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Low frequency effects of macroeconomic news on government bond yields[☆]

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ABSTRACT

Are macroeconomic releases important drivers of Treasury bond yields? We develop a two-step regression strategy that fully exploits the available high-frequency market reaction data to identify the impact of macroeconomic releases and to quantify the effects at lower frequencies. While macroeconomic surprises explain only one tenth of the daily variation in bond yields, their explanatory power improves substantially at lower frequencies, accounting for one third of quarterly variations. The finding is explained by the persistent effects that macroeconomic surprises exert on bond yields, and a less persistent impact of residual factors, which tend to average out when focusing on longer-horizon changes.

1. Introduction

In most industrialized countries, national statistical agencies and specialized private firms release various macroeconomic indicators almost every calendar day. Policy-makers, media commentators, and market participants monitor the real-time data flow constantly and somewhat obsessively. Market participants also make a prediction for almost every macroeconomic release, and whenever they are surprised, asset prices, Treasury bond yields among them, tend to move significantly. Seminal contributions by Gürkaynak et al. (2005), Andersen et al. (2007) and Faust et al. (2007) have shown that macroeconomic

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surprises are economically important and have statistically significant impact on daily changes in bond yields. However, as analysis presented in this paper suggests, the influence of these surprises is quite limited, explaining about 10% of the daily variation in bond yields.

Using an approach outlined here, we find that while macroeconomic surprises only weakly explain daily fluctuations in yield, their power improves substantially when moving to lower frequencies. Indeed, the results show that news from the unexpected component in macroeconomic releases can explain up to one fourth of the monthly and one third of the quarterly variation in bond yields. We adopt a two-step regression strategy that fully exploits the available high-frequency market reaction data while also tracking the effects of macroeconomic surprises on monthly and quarterly bond-yield changes. This approach is crucial for correctly identifying causal effects of macroeconomic surprises since it reduces the effects of confounding factors and limits reverse causality issues (see Gürkaynak and Wright, 2013; Cochrane and Piazzesi, 2002; Kuttner, 2001). Model predictions of bond yield changes at monthly (quarterly) frequency are obtained by aggregating the high frequency fit over a month (quarter). As the results show, this aggregation substantially increases the explanatory power of macroeconomic surprises. The finding is mainly owing to the persistent effects that macroeconomic surprises exert on bond yields, and a less persistent impact from the residual component, which tends to average out when focusing on longer-horizon changes.

Aggregating yields over different time periods also has implications for excess bond returns since monthly (quarterly) holding period excess returns are linear functions of monthly (quarterly) yields changes. Results indicate that macroeconomic surprises explain a large fraction of the fluctuations in excess bond returns at different maturities. The external validity of this finding is evaluated by performing a pseudo out-of-sample exercise.

Moreover, using a daily decomposition of the nominal term structure into real interest rates and inflation compensation (extracted from financial markets) indicates that macroeconomic surprises are more important to the latter. In addition, decomposing movement in bond yields related to expected short-term rates and term premia following Kim and Wright (2005) and Adrian et al. (2013) indicates that both components are important for explaining the low-frequency movements in nominal interest rates.

Overall, the results obtained by analyzing bond markets reconcile some apparently contrasting evidence found in previous studies. As stressed above, event studies typically find that macroeconomic surprises account for only a small proportion of the daily variation in bond yields. By contrast, when employing macro-finance models estimated at monthly or quarterly frequencies, macroeconomic variables explain a significant fraction of the bond yield fluctuations (see Ang and Piazzesi, 2003; Diebold et al., 2006; and Coroneo et al. 2016). These findings are rationalized by identifying the role of the persistence of the macroeconomic surprises in influencing bond yield fluctuations over different time spans.

The last part of the analysis evaluates whether the evidence obtained in analyzing the Treasury bond market can be generalized to equity and exchange rate markets. Interestingly, while for equity prices the results are qualitatively similar to (although quantitatively less relevant than) those found for bond yields, the same evidence is not conclusive for exchange rates.

The remainder of the paper is organized as follows. Section 2 describes macroeconomic data releases and their effects on bond yields at different frequencies. Section 3 discusses how the findings affect excess bond returns for investors with different investment horizons and studies the importance of macro news for inflation compensation and the term premia. Section 4 deals with the effects of macroeconomic news on stock price returns and exchange rates at different frequencies. Section 5 concludes this study.

2. Effects of macroeconomic news on bond yields at high and low frequencies

The data employed in the empirical part of the paper comes from various sources. Interest rates on Treasury bonds are the zero-coupon yields constructed by Gürkaynak et al. (2007) with maturities ranging from 2 to 10 years.[1] The analysis considers only bonds with maturities larger than 2 years since their sensitivity to macroeconomic news is less affected during the zero-lower-bound period. This dataset also includes the parameters estimated for the model of Svensson (1994) to smooth the yield data so that, in principle, one can retrieve any desired maturity. The 3-month holding period excess returns, for example, can be easily generated using yields for the maturities that are not available in the dataset in this way.[2]

Data available in the Economic Calendars (ECO) provided by Bloomberg is used to mimic the information that is available in real time to market participants. For each macroeconomic release, this dataset contains its realized value and the predictions made by a panel of market participants. ECO survey forecasts normally start one to two weeks before each release, and they are updated in real time until the macroeconomic variable is officially released. The survey value used in the empirical analysis is the median (consensus) forecast. Using both the official release and the corresponding forecast for each macroeconomic variable permits a calculation of the size and direction of all news that hit the market at each point in time, and possibly leads to changes in financial asset prices.

An overview of the macroeconomic variables used in the analysis is reported in the first column of Table 1. The sample period goes from January 1, 2000, to July 20, 2016. All U.S. macroeconomic surprises available over the entire sample are

[1] This dataset is publicly available on the website of the Federal Reserve Board. The daily data can be obtained at http://www.federalreserve.gov/pubs/feds/2006/.

[2] These data are publicly available on the website of the Federal Reserve of St Louis at http://www.research.stlouisfed.org/fred2/.

Table 1
Macroeconomic releases.

Releases	Relevance	Freq	Pub. delay
Advance retail sales	89	M	15
Business inventories	34	M	45
Capacity utilization	61	M	16
Change in nonfarm payrolls	98	M	4
Consumer confidence	95	M	2
Consumer credit	36	M	38
Consumer price index (MoM)	93	M	18
CPI ex food & energy (MoM)	75	M	18
Domestic vehicle sales	30	M	3
Durable goods orders	91	M	21
Employment cost index	71	M	31
Factory orders	82	M	34
Housing starts	88	M	19
Import price index (MoM)	78	M	11
Industrial production	87	M	16
Initial jobless claims	99	W	5
ISM manufacturing	94	M	2
ISM non-manf. composite	70	M	2
Leading indicators	84	M	24
Monetary policy surprise	–	8/year	0
New home sales	90	M	25
Personal income	83	M	21
Personal spending	83	M	21
Philadelphia fed.	75	M	−14
PPI ex food & energy (MoM)	68	M	14
Producer price index (MoM)	85	M	14
Retail sales less autos	62	M	15
Trade balance	81	M	41
Unemployment rate	88	M	4
Wholesale inventories	79	M	40
GDP annualized QoQ A	96	Q	26
GDP annualized QoQ S	96	Q	59
GDP annualized QoQ T	96	Q	80
GDP price index A	77	Q	26
GDP price index S	77	Q	59
GDP price index T	77	Q	80
Nonfarm productivity P	35	Q	31
Nonfarm productivity F	35	Q	65
Unit labor costs P	27	Q	31
Unit labor costs F	27	Q	65
U. of Michigan Confidence P	93	M	−23
U. of Michigan Confidence F	93	M	-9

The table lists the macroeconomic releases used to compute the news indices. In each case, we show the relevance index, indicating the percentage of users who set an alert for a particular event, the frequency, and the average publication delay expressed in days.

considered, thereby including a total of 42 variables in the analysis. Given that macro variables are released in a non-synchronous manner, using such a large dataset helps capture the most recent developments in the economic conditions. For example, with respect to prices, we use several indicators released at different frequencies that become available with varying reporting lags: for example, the GDP deflator is released at quarterly frequency, usually about one month after the reference quarter, and the consumer price index is released, on average, about four days later than the producer price index. Including all of these releases in the analysis allows for the tracking of price developments and the corresponding surprise component over time.

