Time variation in asset price responses to macro announcements*

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Abstract

Although the effects of economic news announcements on asset prices are well established, these relationships are unlikely to be stable. This paper documents the time variation in the responses of yield curves and exchange rates using high frequency data from January 2000 through August 2011. We find significant time variation in news effects. The time variation in effects of payrolls surprises is partly explained by risk conditions: government bond yields increase in response to "good news", but less so when risk is elevated. Risk conditions capture the effects of uncertainty on the information content of news announcements, the interaction of monetary policy and financial stability objectives of central banks, and the effect of news announcements on the risk premium. After controlling for risk, we show that the difference between bond yield responses to payrolls news in the zero-lower-bound period and in the pre-crisis period is small and not statistically significant.

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1 Introduction

A rich literature has established that macroeconomic data announcements, such as inflation releases and employment payrolls reports, move markets. The magnitudes of the effects of economic news are often discussed as if rules-of-thumb underlie the relationships. Yet, there is little reason to expect the relationship between news surprises and asset price responses to be stable over time: these responses likely vary with economic conditions, with the uncertainty in the policy outlook, with evolving perceptions of central bank objectives and with markets' risk sentiment. Furthermore, the sensitivity of asset prices to news is affected by the zero lower bound (ZLB) on nominal interest rates: when short rates are at the ZLB, they cannot fall in response to "bad news", and they may not rise – if short rates are sufficiently constrained – in response to "good news" either.

In recent work, Swanson and Williams (2014a, 2014b) use the sensitivity of bond yields to macroeconomic data announcements as an indicator of the efficacy of monetary and fiscal policy in an environment where short-term interest rates are constrained by the ZLB. At the ZLB, while the central bank cannot stimulate the economy through cuts in the policy rate, monetary policy may still be able to influence longer-term yields through communication or asset purchase programs. Meanwhile fiscal policy is expected to be a more effective tool for stimulating the economy: at the ZLB a fiscal policy expansion is associated with a smaller increase (or no effect at all) in interest rates, and therefore does not "crowd out" investment. The level of short-term interest rates is not a sufficient indicator for whether the ZLB is binding: rather, it is the responsiveness of yields to shocks, including fiscal and monetary policy or their drivers, that matters. For short-term rates this sensitivity to news could decline well before policy rates have reached their lower bound, while longer-term yields may remain sensitive to news even when policy rates are at the ZLB.

In this paper, we explore the pattern of time-variation in the effects of news on bond yields and exchange rates, and argue that time variation should be viewed as an empirical regularity. We document the time variation in consequences of US economic news on the interest rates and exchange rates of the US, UK, Germany, and France using high frequency data for the period from 2000 to 2011. As the source of this time variation is important for policy and real outcomes, we explore the drivers. In particular, we relate the observed time-variation patterns to macroeconomic conditions, to measures of risk (the VIX index, or Libor-OIS spreads as a robustness check), and to the ZLB.

We find that for many economic data announcements, responses of US bond yields are stable. However, those announcements that have the largest effect on markets – especially the non-farm payrolls report, but also CPI and GDP announcements – elicit yield responses that are time-varying and statistically significant. This time variation could have a number of sources, which we motivate in the context of Taylor-rule type models of policy reaction functions. We conjecture that time variation in how yields respond to news can arise as the policy outcomes of news change, which could be attributed to a perceived reweighing of inflation and output preferences within monetary reaction functions, to altered implications of a unit of

news for forecasts of output or inflation as the economy moves closer to or further from targets, to changing risk preferences among investors, or to a change in the role of financial stability conditions in the priorities of central banks. Empirically, we show that risk conditions are the most important driver of changes observed in asset price responsiveness to payrolls news. In particular, while US bond yields usually increase in response to "positive"US macroeconomic news, the increase is smaller when risk conditions are elevated.

The role of risk in explaining time variation in economic news effects likely reflects two possibly complementary channels. First, markets may view the Federal Reserve as less likely to raise rates in times of increased financial turmoil, perhaps due to a latent financial stability objective. Second, markets may place less weight on news announcements when the relationship between these news and the economic outlook is more uncertain: the information content of the news may be diminished when overall risk is elevated. Quantitatively, we find that the responses of US 2-year bond yields to a positive one standard deviation surprise in non-farm payrolls vary between -2 and +13 basis points (measured over the window including 5 minutes before and after the release), compared with an average effect of 5 basis points between 2000 and 2011. Quantitatively similar results arise over the 30 minute and full day windows.

Our estimates indicate that between 2009 and 2011 – with the effective federal funds rate below 25 basis points – responses of 2-, 5- and 10-year yields were similarly responsive to payrolls news as in the 2000-2007 period. While yield responsiveness to news declined at the height of the crisis in fall 2008, this drop was brief and in our regression specification is captured well by the increase in risk at that time. After we control for risk conditions, there is no statistically significant difference between bond yield responses to news in the ZLB period and in the pre-ZLB period. For example, US-2-year yields have on average increased 5 basis points in response to a positive one-standard deviation surprise in non-farm payrolls. During the ZLB-period this effect was 0.6 basis points lower, but this difference is not statistically significant. For 5- and 10-year yields, yield responses to news are slightly larger in 2009-2011 compared to 2000-2008. Risk sentiment, rather than a ZLB-constrained short-term nominal interest rate, explains the drop in yield sensitivity at the height of the crisis.

The remainder of the paper is structured as follows. Section 2 provides a brief review of the related literature. Section 3 describes data and empirical methods, and section 4 reports the baseline results for responses of US yields to 8.30am US data announcements, as well as tests for evidence of gradual time variation in these responses. Section 5 explores how asset price responses to news announcements vary with changes in macroeconomic and financial conditions. Section 6 reports results for news responses of exchange rates and international bond yields. Section 7 reports robustness of our results to alternative empirical specifications. Finally, section 8 concludes with a discussion of the economic relevance of time variation and open questions for research.

2 Relationship to the previous literature

A large number of papers has established that asset prices respond to macroeconomic data announcements, and are thus directly linked to underlying economic fundamentals. Most authors find that economic news is incorporated quickly (within minutes) into asset prices, with some measurable persistence of these effects. Some types of news – for example, US non-farm payrolls announcements – generate larger asset price responses than others. News which are more timely (in the sense that the announcement date and the reference date are close together), more precise (in the sense of being subject to smaller revisions on average), and contain more information (in the sense of being better able to better forecast GDP growth, inflation or central bank policy decisions) have a larger effect on asset prices (Andersen et al. (2003), Hautsch and Hess (2007), Gilbert et al. (2014)).

Several studies have also considered time variation in the effect on asset prices of a given type of announcement. In an early contribution, Cocco and Fischer (1989) find evidence that the response of US interest rates to money announcement surprises is stable over time within a linear model where the news response coefficient is assumed to follow an AR(1) process.[1] More recently, studies have estimated the effect of news separately over different sample periods and tested for parameter constancy. Using a Nyblom (1989) test, Faust et al. (2007) argue that the effects of news are mostly stable over time. However, they also find evidence that some news effects on asset prices have fallen over time in absolute magnitude. Fratzscher (2009) finds that positive US macro announcements were associated with an appreciation of the US dollar between 1994 and 2008, but with a depreciation of the US dollar between 2008 and 2009. Using rolling regressions and random effects models applied to data that span 1993 to 2008, Ehrmann et al. (2011) find that the responses of euro area bond yields to data announcements became more similar across countries after the introduction of the EMU.

A number of papers have gone beyond showing that time variation exists and have highlighted specific reasons for that variation. Four findings emerge. First, asset price responses to news often appear to be non-linear: negative surprises have larger absolute effects than positive surprises, and larger surprises generate a disproportionately larger response (Andersen et al. (2003), Andersen et al. (2007), Ehrmann and Fratzscher (2005), Hautsch and Hess (2007)). Second, policy reaction functions are constrained by the existence of a zero lower bound on interest rates (Swanson and Williams (2013a, 2013b) and Kiley (2013)). Third, the reaction may depend on the state of the economy with news announcements have a larger effects on bond yields during economic contractions (Andersen et al. (2007). The sign of the response of stock prices to real announcements (unemployment) also depends on the state of the economy: higher than expected unemployment increases stock prices in expansions and reduces stock prices in recessions. This asymmetric response could reflect the effect of news on expected interest rates, expected cash flows or the risk premium. As argued by Boyd et al. (2005), the discount rate effect dominates in expansions (higher unemployment implies lower expected interest rates), while the cash flow effect dominates in contractions (higher unemployment implies lower ex-

[1] See also Fischer (1989).

pected earnings).[2] Ehrmann and Fratzscher (2007) find larger exchange rate responses to news following weeks of high FX volatility, following a string of news announcements that surprised markets in the same direction, and following a string of large surprises. They conclude that uncertainty matters for the news response. Fourth, market participants may change their view of central bank priorities. Goldberg and Klein (2011) find that time variation in euro area bond yield responses to news evolved in the years after the introduction of the euro. They show that the pattern of evolution was consistent with the markets viewing the ECB as having established more inflation-fighting credibility after a few years of operation and responses to macroeconomic conditions.

