-year three- to nine-year-ahead euro-area Harmonized Index of Consumer Prices (HICP)-linked swap rates to surprises in the macroeconomic announcements in the United States. PMI is purchasing managers index; NFP is nonfarm payrolls; UNEMP is unemployment rate; IJC is initial jobless claims; GDP is gross domestic product; CPI is consumer price index; PCE is personal consumption expenditures; MP shock is monetary policy shock. The MP shock is the Federal Reserve monetary policy shock constructed by Bauer and Swanson (2023). Macroeconomic surprises are normalized by their standard deviation, so that the coefficients represent a basis point per standard deviation response. MP surprises are in basis points so that the coefficients represent a basis point per basis point response. Inflation compensation is the difference between the nominal and real rates. The ordinary least squares standard errors are reported in parentheses. The *, **, and *** denote the 10-, 5-, and 1-percent significance levels, respectively. The sample period is from November 2004, to February 2023.
Source: Bloomberg, Action Economics, Federal Reserve Bank of San Francisco, and authors' calculations.