Moreover, for some of the variables listed in Table 1, market participants monitor more than one release. Examples include real GDP and the GDP price index, which have advanced (A), second (S), and third (T) releases; nonfarm productivity, unit labor costs, and the University of Michigan Confidence indicator, which have preliminary (P) and final (F) releases. The analysis treats these releases as separate variables. Importantly, the number of releases (and the associated forecasts) observed for each variable over a specific period, such as a quarter, depends on its frequency, whether weekly (W), monthly (M), or quarterly (Q), a detail reported in the third column of Table 1.

To assess the importance of each release for market participants, the second column of Table 1 reports a relevance index, which corresponds to the percentage of Bloomberg users who set an alert for a particular event. For example, over 98% of the users set an alert for the scheduled release of nonfarm payrolls. The relevance of various data releases is not only determined by the strength of their relationship with overall economic conditions but also by their timeliness (see Giannone et al., 2008; Gilbert et al., 2015).

The fourth column of Table 1 gives information on the timeliness of each macroeconomic release, reporting the publication delay, defined as the average number of days from the end of the reference period to the day of release. For example, the change in the nonfarm payrolls data is usually released 4 days after the end of the reference month. A negative entry, such as the University of Michigan Confidence indicator, means that the variable is released before the end of the reference period.

Surprises related to monetary policy actions are also included as an additional control variable in the regression. More specifically, monetary policy surprises are measured 'a la Kuttner (2001), i.e. by using high frequency data on federal funds futures rates on days when the funds rate target was changed as well as the information about the exact timing of FOMC policy announcements.

2.1. Empirical analysis at high frequencies

The empirical analysis starts by evaluating the daily reaction of bond yields to macroeconomic news. Practically, daily changes in bond yields Δy_t^τ at maturity τ on day t are regressed on a constant and on the surprise component of the news released on day t, according to Eq. (1). If variable i is not released at time t, then $news_{i,t} = 0$.[3] Otherwise, it is defined as the difference between the released data and the consensus forecasts.

$$\Delta y_t^\tau = c + \sum_{i=1}^{n} \beta_i^\tau news_{i,t} + \varepsilon_t^\tau \tag{1}$$

Table 2 shows the regression coefficients (β) based on the regression described in Eq. (1) for the bond yields with 2-, 5-, and 10-year maturities.[4] Boldface denotes coefficients that differ significantly from zero at the 5% confidence level.

Several releases significantly influence the daily changes in yields over the entire maturity spectrum. A first set of market-moving indicators includes qualitative surveys such as the Conference Board Consumer Confidence index, the ISM manufacturing and non-manufacturing surveys, the Philadelphia Fed economic outlook, and the University of Michigan Consumer Confidence index. Because of their timeliness, these soft data are particularly important for an early read on broad economic conditions. A second set of indicators includes hard data that is strongly related to economic fundamentals. Variables summarizing labor market dynamics, such as the change in nonfarm payrolls and initial jobless claims, are found to be important for explaining fluctuations in bond yields. Like soft data, these variables are also very timely (jobless claims, for example, are released on a weekly basis). Other macroeconomic announcements significantly affecting bond yields developments are the advanced releases of real GDP and retail sales. Finally, the pricing of sovereign yields is significantly affected when central bank policy shifts surprise markets.

Overall, our findings are in line with the existing studies showing that: (i) both the timeliness and the strength in the relation to fundamentals are important determinants of the informativeness of the data in nowcasting economic activity (see Giannone et al., 2008) and (ii) the nowcasting ability is an important determinant of the strength of the announcements' impact on asset prices (see Scotti et al., 2015).

The Table also reports the R^2 values for the regression described in Eq. (1). The results point out that although several regression parameters are statistically significant, macroeconomic surprises explain only a small fraction (less than 10%) of the daily variation in bond yields.

2.2. Empirical analysis at lower frequencies

Let us define a daily news index $nix_t^{1,\tau} := \widehat{\Delta^1 y_t^\tau}$ as the fitted value from Eq. (1), where the superscript "1" indicates that the frequency used to obtain the index is 1 day. In order to analyze the persistence of the effects of macroeconomic news on yield changes, both the daily changes in bond yields and the daily news indices are aggregated over different time spans, thereby obtaining changes over longer time horizons. For bond yields, these changes take the following form:

$$\Delta^h y_t^\tau := y_t^\tau - y_{t-h}^\tau = \sum_{j=0}^{h-1} \Delta y_{t-j}^\tau \tag{2}$$

Similarly, by summing the daily news indices, longer-horizon news indices at daily frequencies are obtained as follows:

$$nix_t^{h,\tau} = \sum_{j=0}^{h-1} nix_{t-j}^{1,\tau} \tag{3}$$

The effect of these aggregations on yields is to filter out high-frequency fluctuations while at the same time retaining fluctuations with frequencies lower than h days.

[3] Note that as the large majority of the macroeconomic variables considered in the analysis are released in a non-synchronous manner, our regressors are not affected by collinearity problems.

[4] In order to facilitate the comparison, macroeconomic surprises were standardized by dividing the difference between the actual and the predicted value of each variable by the corresponding sample standard deviation.

Table 2
Macroeconomic news effects on bond yields at high frequency.

Releases	2-year	5-year	10-year
Advance retail sales	**1.67**	**1.69**	**1.38**
Business inventories	−0.13	−0.10	−0.04
Capacity utilization	**1.42**	**1.49**	**1.18**
Change in nonfarm payrolls	**4.37**	**4.49**	**3.59**
Consumer confidence	**0.80**	**0.87**	**0.89**
Consumer credit	0.00	−0.10	−0.17
Consumer price index (MoM)	0.31	0.42	0.15
CPI ex food & energy (MoM)	0.61	0.39	0.27
Domestic vehicle sales	**0.63**	0.29	0.04
Durable goods orders	0.51	0.57	0.53
Employment cost index	0.35	0.55	0.47
Factory orders	0.04	0.15	0.22
Housing starts	0.31	0.46	0.27
Import price index (MoM)	0.09	−0.03	−0.19
Industrial production	0.10	−0.14	−0.57
Initial jobless claims	−**1.30**	−**1.44**	−**1.30**
ISM manufacturing	**2.46**	**2.71**	**2.62**
ISM non-manf. composite	**1.94**	**2.03**	**1.81**
Leading indicators	0.12	0.39	0.53
Monetary policy surprise	**2.18**	**0.91**	0.07
New home sales	0.43	0.52	0.65
Personal income	−0.33	−0.32	−0.25
Personal spending	0.13	−0.03	−0.07
Philadelphia fed.	**1.43**	**1.71**	**1.50**
PPI ex food & energy (MoM)	0.61	**0.93**	**1.18**
Producer price index (MoM)	−0.35	−0.29	−0.13
Retail sales less autos	0.77	**1.03**	**1.19**
Trade balance	0.41	**0.73**	**1.03**
Unemployment rate	−**0.75**	−0.45	−0.21
Wholesale inventories	0.07	0.04	0.00
GDP annualized QoQ A	**2.04**	**1.90**	**1.70**
GDP annualized QoQ S	0.36	0.44	0.06
GDP annualized QoQ T	0.20	−0.01	0.00
GDP price index A	0.43	0.76	0.52
GDP price index S	0.16	0.73	1.13
GDP price index T	−0.38	−0.67	−0.39
Nonfarm productivity P	−0.92	−1.20	−1.12
Nonfarm productivity F	0.77	1.28	1.51
Unit labor costs P	−0.17	−0.15	−0.14
Unit labor costs F	0.16	0.12	0.23
U. of Michigan Confidence P	**1.10**	**1.43**	**1.23**
U. of Michigan Confidence F	−0.14	−0.06	0.21
R^2	0.09	0.08	0.06

The table lists for each macroeconomic release used to compute the news indices the value of the coefficient (in basis points) estimated from Eq. (1) for the bond yields with maturities (τ) at 2, 5, and 10 years. The values in bold are significantly different from zero at the 5% confidence level (t-stat values are based on HAC standard errors). The sample period goes from January 1, 2000 to July 20, 2016.