Building on these earlier papers, we focus squarely on time variation in the response of cross-country bond yields and exchange rates to US macroeconomic announcements using high frequency data for the period between 2000 and 2011. Relative to the previous literature our paper makes three contributions. First, we provide a deeper evaluation of time variation in the effects of economic news on asset prices, applying the econometric techniques of Elliott and Müller (2006) and Müller and Petalas (2010). Second, we show that time variation should be viewed as the default condition and that asset price responses to news regularly change with risk conditions and macroeconomic context, as well as with (likely less frequent) changes in perceived policy reaction functions. Third, we provide evidence using a rich set of data, including across countries, and over a relevant historic period. The high frequency asset price data covers the period from 2000 to 2011, which encompasses the global financial crisis and changes in the state of the macroeconomic and policy environment.[3]

Our results also relate to work on the sensitivity of news at the ZLB. Swanson and Williams (2014a,b) estimate a specification where the news sensitivity of asset prices changes over time, but where the relative sensitivity to different news indicators remains stable. We take a different route: using the Elliott and Müller (2006) test we begin by assessing time variation for each individual macroeconomic data announcement. In a second step, we focus only on those announcements where news responses are found to be time-varying. We then ask whether news responses are significantly smaller at the ZLB, after controlling for economic and financial factors that might also drive time variation in news responses. We conclude that the ZLB effect is generally insignificant in specifications that control for changes in market risk conditions. The implication is that the effects of key ecnomic news variables on financial market asset prices are not restricted by the ZLB in general. Rather elevated risk conditions would be the driver of reduced responsiveness of asset prices.

[2]Conrad et al. (2002) show that the response of stock prices to earnings announcements depends on the level of the overall stock market.

[3]A paper that is related to ours is Liebermann (2011), which studies time variation in the response of US government bond yields to US macro news. Our paper differs from Liebermann (2011) in several ways: (1) we use high-frequency data, rather than daily data; (2) we apply modern econometric tests that can detect gradual time variation in bond yield sensitivity; and (3), we explore the drivers of time variation, including risk conditions and the role of the ZLB.

3 Data and methodology

3.1 Data

The data releases we examine pertain to United States economic activity, including those indicators that have been previously established as important for generating price reactions, and are those for which market expectations are available.[4] We focus on only those data releases that have announcement times of 8:30am Eastern Standard Time (EST), a restriction that facilitates our work of collecting high frequency asset price data over an eleven year interval and still captures the majority of important US announcements. The data releases we include are: the consumer price index (CPI, total and excluding food and energy), the change in non-farm payrolls, the unemployment rate, GDP, housing starts, core inflation in personal consumption expenditures (PCE), personal income and spending, retail sales less autos, and the empire manufacturing survey. Data sources, frequency, and units are provided in Table 1. Most series have 140 observations for the 2000 to 2011 period, given that releases are typically monthly and the sample spans about eleven years.

[Table 1 about here]

The economic news that lead to asset price updating are constructed, following the convention in the literature, as the difference between the actual release value and the markets' prior expectation of the contents of the release. The expectations data we use are median responses from weekly surveys of market participants conducted by Money Market Services, a division of Standard & Poor's, for the early part of the sample and more recently from Action Economics or Bloomberg News.[5]

The bond yield and exchange rate series are constructed from high-frequency data drawn from transaction-level databases from Thomson-Reuters, supplemented by BrokerTec data for U.S. bond yields (Table 2). We focus mainly on U.S. 2, 5, and 10 year bond yields for the United States. In section 6 we also report results for 2, 5 and 10 year bond yields for the United Kingdom, Germany, and France, as well as for US dollar exchange rates versus the euro and the pound.[6]

[Table 2 about here]

[4] Some examples are Fleming and Remolona (1999), Andersen, Bollerslev, Diebold and Vega (2003), Goldberg and Leonard (2003), Ehrmann and Fratzscher (2005), Gürkaynak, Sack and Swanson (2005), Faust, Rogers, Wang and Wright (2007), and Bartolini, Goldberg, and Sacarny (2008).

[5] Money Market Services were the source of these data through December 2003. Haver Analytics provided continuous expectations and announcement data through 2005 using data from Action Economics. Gürkaynak and Wolfers (2007) show that these data have been among the best performing expectations series for important macroeconomic variables over the sample period that we analyze. Later period data were drawn from Bloomberg.

[6] The BrokerTec data had the most complete coverage of U.S. 2, 5, and 10 year transactions in Treasuries. However, these data report price information but not the yield. We compile the coupon rates for the 2-, 5-, 10 year treasury over the time period and use the price, settlement date, and maturity date to compute the yields.

From the transaction-level observations we build observed prices for each date and time window relevant for our analysis. The windows are chosen to allow for information diffusion and to generate sufficient transaction observations at each date. The price at a time stamp such as 8:25am in our analysis is constructed as the average of all transaction prices in the two minutes on either side of the indicated time (so 8:23-8:27am in this example). In the case of the spot exchange rate observations, the spot transaction prices are constructed as the average of bid and ask prices, or just the bid or ask price if information on only one of the two prices is reported for a transaction.

Our empirical exposition presents results for asset price responses to news over the windows from 8:25am to 8:35am, and from 8:25am to 4pm. We also have run all specifications for the windows: 8-8:35am, 8-9am, 8am-4pm, 8:25-9am, and 8:25am-4pm. The exposition focuses only on the short window and the long window since these results appropriately reflect the trade-offs associated with window selection and implicit in prior studies. A tight time frame for market reactions – as reflected in the 8:35 end time – has the advantage of capturing a spontaneous market response. Yet the short window could be too abbreviated to capture analysis of news by market participants and thus may miss the full market reaction. The broader time frame, as reflected in a 4pm closing time, allows for a more thorough analysis of the information content of the announcement, but, as stressed in Andersen et al. (2003), introduces the likelihood that additional information during the longer time frame could bias the coefficients (if correlated with the announcement surprise included in the regression) or cloud the significance of the estimated effects.

3.2 Empirical methods

The empirical approach to estimating the relationship between news and asset prices proceeds in three steps. First, the high-frequency asset price responses to economic data surprises are estimated in a setting where the effects of news surprises are assumed to be constant over time. This analysis complements earlier studies which have looked at the same types of effects of news on asset prices but over different sample periods and using different data sources. The results serve as an analytical benchmark for our subsequent analysis of time-varying coefficients. In the second step, we employ econometric methods developed by Elliott and Müller (2006) and Müller and Petalas (2010) to test for time variation in the effects of data surprises on asset prices, and to estimate the parameter paths of these effects. Third, we explore the contributions of

Bond yields are constructed using the formula

$$YIELD = \frac{\left(\frac{redemption}{100} + \frac{rate}{freqency}\right) - \left(\frac{par}{100} + \frac{A}{E} \times \frac{rate}{freqency}\right)}{\frac{par}{100} + \frac{A}{E} \times \frac{rate}{freqency}} \times \frac{frequency \times E}{DSR}$$

where A denotes the number of days from the beginning of the coupon period to the settlement date (accrued days); DSR is the number of days from the settlement date to the redemption date; E is the number of days in the coupon period; and $frequency$ is the number of coupon payments per year. For annual payments, $frequency = 1$; for semiannual, $frequency = 2$; for quarterly, $frequency = 4$; $rate$ is the security's annual coupon rate; $redemption$ is assumed to be \$100, for every \$100 of the bond; and par is the quoted transaction price in dollars for every \$100 of the bond.

macroeconomic and financial conditions to the observed time variation in the effects of economic data surprises on financial markets.

For the first step we estimate the linear model:

$$q_{t^+} - q_{t^-} = \sum_{k=1}^{K} \beta_k s_{k,t} + \varepsilon_t \tag{1}$$

where $q_{t^+} - q_{t^-}$ is the change in asset price q over a time window from t^- to t^+ around t, $s_{k,t}$ is the surprise component of the kth data announcement released at time t, and β_k are parameters assumed to be constant.[7] US announcements made at t =8.30am Eastern time and the alternative time windows $t^+ - t^-$ have $t^- \in \{8\text{am}, 8{:}25\text{am}\}$ and $t^+ \in \{8{:}35\text{am}, 9\text{am}, 4\text{pm}\}$. The asset prices are both exchange rates (US dollar per foreign currency, in logs) and US and foreign bond yields. The economics news surprises are defined as

$$s_{k,t} = \frac{x_{k,t} - E\left(x_{k,t}\right)}{\widehat{\sigma}_{x_k}}$$

where $E\left(x_{k,t}\right)$ is the median expectation from the surveys of market participants conducted prior to the release of announcement $x_{k,t}$ and $\widehat{\sigma}_{x_k}$ denotes the standard deviation of $x_{k,t} - E\left(x_{k,t}\right)$. We refer to "positive" surprises as those that indicate that the US economy is more expansionary than expected, such as larger than expected payrolls, housing starts, GDP, manufacturing, retail sales, income, spending, and smaller than expected unemployment. In terms of inflation, we define positive surprises as higher than expected inflation. Higher inflation could reflect stronger demand or more adverse productivity, wage, or cost conditions. As such, inflation news may have less consistent effects on asset prices and exchange rates.