The regression model used in the estimation has the following specification:

$$\Delta^h y_t^\tau = \gamma^{h,\tau} nix_t^{h,\tau} + \upsilon_t^{h,\tau} \tag{4}$$

where $\gamma^{h,\tau}$ measures the impact of the sum of the news on the change in yields over h days and enforces the orthogonality between the explained and residual components at any horizon. Importantly, an estimate of γ larger (smaller) than one indicates a delayed (reversal of the) effect of the news on bond yields. As reported in Table 3, in most cases, the value of the γ is larger than one at a 1% confidence level, indicating that there are indeed delayed effects of the news on bond yield changes.[5] The fitted value of Eq. (4), $\widehat{\Delta^h y_t^\tau}$, represents the part of the $h-$days changes in the bond yields attributable to macroeconomic surprises. On average there are 22 trading days per month, thus $\Delta^{22} y_t^\tau$ and $\widehat{\Delta^{22} y_t^\tau}$ approximately correspond to the actual and fitted monthly changes in the bond yields at maturity τ, respectively. Similarly, $\Delta^{66} y_t^\tau$ and $\widehat{\Delta^{66} y_t^\tau}$ refer to

[5] All standard errors of estimates are corrected for autocorrelation and heteroscedasticity. We do not correct the standard errors of γs in Eq. (4) for the estimation uncertainty in the first stage, i.e. when computing the news index. The reason is that performing this correction is not trivial due to the aggregation in the two stages.

Table 3
Macroeconomic news effects on bond yields at high frequency.

	2-year	5-year	10-year
R^2			
1-day	0.09	0.08	0.06
1-month	0.24	0.20	0.14
1-quarter	0.34	0.36	0.28
γ			
1-month	1.34	1.36	1.31
	(0.13)	*(0.14)*	*(0.17)*
1-quarter	1.61	1.57	1.48
	(0.21)	*(0.18)*	*(0.2)*

The table shows the R^2 and the fitted γ values obtained from Eq. (4), for h = 22 (monthly frequency) and h = 66 (quarterly frequency), for the yields of bonds with maturities (τ) at 2, 5, and 10 years. Standard deviation (heteroskedasticity and autocorrelation consistent, HAC) for γs are reported in parentheses. The sample period goes from January 1, 2000 to July 20, 2016.

the actual and fitted quarterly changes.[6] In the rest of the paper, $\widehat{\Delta^h y_t^\tau}$ and $\Delta^h y_t^\tau - \widehat{\Delta^h y_t^\tau}$ are referred as the explained and residual components of the $h-$days changes in the bond yields with maturity τ, respectively.[7]

It is important to note that the residual fluctuations may still be partially due to unobserved information flow about macroeconomic events. This study only considers a subset of the macroeconomic events that may affect U.S. Treasury yields. For example, while only U.S. variables are employed here, international factors could also play an important role. In addition, the analysis controls only for partial measures of the news because Bloomberg collects expectations for headline information only, whereas macroeconomic data releases include numerous disaggregated details. Recently, Gürkaynak et al. (2016) showed that considering these details could substantially increase the explanatory power of macroeconomic releases. Finally, at both daily and lower frequencies, part of the residual fluctuation is likely to be due to the omission of political news, announcements by large corporations, and fiscal policy surprises.

Fig. 1 shows the actual (blue solid lines) and fitted (red dashed lines) values for the daily, monthly, and quarterly yield changes ($h = 1, 22, 66$) in government bond yields with $\tau = 2, 5,$ and 10-year maturities. The estimated regression coefficients (γ) and the measure of fit (R^2) are reported in Table 3.

Focusing first on the figure, it is evident that while the fit for daily changes is quite poor (first row), it improves substantially when moving to monthly changes (middle row) and quarterly changes (last row).

As Table 3 shows, macroeconomic news can explain up to 24% of the monthly and 36% of the quarterly variation in bond yields. In addition, the estimated coefficients (γ) becomes significantly larger than one at lower frequencies.

The measures of fit are shown graphically in Fig. 2. The R^2 is reported on the vertical axis, whereas the horizontal axis refers to different maturities, from 2 to 10 years. The three horizons - daily, monthly and quarterly - are represented by different markers and colors. The figure illustrates that the increase in the share of variance explained over the aggregation horizons is a general result that applies to all available maturities especially at intermediate ones.

How much a shock affects bond yields at different maturities and aggregation horizons is assessed by constructing a measure of persistence following Cochrane (1988) and Cochrane and Sbordone (1988). The persistency of a series, such as x_t, can be gauged by considering $1/h$ times the variance in the h-period change, i.e., $1/h\ var(x_t - x_{t-h})$, as a function of h. If all the shocks to x_t tend to be immediately and permanently incorporated, then the series comprises a random walk component and $1/h\ var(x_t - x_{t-h})$ is constant with respect to h. However, if the effect of shocks on x_t is partially reversed after some time, the reversion will be reflected in the decline of $1/h\ var(x_t - x_{t-h})$ from a given horizon onward. By contrast, if it takes time for the shocks to be incorporated, then $1/h\ var(x_t - x_{t-h})$ will tend to increase.

Since the R^2 for different horizons can be written as:

$$R^2(h, \tau) := \frac{1/h \ \mathrm{var}\left(\widehat{\Delta^\mathrm{h} \mathrm{y}_\mathrm{t}^\tau}\right)}{1/h \ \mathrm{var}\left(\widehat{\Delta^\mathrm{h} \mathrm{y}_\mathrm{t}^\tau}\right) + 1/\mathrm{h} \ \mathrm{var}\left(\Delta^\mathrm{h} \mathrm{y}_\mathrm{t}^\tau - \widehat{\Delta^\mathrm{h} \mathrm{y}_\mathrm{t}^\tau}\right)},$$

it follows that the increased importance of macroeconomic news for explaining changes in government bond yields over longer horizons can be attributed to the relative persistence of two orthogonal components: the macro-news-related (the fit) and non-macro-news-related (the residual).

The various pieces of the R^2 are shown in Fig. 3. The vertical axis reports $1/h$ times the variance of the change in bond yields over h periods (right panel), in their fit explained by the macro-news-related (central panel) and in their residual

[6] The results are robust to constructing the news index over non-overlapping time windows coinciding with the exact calendar month/quarter.

[7] The regression could have been carried out with the surprises within the h-day period rather than with the fitted values. We adopt, instead, a two-step regression strategy that fully exploits the high-frequency data and preserves the identification of the effects of the macroeconomic surprises on the monthly/quarterly bond yield changes. This approach is crucial for correctly identifying the causal effects of macroeconomic news on bond yields as it reduces the effects of confounding factors and limits reverse causality issues.

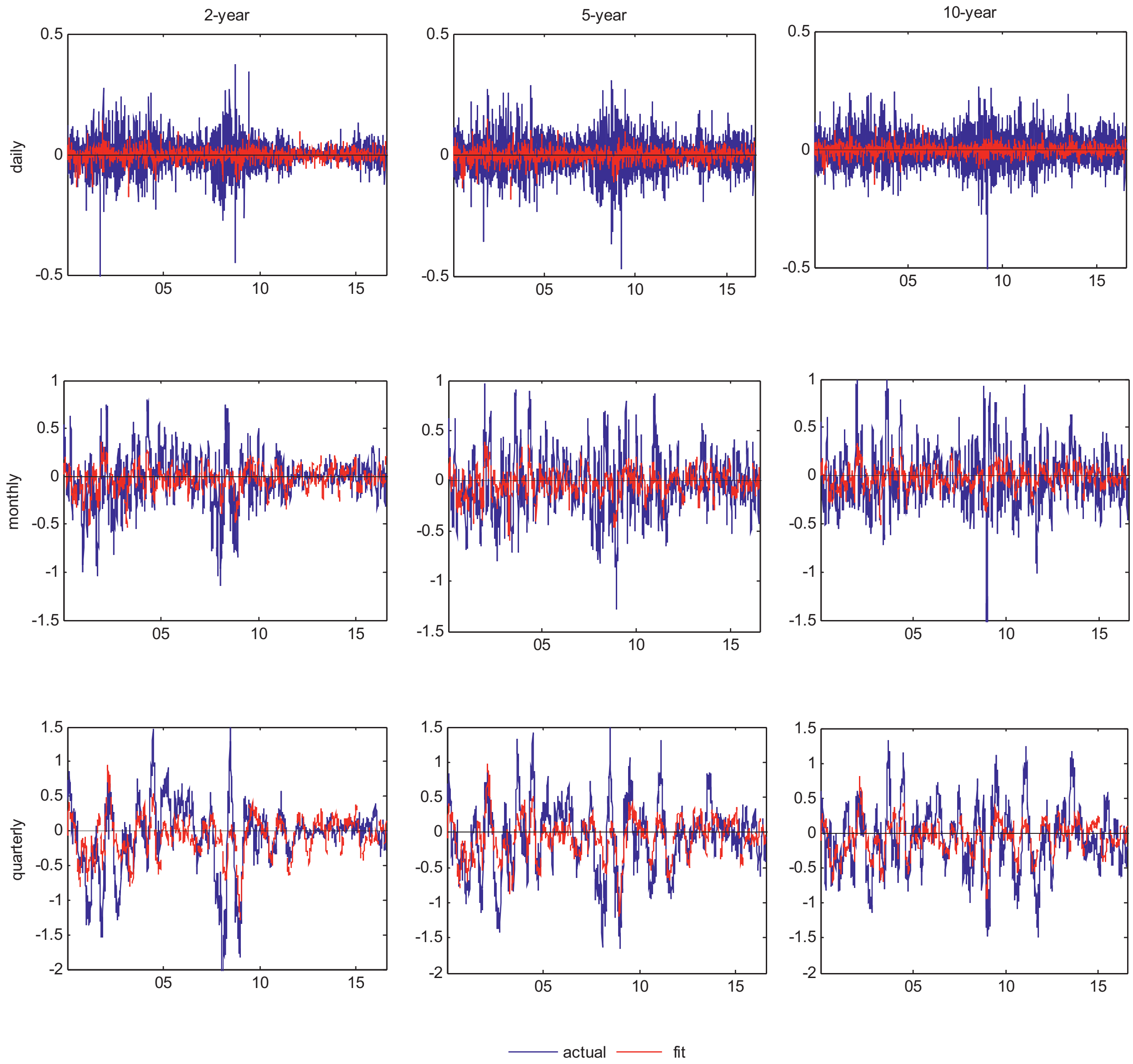

Fig. 1. Daily, monthly, and quarterly bond yield changes.

components (left panel). As in Fig. 2, the horizontal axis refers to different maturities, from 2 to 10 years. Different horizons - daily, monthly and quarterly - are represented by different markers and colors.

In the right panel of Fig. 3, it is evident that the $1/h$ times the variance of the h-period change decreases for the residual part when moving from daily to monthly and from monthly to quarterly horizons. By contrast, as the central panel of Fig. 3 shows, $1/h$ times the variance of the fitted h-period change increases with the horizon h.

Summing up, these results show that the residual fluctuations of yields tend to be filtered out via temporal aggregation. Instead, macroeconomic surprises have persistent effects and hence a stronger explanatory power at lower frequencies. The persistence of the macro-news-driven component reflects the increase of $\gamma^{h,\tau}$ with the horizon h, which is not only large but also statistically significant (see Table 3).[8] As previously discussed, this pattern indicates a slow absorption of the macroeconomic news.

[8] Indeed, we have: $1/h\ \mathrm{var}\left(\widehat{\Delta^{h} y_t^{\tau}}\right) = 1/h\ \left(\widehat{\gamma}^{h,\tau}\right)^2\ \mathrm{var}\ (nix_t^{h,\tau})$. In principle, the higher explanatory power of macroeconomic surprise at lower frequencies might arise also from serial correlation in the daily news index due to unexploited predictability of the releases. Results indicate that this does not play a major role.

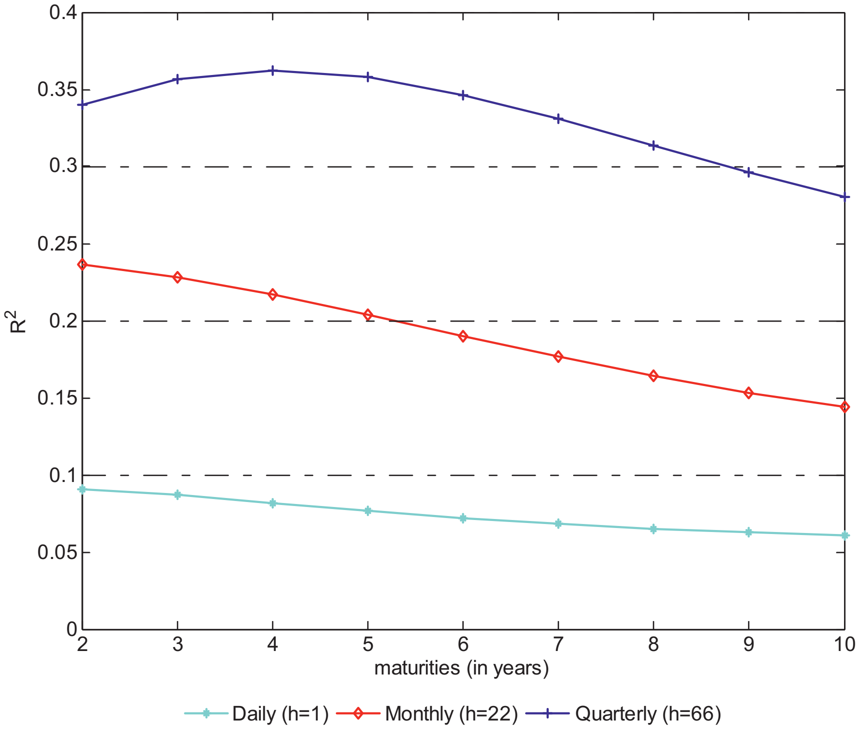

Fig. 2. Measures of fit for daily, monthly, and quarterly bond yield changes.