The second step of our analysis tests whether β_k is time-varying. We conjecture that the standard assumption that the slope coefficient β_k in model (1) is constant over time is unrealistic. This is due both to business cycle variation and economic and financial market turmoil such as observed in the global financial crisis. If time varying, the third step examines the economic mechanisms that explain the observed behavior of β_k. We allow β_k to change gradually over time, rather than restricting β_k to exhibit discrete changes over a set of break points. Gradual movements in coefficients are economically more plausible than discrete changes if market participants are learning and updating their expectations over time. We consider the following specification:

$$q_{t^+} - q_{t^-} = \sum_{k=1}^{K} \beta_{k,t} s_{k,t} + \varepsilon_t \tag{2}$$

To test whether $\beta_{k,t}$ indeed varies significantly over time and to compute its path we employ recently developed methods by Elliott and Müller (2006) and Müller and Petalas (2010). Elliott and Müller (2006) suggest a *quasi-local level* test that for a wide range of models is asymptoti-

[7] In our regressions we have either $K = 1$ or $K = 2$. Three pairs of indicators have simultaneous releases: non-farm payrolls and the unemployment rate, personal spending and personal income, and CPI and CPI ex-food and energy.

cally (in large samples) equivalent to the optimal test for a particular process of time variation.[8] That is, we do not need to make specific assumptions about the process for $\beta_{k,t}$ – for example, assumptions about specific discrete break dates – and then employ a test that is valid and efficient under these assumptions; a single test is sufficient, at least for sufficiently large samples, to judge whether $\beta_{k,t}$ exhibits time variation.[9] Elliott and Müller (2006) provide critical values for the test, with the null hypothesis of parameter stability being rejected if the test statistic is smaller (more negative) than the critical values. Müller and Petalas (2010) complement those tests with an algorithm that computes the asymptotically accurate path for $\beta_{k,t}$ over time. They also show how to compute the approximate equal-tailed posterior probability interval for the estimated parameter path. Strictly speaking this is not a confidence interval, but rather an estimate of the interval that minimizes weighted average risk. Using these methods we present the estimated parameter path for $\beta_{k,t}$ in model (2) and report tests for whether the observed time variation is statistically significant.

4 Results for US bond yields

4.1 Asset price responses to macroeconomic data announcements

The first set of results presented replicates the type of evidence in prior studies, and covers the response of US government bond yields to US macroeconomic data announcements using the standard specification of equation (1), with coefficients assumed to be stable over time. Table 3 summarize the results, with columns corresponding to specific types of economic news. The reported coefficients correspond to the average change in 2, 5 or 10 year bond yields over the window, expressed in basis points, associated with a one-standard deviation news surprise. We expect coefficients pertaining to expansionary US economic news to be positive. The ex ante sign of the effect of US inflation surprises is ambiguous, although one would expect a positive coefficient if central banks raise interest rates more than one-for-one with inflation, for example as suggested by a Taylor-rule type principle.

[Table 3 about here]

Consistent with earlier studies, most macroeconomic data announcements have highly significant effects on US bonds yields, across all maturities. By the far the strongest effects are due to news in non-farm payrolls. Where responses to real activity announcements are statistically significant, they always have the expected sign: announcements which show that real economic

[8] Elliott and Müller (2006) report simulations that show that using the small-sample efficient test rather than the asymptotically equivalent quasi-local level test does not result in a significant loss of power in finite samples.

[9] In the model

$$y_t = \beta_{1t} x_{1t} + \beta_{2t} x_{2t} + \varepsilon_t$$

the Elliott-Müller quasi-local-level test can be used to test whether either (1) β_{1t} is time varying given that $\beta_{2t} = \beta_2$ is constant, (2) β_{2t} is time varying given that $\beta_{1t} = \beta_1$ is constant, or (3) β_{1t} and β_{2t} are jointly time varying. Thus we cannot test time variation of β_{1t} independently of time variation of β_{2t}.

activity is stronger than expected are associated with an increase in bond yields. Core inflation announcements have a statistically significant impact on US bond yields across horizons, while headline CPI news (released in the same report) are mostly not statistically significant and typically negative. For most announcements, and in particular for those announcements with highly significant effects on US bond yields, 2- and 5-year yields react more strongly than 10-year yields. This finding is consistent with the hump-shaped response of bond yields to US macro news documented by Faust et al. (2007).

4.2 Time variation in the effects of news

The time variation in asset price responses to US macroeconomic data announcements is captured using results from the Elliott and Müller (2006) quasi-local level test. The null hypothesis that β_k in regression model (1) is stable is rejected if the test statistic is sufficiently negative. If two economic news indicators a and b are released simultaneously, the test statistic for data release a corresponds to the null that β_a is stable, computed under the assumption that β_b is stable as well.

[Table 4 about here]

Table 4 reports the test statistics for alternative time windows. The null that the responses of US bond yields to non-farm payrolls over the 8.25-8:35am window are stable can be rejected at the 1% level. Thus, the economic news announcements with by far the largest effects on markets have time-varying effects on bond yields. For core consumer prices and GDP announcements parameter stability can be rejected at least at the 5% level. The standard assumption of parameter stability in asset price responses to news is a good approximation for some news announcements, as Faust et al. (2007) concluded using different tests, data, and estimation windows. However, this assumption of stability can be rejected for those announcements that are associated with the largest market movements – in particular, the non-farm payrolls announcements, core CPI and GDP – each of which exhibits significant time variation.[10]

4.3 Estimated parameter paths

To provide more in depth analysis of the magnitude and drivers of this time variation, we narrow both the set of asset prices and news announcements. We focus on US payrolls announcements, which have the largest effects on markets as well as being the indicator with the strongest evidence for time variation in asset price responses and clear ex ante priors on directional effects.[11] We focus on US 2- and 10-year yields and the short response window.

[10] As shown in section 7, our findings of time variation in coefficient β_k in regression (1) are not simply the consequence of our assumption of a linear relationship between news surprises and asset price responses.

[11] The critical values for the Elliott and Müller (2006) quasi-local level test are based on the assumption of normally distributed shocks. While this assumption may be problematic for several our regressions, it appears to be a good approximation for regressions with US bond yields and non-farm payrolls / unemployment rate

Figure 1 presents estimated parameter paths for the responses of US 2- and 10-year yields to payrolls surprises over the 8.25-8:35am window, computed using the Müller and Petalas (2010) method, together with an indication of the uncertainty associated with the estimates.[12] The effect of a unit of news in non-farm payrolls on US bond yields ranges between -2 and +13 basis points per one-standard deviation surprise. This compares to a highly significant 4-6 basis points estimate in the constant-coefficient regression model. The estimated coefficient paths peak in 2004, during a period of robust economic growth when the Federal Reserve began a series of 25 basis point rate hikes (starting in May 2004). The timing of the estimated peaks also matches the statement by Federal Reserve Chairman Alan Greenspan in February 2004 that the Fed was paying particular attention to the payrolls data.[13] The estimated effects of payroll surprises on US bond yields decline in fall 2008, in particular during the months before and after the Lehman bankruptcy. The response US 10-year yields over the 8:25am-4pm window briefly turned negative in fall 2008.

[Figure 1 about here]

5 Exploring the sources of time variation

5.1 Empirical framework

In this section we formally relate time variation in asset price responses to news to changes in macroeconomic and financial conditions. To fix ideas, suppose that market interest rates i_t evolve according to the process:

$$i_t = \phi_t \left[\mathbb{E}_t \left(y_t \right), \mathbb{E}_t \left(\pi_t \right), R_t \right] \tag{3}$$

where $\phi_t \left(\cdot \right)$ denotes some possibly non-linear function; y_t is a measure of economic activity such as the unemployment rate, the output gap or GDP growth; π_t is the inflation rate; R_t stands for "risk"; and $\mathbb{E}_t \left(\cdot \right)$ denotes expectations formed by market participants. This equation is general enough to capture the fact that, according to the expectations hypothesis of the term structure of interest rates, longer-term bond yields reflect markets' expectations about future short-term yields. Short-term yields are determined by central bank policy decisions, which in turn can be modelled as some version of the Taylor rule. The inclusion of risk as one determinant of interest

surprises. In Jarque-Bera tests the null that the disturbances of these regressions over the 8.25-8:35am window come from a Gaussian distribution can never be rejected at conventional levels of statistical significance (p-values of 0.24 for 2-year yields, 0.50 for 5-year yields and 0.45 for 10-year yields). In the corresponding regressions over the longer 8:25am-4.00pm window the assumption of normal shocks may be problematic for US 2-year yields (p-value of 0.06), but not for 5- and 10-year yields.

[12] The time paths are computed under the assumption that the coefficient on unemployment rate surprises is constant, as suggested by the tests reported in Tables 4. If the coefficients on both payrolls and unemployment are allowed to change over time the estimated time paths for payrolls are very close to those reported here.

[13] See Gürkaynak and Wright (2013) for a description of this episode.

rates is intended to capture three separate effects. First, the central bank could have a financial stability mandate and thus directly react to increases in risk. Second, the risk premium on government bond yields could depend on changes in measures of risk appetite. And third, risk could affect the (perceived) forecasting power of macro announcements for subsequent economic outcomes.[14] The subscript t of the function $\phi_t(\cdot)$ allows for the possibility that the central bank reaction function changes over time.

The response of a bond yield to the surprise component of some macroeconomic data announcement, s_t, is given by

$$\frac{di_t}{ds_t} = \sum_i \frac{\partial \phi_t}{\partial Z_{it}} \frac{dZ_{it}}{ds_t} \tag{4}$$

where $Z_{it} \in \{\mathbb{E}_t(y_t), \mathbb{E}_t(\pi_t), R_t\}$. This equation succinctly captures three reasons why the response of bond yields to macroeconomic data surprises of a given magnitude are likely to vary over time. First, the implications of the surprise for market expectations of the relevant macroeconomic variables, dZ_{it}/ds_t, could vary with the state of the business cycle. Second, the market-perceived monetary policy reaction function could vary as $\partial\phi_t/\partial Z_{it}$ changes over time. This is naturally the case if the Taylor rule is non-linear, that is if $\partial\phi_t/\partial Z_{it}$ itself depends on Z_{it}. And third, the reaction of risk premia to macroeconomic data announcements could change.