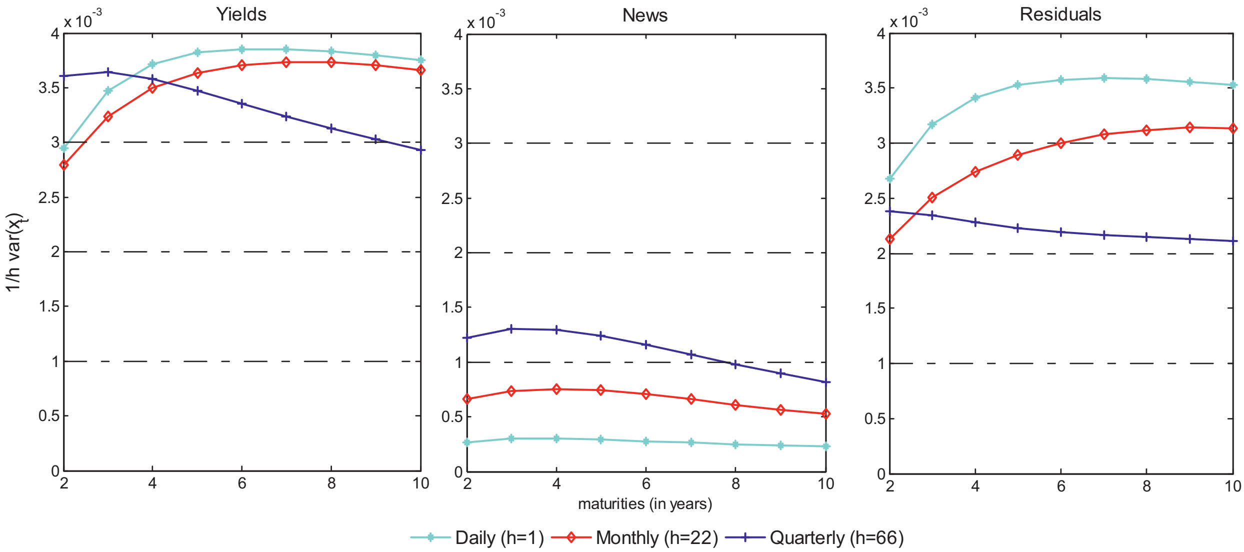

Fig. 3. 1/h times variance of the h difference in bond yield, the fit, and the residuals.

These results reconcile the findings of the high-frequency event-study literature with the evidence obtained in the macro-finance literature. Ang and Piazzesi (2003), Diebold et al. (2006) and Coroneo et al. (2016) show that when estimating models at monthly or quarterly frequencies, significant proportions of the bond yield fluctuations are driven by macroeconomic variables that measure real activity and prices.

Importantly, the results are robust when analyzing the changes in yields using intraday data. More specifically, this analysis estimates the high-frequency regression, shown in Eq. (1), using a window of 30 min instead of 1 day. Following the same methodology of Eqs. (2) to (4), it aggregates the changes in yields and the corresponding fit at daily, monthly, and quarterly frequencies. As reported in Fig. 4, the fits at daily and lower frequencies are essentially the same when the analysis employs intraday data instead of daily data on bond yields.

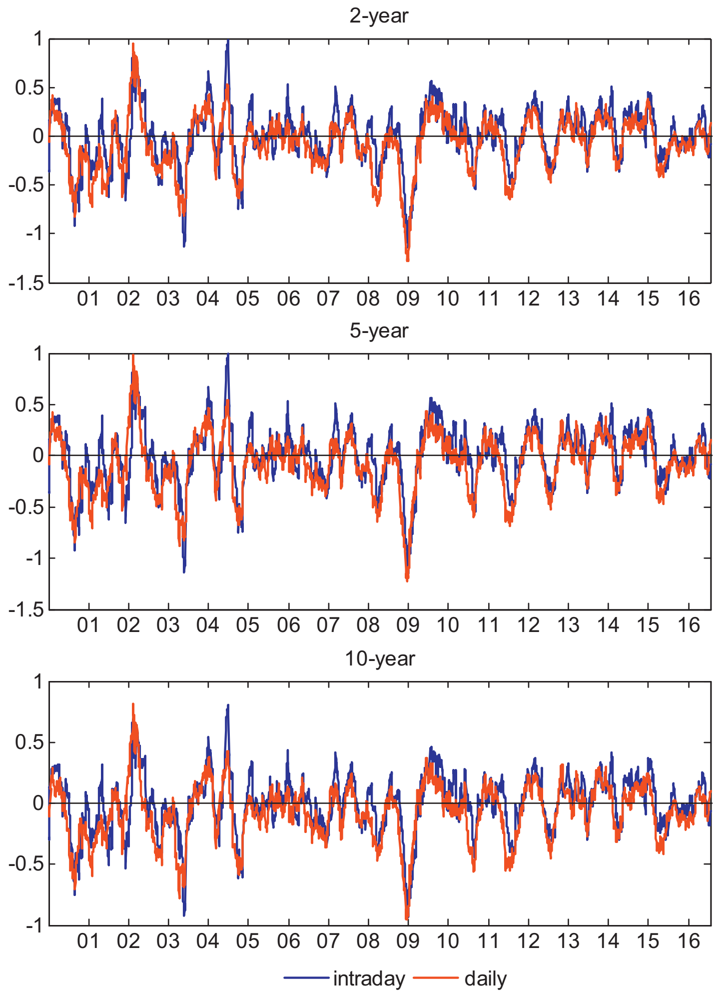

Fig. 4. Low-frequency fit using intraday and daily data.

Interestingly, the general pattern of more variance explained at lower frequencies holds when moving not only from daily to lower frequencies, but also from intraday to daily frequencies. This result might appear to stand in contrast to existing studies that often find an increase in R^2 when the frequency of the observations changes from intraday to daily frequency. That literature, though, typically considers R^2 conditional on macro news being released. Since our interest lies in understanding how much macroeconomic news explain the total fluctuations of bond yields, independently of whether macroeconomic data are released or not, the focus here is on an unconditional R^2.

Fig. 5 shows that macroeconomic surprises explain around 30% of the fluctuations in bond yields in the 30 min window after the releases, as measured by the conditional R^2. However, the number of observations used to compute the conditional R^2, i.e., the number of changes in yields that include a macro release, is only 10% of the total number of observations available in our intraday dataset. The data is limited since during one day very few data are released, with the publication time clustered around 8:30 a.m. As a consequence, only 3% of the total variance is explained, as measured by the unconditional R^2. Enlarging the event window give rise to two contrasting effects: (1) the conditional R^2 decreases due to noise, as traditionally discussed in the event-study literature; and (2) a larger percentage of total variance is captured since the coverage of the sample increases. Results show that the second effect dominates. Of course, at daily frequency, the conditional and unconditional R^2 become very similar since there are releases almost every day.

3. Implications for excess returns, term premia and inflation compensation

The low-frequency fluctuations in yields are closely related to bond returns for investors with holding periods longer than one day.

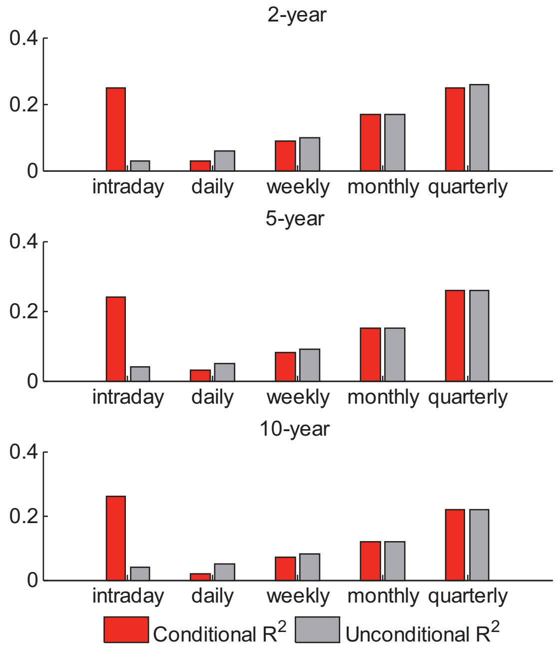

Fig. 5. Conditional and Unconditional measures of fit using intraday data.