The first case has received some attention in the literature, as discussed in section 2, with di_t/ds_t depending on whether recent data announcements have persistently surprised on the upside or downside, on the absolute magnitude of past surprises, or on asset price volatility before the release. These papers argue that this finding reflects changes in how markets interpret the news surprise, i.e. reflecting time variation in dZ_{it}/ds_t. The second case of $\partial\phi_t/\partial Z_{it}$ has some support from Hamilton et al. (2011), who use the response of fed funds futures to news announcements, together with postulated updating equations for expectations of inflation and output, to argue that market expectations of the Fed's reaction function have changed over time.[15] Other support is provided by Goldberg and Klein (2011), who show that changing news effects on euro area yields are consistent with a perceived firmer anti-inflation stance of the ECB in its early years. The third effect of risk premia consequences from news has received limited attention, with the exception of Faust et al. (2007) who combine estimates of the response of US and foreign bond yields and exchange rates to macro announcements with the assumption of a constant expected depreciation rate to deduce implications of announcement surprises for foreign exchange risk premia. In their analysis, positive US macro news are interpreted as associated with a decline in the foreign exchange risk premium required to hold foreign currency investments.

[14] Engel and West (2005) and Engel, Mark, and West (2007) make this point forcefully in the context of exchange rate models.

[15] There is an active debate over whether monetary policy responses to macroeconomic conditions has changed over time. See for example Clarida, Gali and Gertler (2000), Sims and Zha (2006), Goldberg and Klein (2011), and Hamilton et al. (2011). For evidence of non-linearities in the central bank reaction function see for example Assenmacher-Wesche (2006) and Markov and Porres (2012).

We explore how asset price responses to news depend on Z_{it} by estimating the regression:

$$q_{t^+} - q_{t^-} = \sum_{k=1}^{K} \delta_k s_{k,t} + \sum_{k=1}^{K} \sum_{i=1}^{3} \tau_k s_{k,t} Z_{it} + \varepsilon_t \tag{5}$$

This specification allows for a differential impact of news surprises depending on the value of Z_{it}. The coefficients τ_k capture the joint influence of the three effects discussed in the previous paragraph. In the baseline specification reported below we use the CBOE volatility index (VIX) as a measure of risk. The VIX is a key measure of (risk-neutral) market expectations of near-term volatility conveyed by S&P 500 stock index option prices.[16] As the VIX index trades from 9:15-4:15pm (EST), the regressions use prior day close values. We measure US macroeconomic conditions using real-time data for PCE inflation and the unemployment rate from the Alfred database at the Federal Reserve Bank of St. Louis.

5.2 Results

As before, we focus on the time variation in responses of US bond yields to payrolls announcements. Because non-farm payrolls and the unemployment rate are released jointly we include both indicators in the regression. However, since only the payrolls response was found to exhibit statistically significant time variation we include interaction terms for our macroeconomic- and financial variables with payrolls only.

[Table 5 about here]

The results confirm the strong effects of payrolls news across the US yield curve. While the non-interacted payrolls news enters with the expected positive sign, economic and financial conditions could influence the magnitude and potentially the sign of this effect both over the short and longer windows. The Taylor rule variables inflation and unemployment never enter significantly when they are included individually.[17] However the VIX index is robustly linked with the time-variation in the responses of US bond yields to payrolls announcements. While US yields increase on average following positive payrolls surprises, the increase is smaller when risk is elevated. The coefficient on the VIX index is always negative and significant at the 1 percent level, across all maturities and across time windows.

We also examine whether there is time variation in payrolls effects that is specifically attributable to the ZLB. We capture the ZLB period through a dummy variable that equals one if the federal funds target rate has reached its lowest level (the target rate was lowered to the range of 0 to 25 basis points in December 2008), and zero otherwise. For 2-year yields the coefficient on the ZLB dummy is negative, consistent with the idea that the ZLB on short rates

[16] See `http://www.cboe.com/spx`.

[17] Curiously, when all variables are included jointly, inflation and unemployment turn out to have a statistically significant link with US bond yield responses to payrolls surprises.

dampens the responsiveness of yields to news. But the coefficient is never statistically significant, and moreover turns positive for 5-year yields (not shown in the table) and 10-year yields. This observation is consistent with Figure 1: yield responsiveness dropped temporarily in 2008, but in our regression specification this drop is well captured by the increase in risk during this period. Figure 1 does not show any major *permanent* downward shift in news responsiveness during the crisis. Therefore, these results imply that longer-term bond yields were surprisingly responsive to news in 2009-2011, despite the fact that very short rates were constrained by the ZLB.

Consider the effects of a payroll report that is 80000 jobs higher than expected (a one standard deviation surprise) at a time when risk conditions are low, as characterized by a VIX of 16 which is at the 25 percentile of the distribution of values observed during the time period that we examine. The expected effect on 2 year yields would be an increase of 6.4 basis points, with an increase of 5.5 basis points on 10 year yields. By contrast, with an elevated VIX at 26, which is at the 75 percentile of the observed distribution, the effects on yields would decline to 4.5 and 3.7 basis points respectively.

6 Results for exchange rates and international bond yields

As international transmission of US economic conditions and policy also is important, we perform similar econometric analysis on exchange rates between the US dollar and the euro and pound, and for 2, 5 and 10 year yields on UK Gilts, German Bunds, and French BTANs (maturity 2 and 5 years) and OATs (10 year). As expected, the effects of US news surprises on US financial markets are much stronger than their effects on foreign markets. The order of magnitude of news effects across European bonds is similar for the German, French and UK yields, consistent with the results of earlier studies such as Ehrmann and Fratzscher (2005) and Goldberg and Klein (2011). However, over the full interval of our study (2000 to 2011) and using the shorter response window (8:25-8:35am), only a selection of news announcements are associated with a statistically significant effect on foreign bond markets, especially non-farm payrolls reports and inflation releases.

[Table 6 about here]

Table 6 shows broader patterns of significant asset price responses over the 8:25am to 4pm window, where payrolls, unemployment, retail sales, core inflation and GDP releases all enter significantly. The effects of non-farm payrolls on US dollar exchange rates have the expected signs and are significant at the 1% level, with an R^2 of between 0.16 and 0.22. Whenever the news effects on exchange rates are statistically significant at least at the 10% level, the corresponding coefficients have the expected negative sign, so that positive US macro surprises are associated with dollar appreciation. This result accords with Ehrmann and Fratzscher (2005), but contrasts with findings in the earlier literature, such as Faust et al. (2007) and Andersen et al. (2003, 2007), all measured over earlier periods.

[Table 7 about here]

Table 7 presents evidence for time variation in the responses of foreign interest rates and exchange rates to US news, with significance primarily found for US non-farm payrolls and (for some asset prices) unemployment announcements. We again explore the sources of this time variation using specification (5). We conjecture that the forces at work for foreign yields are likely to be similar to those driving variation in US bond yields, with some modifications: the response of the risk premium to macro announcements would depend on whether foreign government bonds are considered "safe-haven"assets or not, the importance of financial stability considerations would depend on foreign financial stability concerns, and the strength of the spillover effects through trade and financial links with the US.[18] The response of US dollar bilateral exchange rates to macro announcements during the crisis should reflect the expected movements of US and foreign interest rates, as well as the movement of the risk premium of foreign currency versus the US dollar. For example, the finding in Fratzscher (2009) that the US dollar appreciated in response to negative US data surprises rather than depreciated (as is usually the case) in 2008-2009 could be interpreted as evidence for an increase of the risk premium on foreign currency.[19] In related work, Faust et al. (2007) decompose exchange rate responses to macro announcements into the components attributable to changes in interest rates, changes in expected future depreciation rates, and changes in the risk premium.

[Table 8 about here]
[Table 9 about here]

Selected results on the decomposition of drivers of time variation are reported in Table 8 for German bond yields and in Table 9 for exchange rates. The coefficient on the VIX index in the regressions for German bond yields is negative, consistent with the results for US yields, but only weakly statistically significant in long rates. Risk is again the only variable that is found to exhibit a statistically significant link with USD bilateral exchange rate returns in response to payrolls news. The US dollar appreciates versus the euro and the pound on average when payrolls surprise on the upside, but less so when the VIX index is elevated. This is consistent with the finding that the coefficients on risk conditions are always larger in magnitude for US bond yields than for German bond yields: when the VIX index is elevated the payrolls effect on US bond yields falls by more than that on foreign yields (relative to the average effects), corresponding to a smaller than average appreciation of the US dollar versus the euro. The ZLB does not significantly influence the effect of US economic news on these asset prices and exchange rates

[18] Habib and Stracca (2012) explore the empirical determinants of safe-haven currencies.

[19] Alternatively, the US dollar may have appreciated as international investors scrambled for US dollar liquidity. For a discussion of the drivers behind the US dollar appreciation in 2008 see also Kohler (2010) and McCauley and McGuire (2009).

7 Robustness

7.1 Non-linear effects of news announcements

In this section we provide evidence that our findings of time variation in coefficient β_k in regression (1), reported in Table 4, are not simply the consequence of our assumption of a linear relationship between news surprises and US asset price responses. As mentioned in section 2, previous studies have found evidence for non-linear effects of macroeconomic data announcements, with negative surprises having larger effects than positive surprises, and larger surprises having disproportionately larger effects. Posited reasons for such asymmetry could be that policy itself may be asymmetric, with fast rate cuts and slow, smoothed rate increases.[20]

We therefore consider the following regression:

$$q_{t^+} - q_{t^-} = \sum_{k=1}^{K} \left(\mathbb{1}_{s_{k,t}>0} \beta_{1kt} s_{k,t} + \mathbb{1}_{s_{k,t}<0} \beta_{2kt} s_{k,t} + \beta_{3kt} s_{k,t}^2 \right) + \varepsilon_t \tag{6}$$

where $\mathbb{1}_{s_{k,t}>0}$ is an indicator function which equals one if the kth surprise is positive, $s_{k,t} > 0$, and zero otherwise. There is indeed evidence that news surprises have non-linear effects.[21] Table 10 reports Elliott and Müller (2006) quasi-local-level tests for all news announcements, for the 8:25-8:35am window. The null hypothesis in these tests is that all coefficients in regression (6) that correspond to the news announcement listed in the columns are jointly time-varying.[22] Even after controlling for non-linear effects, we still find strong evidence of time variation in the response of US bond yields to non-farm payrolls and core inflation over the short and medium window.

[Table 10 about here]

7.2 Alternative methods for assessing time variation

In this section we compare our assessment of time variation in news responses – obtained using methods recently developed by Elliott and Müller (2006) and Müller and Petalas (2010) – to more standard approaches. While the methods we use have a number of desirable statistical properties, there have so far been only few applications of them. Therefore it is useful to see how results differ from those obtained with more widely used methods. In particular, we consider Nyblom tests for an unknown breakpoint.

[Table 11 about here]

[20] This would be the case for a central bank that has financial stability concerns and thinks the Ricardian equivalence fails, with the private sector being effectively net long holders of government debt. In that case, rate cuts will be fast as these help private balance sheets but increases will be slow and these hurt holders of bonds, particularly banks.

[21] Detailed results are available from the authors upon request.

[22] Note that the critical values depend on the number of coefficients that are allowed to be time-varying in the regression. Therefore the test statistics from Tables 4 and 10 are not directly comparable.

Table 11 reports Nyblom tests applied to the responses of US yields to news. Using this standard test, the null of no structural breaks can almost never be rejected. Even for non-farm payrolls, stability can only be rejected over the short 8.25-8.35am window, and only at the 10 percent level. However, this test is not well suited to pick up variation in news responses that are gradual and do not exhibit clear structural breaks. In contrast, the Elliot-Müller (2006) test is designed to pick up gradual time variation; and yields evidence of time variation for a number of response coefficients.

We also compared our results for the time-varying effects of payrolls on US yields (Figure 1) with results obtained from rolling regressions and random coefficient models.[23] The paths for the random coefficients model and Müller and Petalas (2010) are very similar. The rolling regressions paths is sightly more volatile, depending on the window length chosen. Overall these alternative approaches for computing parameter paths give very similar results.[24]

7.3 Sources of time variation

This subsection discusses the robustness of the results for the drivers of time variation in responses of US government bond yields to payrolls surprises. Detailed results for the robustness checks are available from the authors upon request.

First, the results are robust to alternative ways of measuring macroeconomic- and financial conditions. We implemented a variety of alternative specifications, with risk proxied by Libor-OIS spreads rather than the VIX index, and with expectations of future inflation and unemployment measured from the survey of professional forecasters, published by the Federal Reserve Bank of Philadelphia. For this latter set of robustness checks, we proxy for the macroeconomic outlook on day t by using the latest available survey published prior to day t. Let t' denote the quarter during which this latest survey was conducted. We measure the outlook for inflation as the mean response for CPI inflation between quarters $t'-1$ and $t'+3$, and the outlook for real activity using forecasts for the unemployment rate in quarter $t'+3$.[25] These alternative measures of US macroeconomic conditions have advantages and drawbacks for the purpose of explaining time variation in financial market responses to news. Real-time data for output, unemployment and inflation has the advantage that it is available on a monthly basis, and therefore may most accurately capture the data available on a given day. In contrast data from the survey professional forecasters is available only quarterly and can therefore be somewhat stale when explaining the effects of news on a given day. On the other hand, the macro outlook is likely to be more important for markets and for monetary policy makers than

[23] Payrolls and unemployment are released jointly, but as in Figure 1 we only allow the coefficient of payrolls ($s_{1,t}$) to vary (as indicated by the results from the time variation tests):

$$\begin{aligned} q_{t^+} - q_{t^-} &= \beta_{1,t} s_{1,t} + \beta_2 s_{2,t} + \epsilon_t \\ \beta_{1,t} &= \beta_{1,t-1} + \upsilon_t \end{aligned}$$

with β_2 assumed stable.

[24] Detailed results are available from the authors upon request.

[25] We also experimented with output gap data computed by HP-filtering US real GDP, and with using expected changes in real activity (unemployment or GDP).

the current situation. Overall, the results are consistent with those reported in Table 5: risk exhibits a statistically significant link with payrolls responses, with a negative coefficient; the other variables are not statistically significant when included individually or jointly with the risk measure.

Second, we checked whether the time-variation results are driven by a particular sample period. We ran the specifications excluding the early part of the crisis period (2008-2009) to test whether the results for the VIX index are driven by this particular episode. We also ran a specification excluding the 2003-2005 period which contained a series of 25 basis point increases in the federal funds rate. The results for both specifications are again consistent with Table 5.

Third, we consider an alternative to the regression specification (5), using $\hat{\beta}_{kt}$, the Müller-Petalas estimate of the coefficient on announcement k at time t from regression (2), as a dependent variable:

$$\hat{\beta}_{kt} = \gamma_0 + \sum_{i=1}^{3} \gamma_i Z_{i,t} + \varepsilon_t \tag{7}$$

We adjust the standard errors of the estimates of γ_i to account for the use of a generated dependent variable, as proposed by Dumont et al. (2005).[26] This specification has the advantage that it permits a direct decomposition of the time variation in news effects into the components associated with the economic state variables and with a risk proxy. The disadvantage is that errors are highly serially correlated. The results again are closely in line with those from Table 5.

8 Conclusion

The effects of economic news on government bond yields and US dollar exchange rates vary considerably. We have shown that this variation occurs both in regular economic conditions and in more stressed periods. The changes are particularly pronounced for those macro announcements that have the largest impact on markets. Time variation in news effects can be economically important. For example, the estimated response of US 2-year government bond yields to a 1 standard deviation surprise in payrolls announcements – representing about 80000 jobs – varies between -2 and +13 basis points. We show that gradual and large quantitative time variation in news effects, and that time variation in news effects is explained by macroeconomic and financial conditions. US bond yields usually increase in response to "good news", but less so when risk is elevated. This result reflects some combination of a market perceived financial stability objective for the monetary policy in the United States and an influence of risk on the uncertainty associated with the link between macro announcements and the economic outlook.

[26] In particular, let $\gamma = [\gamma_0, \gamma_1, \gamma_2, \gamma_3]'$ and define Z as a $T \times 4$ matrix whose tth row is $Z_t = [1, Z_{1t}, Z_{2t}, Z_{3t}]$. Then we can estimate the unconditional variance of $\hat{\gamma}$ as

$$Var\left(\hat{\gamma}\right) = \left(Z'Z\right)^{-1} Z' \left[Var\left(\hat{\beta}_k\right) + \sigma_\varepsilon^2 I\right] Z \left(Z'Z\right)^{-1}$$

Müller and Petalas (2010) show how to compute the $T \times T$ variance-covariance matrix $Var(\hat{\beta}_k)$, whose (t,t)th entry is the variance of $\hat{\beta}_{kt}$. For σ_ε^2 we use the Newey-West corrected estimate of the variance of the residuals of (7).

Spillovers to foreign markets are consistent with results along the US yield curve.

We find that US bond yields were responsive to key news releases in 2009-2011, despite the fact that the policy rate was constrained by the zero lower bound. While yield responsiveness did decline at the height of the crisis, this drop was temporary and can empirically be well explained by the increase in risk during this episode. Despite constraints on interest rates at the very short end of the yield curve, the zero lower bound did not significantly change the responsiveness of longer maturity bond yields. Disentangling the reasons for this effect, for example whether due to quantitative easing and communications effects, is an important area for future research.