To observe this relationship, define the k-day holding period excess bond return ($rx_t^{\tau,k}$) as follows:

$$rx_{t+k}^{k,\tau} = -(\tau - k)y_{t+k}^{\tau-k} + \tau y_t^{\tau} - y_t^{k}, \tag{5}$$

where $-(\tau - k)y_{t+k}^{\tau-k}$ is the (log) price at which a bond with maturity $\tau - k$ is sold at time $t + k$; $-\tau y_t^{\tau}$ is the (log) price paid at time t to buy the same bond when it had maturity τ, and y_t^k is the interest paid for borrowing money at time t for k days. Thus, Eq. (5) can be rewritten as:

$$rx_{t+k}^{k,\tau} = -(\tau - k)y_t^{\tau-k} - (\tau - k)\sum_{i=1}^{k} \Delta y_{t+i}^{\tau-k} + \tau y_t^{\tau} - y_t^{k}. \tag{6}$$

By substituting $\sum_{i=1}^{k} \Delta y_{t+i}^{\tau-k}$ with the fit obtained from Eq. (4), the fitted k-day holding period excess bond return is obtained as follows:

$$\hat{rx}_{t+k}^{k,\tau} = -(\tau - k)y_t^{\tau-k} - (\tau - k)\gamma^{q,\tau-k} nix_{t+k}^{q,\tau-k} + \tau y_t^{\tau} - y_t^{k}. \tag{7}$$

Computing the k-day holding period excess bond returns for maturities of $\tau =$ 24, 36, 48, 60, 72, 84, 96, 108, and 120 months requires the yields with maturity $\tau - k$. These yields can be generated using the parameters of the model proposed by Svensson (1994), which are included in the dataset of Gürkaynak et al. (2007).

Fig. 6 shows the 3-month holding period excess returns for an equally weighted portfolio of bonds with maturities ranging from 2 to 10 years, for the three maturity specific bond yields (2- 5- and 10-year), and the implied fitted values obtained from Eq. (7).

A pseudo out-of-sample exercise helps evaluate the external validity and the robustness of these findings. The regression parameters are estimated only with data up to December 15, 2008, a sample split selected to coincide with the date when the short-term interest rate reached the zero lower bound. The fitted returns for the entire sample are computed using these parameters. The out-of-sample fit is shown in Fig. 6, where the shaded area highlights the period excluded in the estimation and used for the out-of-sample validation.

Fig. 6 shows clearly that the macroeconomic surprises perform well in tracking the 3-month holding period excess bond return and explaining 35% of its fluctuations. The in-sample and out-of-sample fits are almost indistinguishable, indicating that the importance of macroeconomic news in driving bond returns is a robust result and not an artefact due to overfitting or to other spurious effects.

3.1. Implications for term premia

Since the excess return is a proxy for the risk premium, the results above indicate that macroeconomic news might be an important driver not only of expected future rates, but also of the term premia.

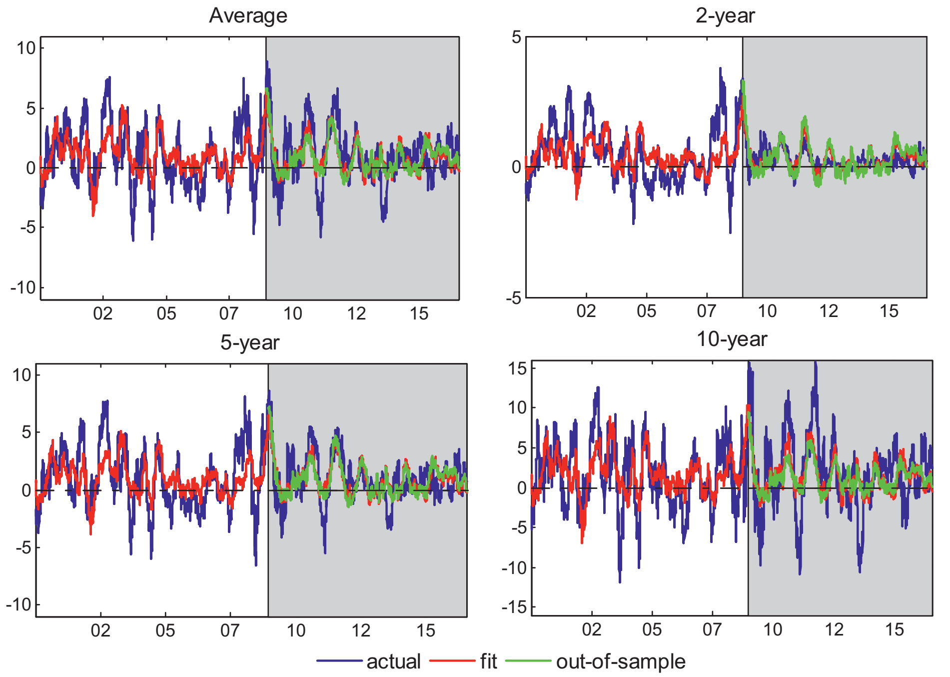

Fig. 6. Three-month holding period excess bond returns.

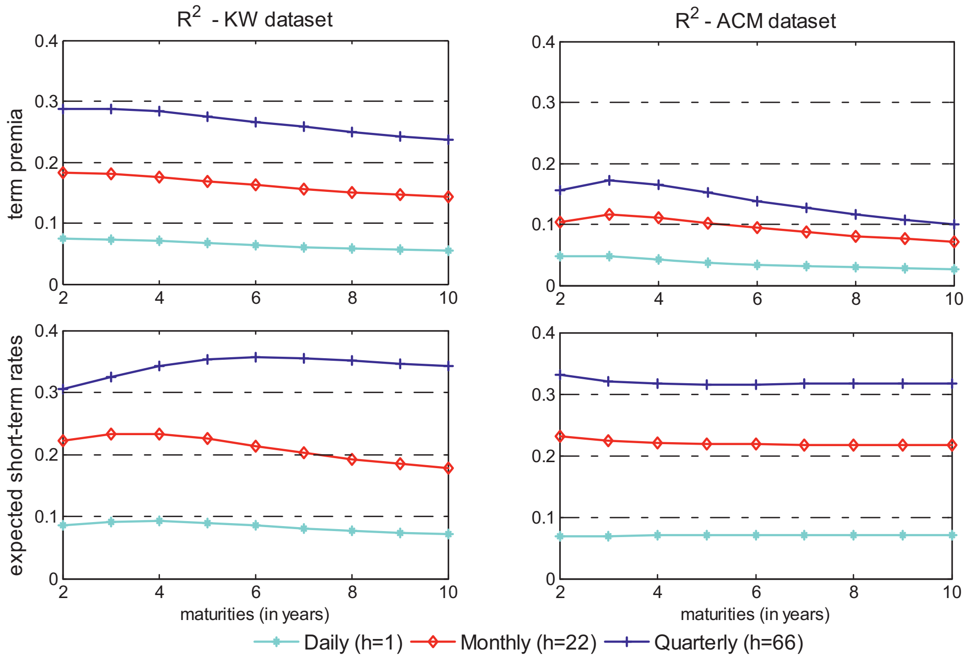

Fig. 7. Measures of fit for term premia and short-term rate expectations.

To explore this question, we use a decomposition of daily bond yields into expected short-term rates and term premia implied by two different models developed by Kim and Wright (2005) and Adrian et al. (2013).[9]

Fig. 7 reports the R^2 obtained by performing the analysis on these two components separately. The results show that macroeconomic surprises are a key factor in the low-frequency fluctuations of both components, with the relative im-

[9] These data are regularly updated and publicly available from the Board of Governors and the New York Fed websites: http://www.federalreserve.gov/pubs/feds/2005/200533/200533abs.html and https://www.newyorkfed.org/research/data_indicators/term_premia.html.