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Table 1: US macroeconomic announcements

Data Release	Source[1]	Frequency	First release	Last release	Units	Obs.
Nonfarm Payrolls	BLS	Monthly	1/7/2000	8/5/2011	Change MoM[2]	140
Unemployment Rate	BLS	Monthly	1/7/2000	8/5/2011	% rate	140
Retail Sales Less Autos	Census	Monthly	1/13/2000	8/12/2011	% change MoM[2]	140
CPI Ex Food & Energy	BLS	Monthly	1/14/2000	8/18/2011	% change MoM[2]	139
CPI	BLS	Monthly	1/14/2000	8/18/2011	% change MoM[2]	140
Housing Starts	Census	Monthly	1/19/2000	8/16/2011	Millions	140
GDP	BEA	Quarterly	1/28/2000	7/29/2011	% change QoQ[2,3]	47
Personal Income	BEA	Monthly	1/31/2000	8/2/2011	% change MoM[2]	138
Personal Spending	BEA	Monthly	1/31/2000	8/2/2011	% change MoM[2]	137
Empire Manufacturing	NY Fed	Monthly	11/15/2002	8/15/2011	Diffusion index	105
PCE Core	BEA	Monthly	6/30/2005	8/2/2011	% change MoM[2]	74

[1]Acronyms for the sources: BEA, Bureau of Economic Analysis; BLS, Bureau of Labor Statistics; Census, Bureau of the Census; NY Fed, Federal Reserve Bank of New York; Acronyms for units: MoM, month over month; QoQ, quarter over quarter.
[2]Seasonally adjusted
[3]Annualized

Table 2: High-frequency exchange rate and bond yield data

Asset	Country	Source	Data starts	Data ends
Bond Yields[1]	United States	BrokerTec, Thomson-Reuters	1/2000	8/2011
	United Kingdom	Thomson-Reuters	1/2000	8/2011
	Germany	Thomson-Reuters	1/2000	8/2011
	France	Thomson-Reuters	1/2000	8/2011
Spot Exchange Rate	EURUSD	Thomson-Reuters	1/2000	8/2011
	GBPUSD	Thomson-Reuters	1/2000	8/2011

[1]Two, five and ten year bonds

Notes: Exchange rates are expressed in terms of USD per foreign currency.

Table 3: Effects of news on US bond yields: constant coefficient estimation

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire	PCEcore
8.25am-8.35am											
2-year yields	4.83***	1.88***	1.49***	1.41***	0.02	0.30**	1.80***	-0.16	0.31***	0.59***	0.31**
5-year yields	5.25***	1.74***	1.56***	1.49***	-0.03	0.30**	1.87***	-0.15	0.33***	0.69***	0.37***
10-year yields	4.01***	1.16***	1.33***	1.33***	-0.06	0.31***	1.53***	-0.01	0.26***	0.49***	0.36***
8.25am-4pm											
2-year yields	5.92***	1.30*	1.72***	1.47**	-0.11	0.39	2.52**	-0.30	0.74	0.98**	0.84
5-year yields	4.60***	1.00	2.21***	1.29*	0.14	0.10	2.32**	-0.29	0.76	1.14**	0.86
10-year yields	3.57***	0.78	1.49***	1.42**	-0.46	0.19	1.82*	-0.27	0.39	1.02**	0.96

Notes: This table reports coefficients β_k from regression (1). ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. The announcement surprises in columns are: change in nonfarm payrolls, unemployment rate, retail sales less autos, CPI ex food & energy, (MoM), CPI (MoM), housing starts, GDP (QoQ, annualized), personal income, personal spending, empire manufacturing, core PCE (MoM). Yields refers to benchmark government bond yields.

Table 4: Tests for time variation in effects of news on US bond yields

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire	PCEcore
8.25am-8.35am											
2-year yields	-14.58***	-5.97	-8.85**	-12.81***	-2.85	-7.58*	-8.55**	-2.63	-4.12	-4.33	-2.63
5-year yields	-14.68***	-5.36	-5.51	-11.62***	-3.27	-7.25*	-9.87**	-2.01	-5.16	-3.64	-2.82
10-year yields	-15.36***	-5.73	-4.69	-9.89**	-3.94	-8.19*	-10.25**	-0.98	-6.12	-4.68	-4.03
8.25am-4pm											
2-year yields	-8.42**	-3.26	-2.43	-5.02	-5.60	-7.58*	-8.35*	-4.30	-4.78	-5.11	-4.16
5-year yields	-10.54**	-3.61	-5.03	-3.36	-6.14	-10.38**	-8.45**	-2.90	-4.57	-4.13	-3.68
10-year yields	-11.46***	-3.88	-2.53	-3.91	-5.39	-6.48	-8.55**	-3.27	-5.17	-2.89	-5.70

Notes: This table reports test statistics for the Elliott and Müller (2006) *quasi-local level* test. The null hypothesis is that the coefficients corresponding to the announcements listed in columns are stable. The null is rejected if the test statistic is sufficiently negative. ***, **, and * denote rejection of the null at the 1%, 5% and 10% level, respectively. The announcement surprises in columns are: change in nonfarm payrolls, unemployment rate, retail sales less autos, CPI ex food & energy, (MoM), CPI (MoM), housing starts, GDP (QoQ, annualized), personal income, personal spending, empire manufacturing, core PCE (MoM). Yields refers to benchmark government bond yields.

Table 5: Sources of time variation in responses of US bond yields to non-farm payrolls surprises: regression specification (5), 8:25am-8:35am window

	(1)	(2)	(3)	(4)	(5)	(6)
2-year yields						
Payrolls	4.83***	7.27**	3.98*	9.43***	4.95***	9.51***
Unemployment	1.88***	2.02***	1.90***	2.00***	1.87***	1.99***
Payrolls × inflation		-1.48				
Payrolls × UR			0.14			
Payrolls × VIX index				-0.19***		-0.19***
Payrolls × ZLB dummy					-0.67	-0.49
$\bar{R}^2$	0.46	0.48	0.46	0.54	0.46	0.54
observations	128	126	128	128	128	128
10-year yields						
Payrolls	4.01***	8.55***	1.79	8.41***	3.91***	8.30***
Unemployment	1.16***	1.28***	1.21***	1.28***	1.17***	1.29***
Payrolls × inflation		-2.87*				
Payrolls × UR			0.36*			
Payrolls × VIX index				-0.18***		-0.19***
Payrolls × ZLB dummy					0.51	0.66
$\bar{R}^2$	0.44	0.49	0.45	0.55	0.44	0.56
observations	131	129	131	131	131	131

Notes: This table reports coefficients from regression (5) for US bond yields over the short 8:25am-8:35am window. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. Inflation (core PCE, yoy) and the unemployment rate (UR) are measured based on real time data. VIX is the CBOE VIX index on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

Table 6: Effects of news on exchange rates and international bond yields: constant coefficient estimation for the 8:25am-4:00pm window

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire	PCEcore
FX Spot											
EURUSD	-0.25***	-0.12***	-0.03	-0.01	-0.05	0.03	-0.17**	0.00	-0.10***	-0.05	-0.01
GBPUSD	-0.18***	-0.09**	-0.02	-0.04	0.01	0.01	-0.07	0.04	-0.06**	0.02	-0.05
2-year yields											
DE	2.25***	0.81*	0.66*	0.60*	-0.20	0.08	0.94	-0.05	0.38	0.42	0.07
FR	2.39***	1.06**	0.67**	0.54*	-0.20	0.34	1.44*	-0.11	0.47*	0.43	0.16
GB	3.11***	1.24**	1.85	0.74**	-0.12	-0.05	0.95	-0.35	0.18	0.06	-0.37
5-year yields											
DE	2.65***	0.87*	1.04**	0.73**	-0.40	0.09	1.77**	-0.48	0.46	0.49	0.40
FR	2.53***	0.71	1.07**	0.95***	-0.29	0.04	1.32	-0.10	0.36	0.46	0.07
GB	1.91***	0.94**	0.52	0.74*	-0.55	-0.09	1.31*	-0.45	0.31	0.15	-0.29
10-year yields											
DE	2.13***	0.69*	0.92**	0.81**	-0.46	0.16	1.32**	-0.02	0.44	0.36	0.50
FR	2.11***	0.47	0.77**	0.74**	-0.34	0.11	1.54***	-0.00	0.41	0.22	0.65
GB	2.03***	0.94**	0.75	0.46	-0.06	0.07	1.22	-0.57**	0.25	0.25	-0.13

Notes: This table reports coefficients β_k from regression (1). ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. The announcement surprises in columns are: change in nonfarm payrolls, unemployment rate, retail sales less autos, CPI ex food & energy, (MoM), CPI (MoM), housing starts, GDP (QoQ, annualized), personal income, personal spending, empire manufacturing, core PCE (MoM). Exchange rates are expressed as US dollar per foreign currency (log percentage change). Yields refers to benchmark government bond yields (change in basis points).

Table 7: Tests for time variation in effects of news on exchange rates and international bond yields, 8:25am-4:00pm window

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire	PCEcore
FX Spot											
EURUSD	-8.04*	-4.05	-4.32	-4.34	-7.81*	-4.39	-3.17	-6.95	-4.34	-2.73	-3.35
GBPUSD	-7.95*	-5.26	-4.27	-3.30	-4.40	-3.43	-4.81	-4.50	-3.09	-3.20	-4.99
2-year yields											
DE	-8.13*	-8.38**	-2.94	-5.20	-5.24	-6.83	-5.67	-4.93	-5.25	-4.27	-2.77
FR	-9.07**	-9.14**	-3.74	-7.18*	-5.14	-4.98	-5.71	-3.70	-5.83	-3.26	-3.26
GB	-5.62	-4.04	-2.98	-2.48	-2.43	-6.92	-3.12	-2.21	-5.10	-4.00	-3.29
5-year yields											
DE	-9.42**	-7.73*	-3.47	-4.36	-7.48*	-6.69	-4.19	-3.60	-7.79*	-3.85	-4.23
FR	-10.50**	-6.44	-3.53	-5.53	-7.77*	-6.16	-4.25	-3.96	-8.61**	-3.63	-2.97
GB	-9.52**	-6.78	-3.07	-2.65	-2.27	-5.41	-3.53	-4.69	-5.95	-4.24	-5.06
10-year yields											
DE	-10.01**	-9.72**	-3.93	-3.83	-7.39*	-5.45	-3.12	-4.94	-5.72	-3.57	-4.52
FR	-8.98**	-10.29**	-2.85	-3.46	-6.67	-5.98	-2.70	-3.64	-5.88	-3.36	-5.37
GB	-9.10**	-10.76**	-2.86	-3.83	-6.90	-4.67	-4.75	-3.81	-7.21*	-4.77	-4.75

Notes: This table reports test statistics for the Elliott and Müller (2006) *quasi-local level* test. The null hypothesis is that the coefficients corresponding to the announcements listed in columns are stable. The null is rejected if the test statistic is sufficiently negative. ***, **, and * denote rejection of the null at the 1%, 5% and 10% level, respectively. The announcement surprises in columns are: change in nonfarm payrolls, unemployment rate, retail sales less autos, CPI ex food & energy, (MoM), CPI (MoM), housing starts, GDP (QoQ, annualized), personal income, personal spending, empire manufacturing, core PCE (MoM). Exchange rates are expressed as US dollar per foreign currency. Yields refers to benchmark government bond yields.

Table 8: Sources of time variation in responses of German bond yields to non-farm payrolls surprises: regression specification (5), 8:25am-4:00pm window

	(1)	(2)	(3)	(4)	(5)	(6)
2-year yields						
Payrolls	2.25***	6.38***	0.32	2.89**	2.12***	2.77**
Unemployment	0.81*	0.91**	0.87*	0.83*	0.83*	0.85*
Payrolls × inflation		-1.88**				
Payrolls × UR			0.33			
Payrolls × VIX index				-0.03		-0.03
Payrolls × ZLB dummy					0.87	0.89
$\bar{R}^2$	0.16	0.19	0.17	0.16	0.16	0.17
observations	129	129	129	129	129	129
10-year yields						
Payrolls	2.13***	4.24**	0.61	3.63***	1.94***	3.46***
Unemployment	0.69*	0.74*	0.74*	0.73*	0.72*	0.77*
Payrolls × inflation		-0.96				
Payrolls × UR			0.26			
Payrolls × VIX index				-0.06*		-0.06*
Payrolls × ZLB dummy					1.15	1.20
$\bar{R}^2$	0.20	0.21	0.21	0.22	0.21	0.23
observations	137	137	137	137	137	137

Notes: This table reports coefficients from regression (5) for German bond yields. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. US inflation (core PCE, yoy) and the US unemployment rate (UR) are measured based on real time data. VIX is the CBOE VIX index on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

Table 9: Sources of time variation in responses of exchange rates to non-farm payrolls surprises: regression specification (5)

	(1)	(2)	(3)	(4)	(5)	(6)
EURUSD						
Payrolls	-0.25***	-0.43	-0.16	-0.63***	-0.23***	-0.62***
Unemployment	-0.12***	-0.13***	-0.12***	-0.13***	-0.12***	-0.13***
Payrolls × inflation		0.09				
Payrolls × UR			-0.02			
Payrolls × VIX index				0.02***		0.02***
Payrolls × ZLB dummy					-0.07	-0.08
$\bar{R}^2$	0.16	0.17	0.17	0.23	0.17	0.23
observations	140	140	140	140	140	140
GBPUSD						
Payrolls	-0.18***	0.15	-0.42***	-0.54***	-0.19***	-0.56***
Unemployment	-0.09**	-0.08**	-0.08**	-0.10***	-0.09**	-0.10***
Payrolls × inflation		-0.15				
Payrolls × UR			0.04*			
Payrolls × VIX index				0.02***		0.02***
Payrolls × ZLB dummy					0.11	0.10
$\bar{R}^2$	0.14	0.17	0.16	0.25	0.15	0.25
observations	140	140	140	140	140	140

Notes: This table reports coefficients from regression (5) for exchange rates. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. US inflation (core PCE, yoy) and the US unemployment rate are measured based on real time data. VIX is the CBOE VIX index on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

Table 10: Tests for time variation in effects of news on US bond yields: non-linear specification (6)

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire
8.25am-8.35am										
2-year yields	-27.28***	-12.81	-14.24	-19.07*	-14.60	-12.26	-18.05	-9.86	-11.89	-12.49
5-year yields	-28.31***	-17.10	-11.65	-20.08**	-16.27	-14.08	-17.67	-10.08	-10.33	-11.64
10-year yields	-29.51***	-18.24*	-11.05	-17.86	-17.11	-14.82	-17.56	-9.21	-9.70	-12.29
8.25am-4.00pm										
2-year yields	-17.58	-11.33	-10.93	-14.74	-13.32	-11.42	-19.16*	-8.00	-8.08	-21.92**
5-year yields	-20.46**	-15.43	-13.53	-14.09	-14.44	-13.64	-18.04	-6.31	-9.15	-17.17
10-year yields	-20.29**	-13.32	-10.80	-16.30	-15.26	-12.25	-17.29	-7.94	-10.22	-13.12

Notes: This table reports test statistics for the Elliott and Müller (2006) *quasi-local level* test for specification (6). The null hypothesis is that the coefficients for the non-linear effects of the announcements listed in columns are stable. The null is rejected if the test statistic is sufficiently negative. ***, **, and * denote rejection of the null at the 1%, 5% and 10% level, respectively. The announcement surprises in columns are: change in nonfarm payrolls, unemployment rate, retail sales less autos, CPI ex food & energy, (MoM), CPI (MoM), housing starts, GDP (QoQ, annualized), personal income, personal spending, empire manufacturing, core PCE (MoM). Yields refers to benchmark government bond yields.

Table 11: Tests for time variation in effects of news on US bond yields: Nyblom tests for unknown breakpoint

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire	PCEcore
8.25am-8.35am											
2-year yields	0.38*	0.12	0.29	0.35	0.08	0.18	0.36*	0.04	0.07	0.09	0.08
5-year yields	0.38*	0.09	0.08	0.33	0.08	0.20	0.31	0.04	0.08	0.05	0.05
10-year yields	0.36*	0.10	0.08	0.26	0.12	0.20	0.27	0.01	0.14	0.07	0.05
8.25am-4.00pm											
2-year yields	0.22	0.05	0.03	0.09	0.13	0.45*	0.13	0.28	0.21	0.14	0.05
5-year yields	0.23	0.10	0.08	0.07	0.12	0.68**	0.14	0.12	0.15	0.11	0.07
10-year yields	0.22	0.15	0.06	0.13	0.12	0.36*	0.16	0.10	0.23	0.08	0.12

Notes: Nyblom test for parameter stability. The null of stability is rejected if the test statistic is sufficiently large. ***, **, and * denote rejection of the null at the 1%, 5% and 10% level, respectively. The announcement surprises in columns are: change in nonfarm payrolls, unemployment rate, retail sales less autos, CPI ex food & energy, (MoM), CPI (MoM), housing starts, GDP (QoQ, annualized), personal income, personal spending, empire manufacturing, core PCE (MoM). Yields refers to benchmark government bond yields.