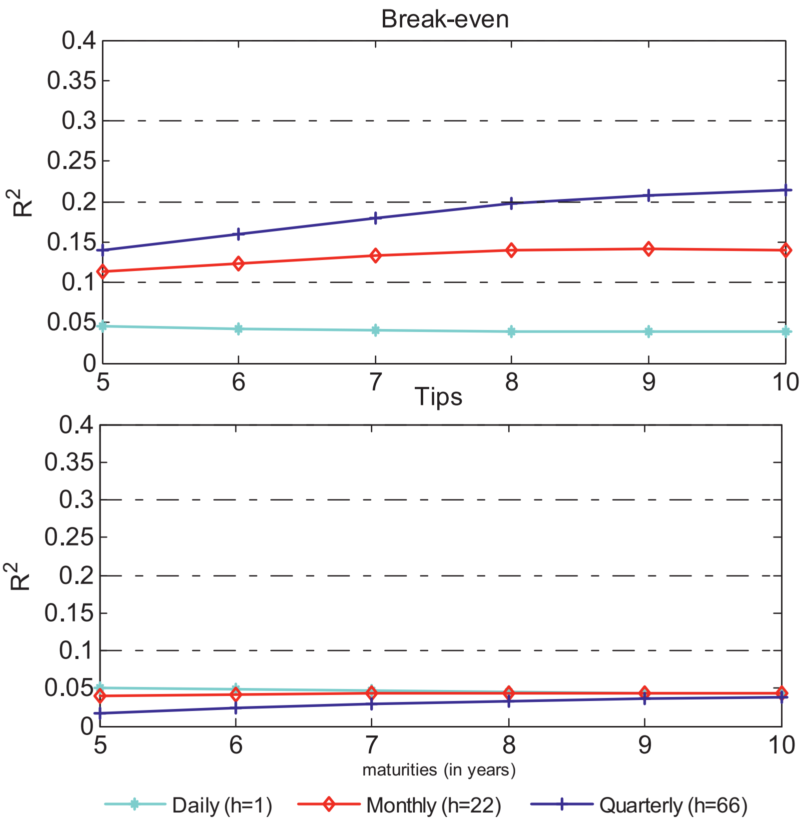

Fig. 8. Measures of fit tor break-even inflation and Tips.

portance of the two components depending on the model used for the decomposition. In particular, macro surprises are important drivers of the term premia of Kim and Wright (2005) but less so of the estimates of Adrian et al. (2013). The importance for the expected short-term rates is large according to both models: macro surprises explain more than 30% of their low-frequency variation at all maturities.

3.2. Implications for inflation compensation

This section analyzes the role of real interest rates and inflation compensation in explaining the low-frequency movements in nominal interest rates. In principle, the explanatory power of the macro releases documented above for the nominal bond yields might reflect a high sensitivity to news of real yields or inflation compensation. In order to disentangle these two components, we use daily data on Treasury Inflation-Protected Securities (TIPS) zero-coupon yields and TIPS break-even inflation (BEI) rates constructed by Gürkaynak et al. (2010b) and available for download (and regularly updated) on the Board of Governors website.

TIPS are indexed bonds issued by the U.S. Treasury, with yields that are linked to future realized (CPI) inflation rates. In the absence of risk and liquidity premia, the difference between the yield on a TIPS for a given maturity and the nominal yield on a Treasury bond at the same maturity would be a good proxy for the market expectations of future inflation. Measures of inflation compensation extracted from TIPS have been extensively used in empirical studies to evaluate the degree to which inflation expectations are anchored. In this literature, the higher the sensitivity of break-even inflation rates to macro surprises, the less anchored inflation expectations are assumed to be. Several empirical studies (e.g., Bauer Michael, 2015; Beechey et al., 2011; Gürkaynak et al., 2010a) found that in the U.S., inflation compensation reacts significantly to surprises in macroeconomic data releases, even at long horizons. This evidence has an important consequence since it would indicate that most of the reaction of nominal interest rates to macroeconomic news can be attributed to inflation compensation rather than to the response of real rates. Beechey and Wright (2009), instead, find that most of the reaction in nominal yields comes from the sensitivity of real rates to macroeconomic news.

Fig. 8 reports the R^2 of TIPS and break-even inflation yields at different maturities. The empirical findings show that inflation compensation is an important factor for explaining the movements in long-term nominal yields following surprises in macroeconomic releases. By aggregating information from a large set of macro surprises through our procedure we can

Table 4
Effects of macroeconomic news on stock prices and the exchange rate .

Releases	TWEX	S&P 500
Advance retail sales	1.47	−2.55
Business inventories	−0.62	−0.02
Capacity utilization	1.70	17.63
Change in nonfarm payrolls	**16.54**	6.59
Consumer confidence	4.30	−5.57
Consumer credit	1.35	6.73
Consumer price index (MoM)	−2.99	−2.00
CPI ex food & energy (MoM)	3.46	−12.37
Domestic vehicle sales	0.76	6.78
Durable goods orders	0.22	10.58
Employment cost index	−0.69	−3.81
Factory orders	**5.50**	**−19.32**
Housing starts	2.71	6.20
Import price index (MoM)	3.72	−14.40
Industrial production	−0.45	−21.07
Initial jobless claims	0.97	−6.76
ISM manufacturing	**9.63**	**21.52**
ISM non-manf. composite	1.91	**19.68**
Leading indicators	5.08	3.31
Monetary policy surprise	5.85	**−25.88**
New home sales	−1.72	−4.02
Personal income	−2.65	−3.36
Personal spending	0.61	8.54
Philadelphia eed.	**−5.46**	**19.14**
PPI ex food & energy (MoM)	**−9.37**	2.01
Producer price index (MoM)	2.25	−5.74
Retail sales less autos	7.63	**35.15**
Trade balance	**6.24**	14.73
Unemployment rate	**−7.20**	0.29
Wholesale inventories	1.44	−7.52
GDP annualized QoQ A	**22.60**	−11.56
GDP annualized QoQ S	9.79	−5.90
GDP annualized QoQ T	−4.64	−3.72
GDP price index A	7.22	6.42
GDP price index S	−2.41	10.83
GDP price index T	−3.95	−27.41
Nonfarm productivity P	−8.62	−3.79
Nonfarm productivity F	**13.16**	−10.66
Unit labor costs P	−8.14	−15.01
Unit labor costs F	5.18	−9.95
U. of Michigan Confidence P	2.76	−2.17
U. of Michigan Confidence F	−0.42	−8.48
R^2		
1-day	0.02	0.01
1-month	0.01	0.04
1-quarter	0.00	0.08
Gamma		
1-month	**0.56**	**1.36**
1-quarter	−0.40**	**1.75**

The table lists the macroeconomic releases used to compute the news indices and the coefficients (in basis points) estimated from Eq. (1) for the trade-weighted U.S. dollar index (TWEX) and the S&P 500 log differences. The values in bold are significantly different from zero at the 5% confidence level and the values with one, two, or three stars are significantly different from one at the 10%,5%, or 1% confidence level (all of the t-stat values are based on HAC standard errors). The final three rows show the R^2 values obtained from: Eqs. (1), daily; and Eq. (4) , monthly (h = 22) and quarterly (h=66). The sample period goes from January 1, 2000, to July 20, 2016.

explain more than 25% of the movements in the 10-year break-even yields but only a marginal fraction of the movements in TIPS (less than 5%).[10]

[10] A possible concern about a direct use of the TIPS yields is that the spread between nominal and indexed bonds would reflect not only a compensation for expected inflation over the life of the bond (the break-even rate), but also liquidity risk premia. Correcting the TIPS and break-even TIPS as in Gürkaynak et al. (2010), i.e., using as a liquidity proxy the trading volume in the TIPS market relative to the entire Treasury market, for a restricted sample (mid-2002 to mid-2016), we again find that macroeconomic surprises explain a substantial fraction of inflation compensation (around 25%, on average, across maturities) with respect to TIPS, but only a marginal fraction of the total variance. Finally, the recent evidence reported in Fleming and Krishnan (2012) suggests that the microstructure of the nominal and real Treasury bond markets is very similar.

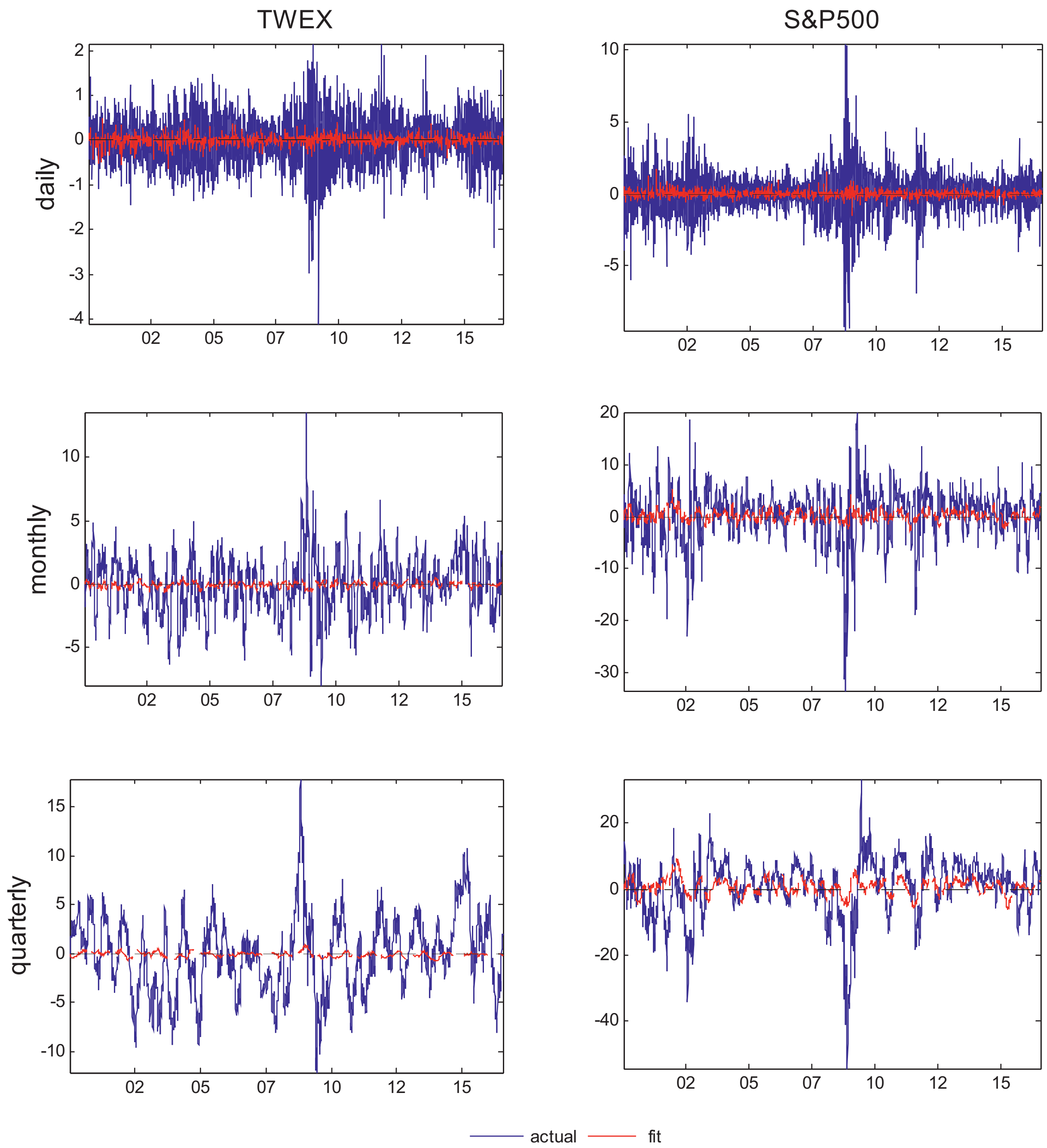

Fig. 9. Other assets.

Results are qualitatively similar when repeating the analysis for the 5-year forward 5-year ahead inflation compensation and TIPS, with macro surprises explaining a larger fraction of the variance for break-even yields (about 15%) than of the TIPS (about 5%).

4. Macroeconomic news, stock prices, and exchange rates

The impact of macroeconomic news on other assets has been previously studied. For example, several event studies have analyzed daily and intraday fluctuations in stock prices and exchange rates (e.g., see Andersen et al., 2003; 2007; Faust et al., 2007), finding generally that these assets are also sensitive to macroeconomic news. This section analyzes the impact of macroeconomic news on longer-horizon changes in the trade-weighted U.S. dollar index (major currencies) and the S&P500

stock price index to assess whether these assets have the same low-frequency sensitivity to macroeconomic news as bond yields. Since foreign macroeconomic news can have an important impact, especially on the exchange rate, the analysis is incomplete.[11] Nevertheless, U.S. economic releases should play a predominant role in determining these asset prices.

Table 4 shows the coefficients obtained from the regression of the daily returns of these assets on the macroeconomic news, which is equivalent to Eq. (1). The fits of the returns due to macroeconomic news over different horizons are shown in Fig. 9.

For the trade-weighted U.S. dollar index, six types of surprises have statistically significant impacts: changes in nonfarm payrolls, the ISM manufacturing index, the producer price index (excluding energy and food), the unemployment rate, the advanced GDP estimate, and the final release of nonfarm productivity. However, macroeconomic surprises do not have a persistent effect on the exchange rate. As shown in Table 4, the R^2 value for the daily changes, obtained using Eq. (1), is equal to 2%, and it becomes lower as we filter out more dependent variables, i.e., the monthly and quarterly R^2 values from Eq. (4) are equal to zero.

In the analysis of S&P500 returns, only four types of macroeconomic surprises have coefficients that differ significantly from zero: news related to capacity utilization, ISM manufacturing and non-manufacturing data, and retail sales data. However, in contrast to the exchange rate results, the effect of U.S. macroeconomic news on the S&P500 stock price index, like bond yields, tends to increase with the horizon, where the R^2 value is 2% for daily changes, 5% for monthly changes, and 15% for quarterly changes. Although the increase in the explanatory power of macroeconomic news with a longer horizon is qualitatively similar to that observed for bond yields, the effect of macroeconomic news on S&P500 returns is quantitatively much smaller.

Part of the reason why the results for stock prices are weaker than the results for government bond yields could be related to the fact that a positive surprise has an ambiguous effect on stock prices since it simultaneously increases expected dividends as well as the discount rate owing to higher interest rate expectations from the central bank. Which effect dominates is an empirical question, since it might depend on several factors such as previous FOMC communications and the current macroeconomic outlook. Since bond prices are influenced only by the discount rate effect, one should expect more unambiguous responses to macroeconomic news. Moreover, it is likely that international macroeconomic surprises are more important for stock returns than for bond yields, but this topic is one for future research.

5. Conclusions

Using high frequency data and a novel approach to isolate low frequency effects, this paper shows that macroeconomic surprises explain a significant fraction of the low-frequency fluctuations in long-term Treasury bond yields. More than one-third of the quarterly movement in bond yields is driven by the unexpected component of macroeconomic releases. This result is mainly owing to the persistent effects that macroeconomic surprises have on bond yields.

Importantly, the findings presented in the paper reconcile the event-studies evidence that macroeconomic surprises account for only a small proportion of the daily variation in bond yields with the evidence coming from macro-finance models, estimated at monthly or quarterly frequencies, where macroeconomic variables explain a significant fraction of the fluctuations in excess bond returns.

Similar results do not emerge when applying the same methodology to other financial assets. The power of macroeconomic surprises to explain stock and exchange rate returns remains small even when cumulating the impact of the surprises at lower frequencies.

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[11] This is certainly part of the reason why the current literature studies exchange rates only with intraday and/or tick data.

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