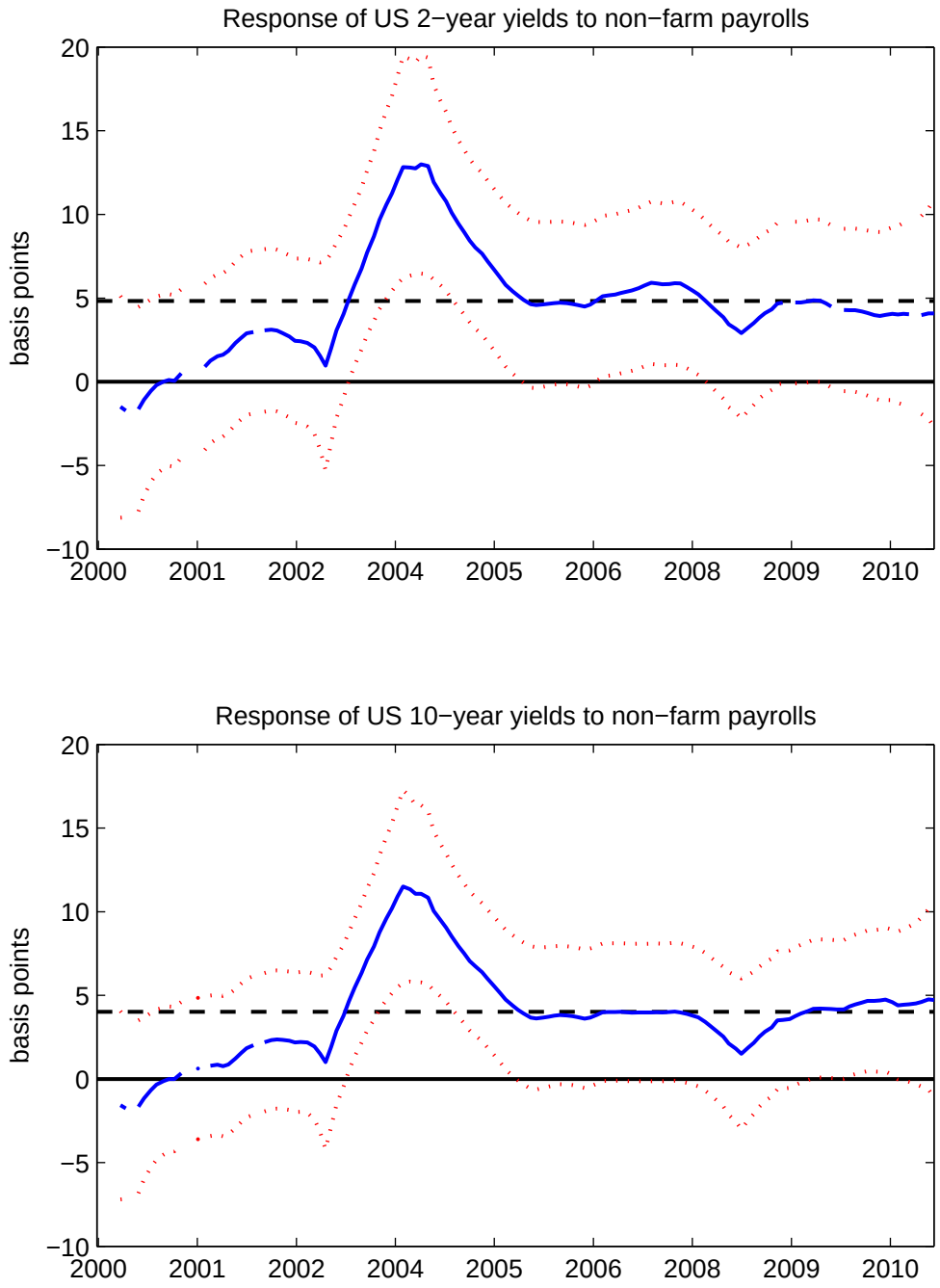

Figure 1: Response of US bond yields to a one standard deviation surprise in non-farm payrolls, 8:25-8:35am window. The parameter paths are computed following Müller and Petalas (2010). The coefficients correspond to the time-varying effect of a one-standard deviation news surprise, in basis points. Dotted lines represent the 95% equal-tailed posterior interval. Dashed lines indicate the baseline estimates in specification (1).

Appendix - not intended for publication

Table 12: Sources of time variation in responses of US bond yields to non-farm payrolls surprises: regression specification (5), 8:25am-4pm window

	(1)	(2)	(3)	(4)	(5)	(6)
2-year yields						
Payrolls	5.92***	7.51*	6.50***	11.83***	6.05***	11.92***
Unemployment	1.30*	1.27*	1.28*	1.38**	1.28*	1.37**
Payrolls × inflation		-1.04				
Payrolls × UR			-0.09			
Payrolls × VIX index				-0.25***		-0.25***
Payrolls × ZLB dummy					-0.53	-0.36
$\bar{R}^2$	0.40	0.40	0.40	0.50	0.40	0.50
observations	105	103	105	105	105	105
10-year yields						
Payrolls	3.57***	10.53**	2.94	11.05***	3.56***	11.03***
Unemployment	0.78	0.75	0.79	1.02	0.78	1.02
Payrolls × inflation		-4.63*				
Payrolls × UR			0.10			
Payrolls × VIX index				-0.31***		-0.31***
Payrolls × ZLB dummy					0.04	0.12
$\bar{R}^2$	0.19	0.23	0.19	0.37	0.19	0.37
observations	112	110	112	112	112	112

Notes: This table reports coefficients from regression (5) for US bond yields over the short 8:25am-8:35am window. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. Inflation (core PCE, yoy) and the unemployment rate (UR) are measured based on real time data. VIX is the CBOE VIX index on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

Table 13: Sources of time variation in responses of US bond yields to non-farm payrolls surprises: regression specification (5), 8:25am-4pm window, non-crisis period (excluding 2008 and 2009)

	(1)	(2)	(3)	(4)	(5)	(6)
2-year yields						
Payrolls	4.86***	7.16**	3.49	12.63***	5.05***	12.73***
Unemployment	1.78***	1.99***	1.83***	2.19***	1.74***	2.15***
Payrolls × inflation		-1.42				
Payrolls × UR			0.24			
Payrolls × VIX index				-0.37***		-0.37***
Payrolls × ZLB dummy					-1.43	-1.10
$\bar{R}^2$	0.47	0.50	0.47	0.58	0.47	0.58
observations	105	103	105	105	105	105
10-year yields						
Payrolls	4.25***	8.36***	0.79	11.18***	4.16***	11.09***
Unemployment	1.34***	1.54***	1.49***	1.70***	1.37***	1.74***
Payrolls × inflation		-2.69				
Payrolls × UR			0.59**			
Payrolls × VIX index				-0.33***		-0.33***
Payrolls × ZLB dummy					0.67	0.93
$\bar{R}^2$	0.48	0.53	0.50	0.60	0.48	0.60
observations	107	105	107	107	107	107

Notes: This table reports coefficients from regression (5) for US bond yields over the short 8:25am-8:35am window. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. Inflation (core PCE, yoy) and the unemployment rate (UR) are measured based on real time data. VIX is the CBOE VIX index on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

Table 14: Sources of time variation in responses of US bond yields to non-farm payrolls surprises: regression specification (5), 8:25am-4pm window, non-crisis period (excluding 2003-2005)

	(1)	(2)	(3)	(4)	(5)	(6)
2-year yields						
Payrolls	3.17***	5.12**	-0.06	5.18***	2.50***	4.39***
Unemployment	2.05***	2.11***	2.17***	2.03***	2.13***	2.10***
Payrolls × inflation		-0.93				
Payrolls × UR			0.49**			
Payrolls × VIX index				-0.08**		-0.07*
Payrolls × ZLB dummy					1.85	1.61
$\bar{R}^2$	0.35	0.36	0.38	0.37	0.37	0.38
observations	92	92	92	92	92	92
10-year yields						
Payrolls	2.50***	3.68	-1.82	4.87***	1.31**	3.39***
Unemployment	1.29***	1.33***	1.44***	1.27***	1.42***	1.39***
Payrolls × inflation		-0.57				
Payrolls × UR			0.64***			
Payrolls × VIX index				-0.09***		-0.07**
Payrolls × ZLB dummy					3.16***	2.89***
$\bar{R}^2$	0.31	0.31	0.38	0.35	0.39	0.42
observations	95	95	95	95	95	95

Notes: This table reports coefficients from regression (5) for US bond yields over the short 8:25am-8:35am window. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. Inflation (core PCE, yoy) and the unemployment rate (UR) are measured based on real time data. VIX is the CBOE VIX index on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

Table 15: Sources of time variation in responses of US bond yields to non-farm payrolls surprises: regression specification (5), 8:25am-8:35am window; inflation and UR from SPF, Libor-OIS spreads as risk measure

	(1)	(2)	(3)	(4)	(5)	(6)
2-year yields						
Payrolls	4.83***	7.13**	4.81**	6.60***	4.95***	7.09***
Unemployment	1.88***	1.93***	1.88***	2.13***	1.87***	2.09***
Payrolls × inflation		-1.09				
Payrolls × UR			0.00			
Payrolls × Libor-OIS				-3.03***		-3.15***
Payrolls × ZLB dummy					-0.67	-2.01
$\bar{R}^2$	0.46	0.46	0.46	0.57	0.46	0.58
observations	128	128	128	113	128	113
10-year yields						
Payrolls	4.01***	5.84*	2.90	5.76***	3.91***	5.91***
Unemployment	1.16***	1.19***	1.19***	1.41***	1.17***	1.40***
Payrolls × inflation		-0.87				
Payrolls × UR			0.18			
Payrolls × Libor-OIS				-3.52***		-3.56***
Payrolls × ZLB dummy					0.51	-0.61
$\bar{R}^2$	0.44	0.45	0.45	0.58	0.44	0.58
observations	131	131	131	116	131	116

Notes: This table reports coefficients from regression (5) for US bond yields over the short 8:25am-8:35am window. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. Inflation (CPI, yoy) and the unemployment rate (UR) are taken from the survey of professional forecasters. Risk conditions are captured by Libor-OIS spreads on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

Table 16: Sources of time variation in responses of US bond yields to non-farm payrolls surprises: regression specification (7), 8:25am-8:35am window

	(1)	(2)	(3)	(4)	(5)
2-year yields					
Constant	6.90**	4.45*	7.59***	5.00***	7.59***
Inflation	-1.20				
Unemployment rate		0.06			
VIX index			-0.13**		-0.13**
ZLB dummy				-0.76	-0.01
$\bar{R}^2$	0.03	0.00	0.15	0.01	0.15
observations	126	128	128	128	128
10-year yields					
Constant	7.30***	2.67	6.66***	4.01***	6.66***
Inflation	-1.96				
Unemployment rate		0.22			
VIX index			-0.12**		-0.13***
ZLB dummy				0.00	0.68
$\bar{R}^2$	0.09	0.02	0.18	0.00	0.19
observations	129	131	131	131	131

Notes: This table reports coefficients from regression (7) for US bond yields over the short 8:25am-8:35am window. ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on standard errors that are corrected for the use of a generated dependent variable following Dumont et al. (2005). Yields refers to benchmark government bond yields. Inflation (core PCE, yoy) and the unemployment rate are measured based on real time data. VIX is the CBOE VIX index on the day prior to the news release. The ZLB dummy equals one if the federal funds target rate has reached its lowest level, and zero otherwise.

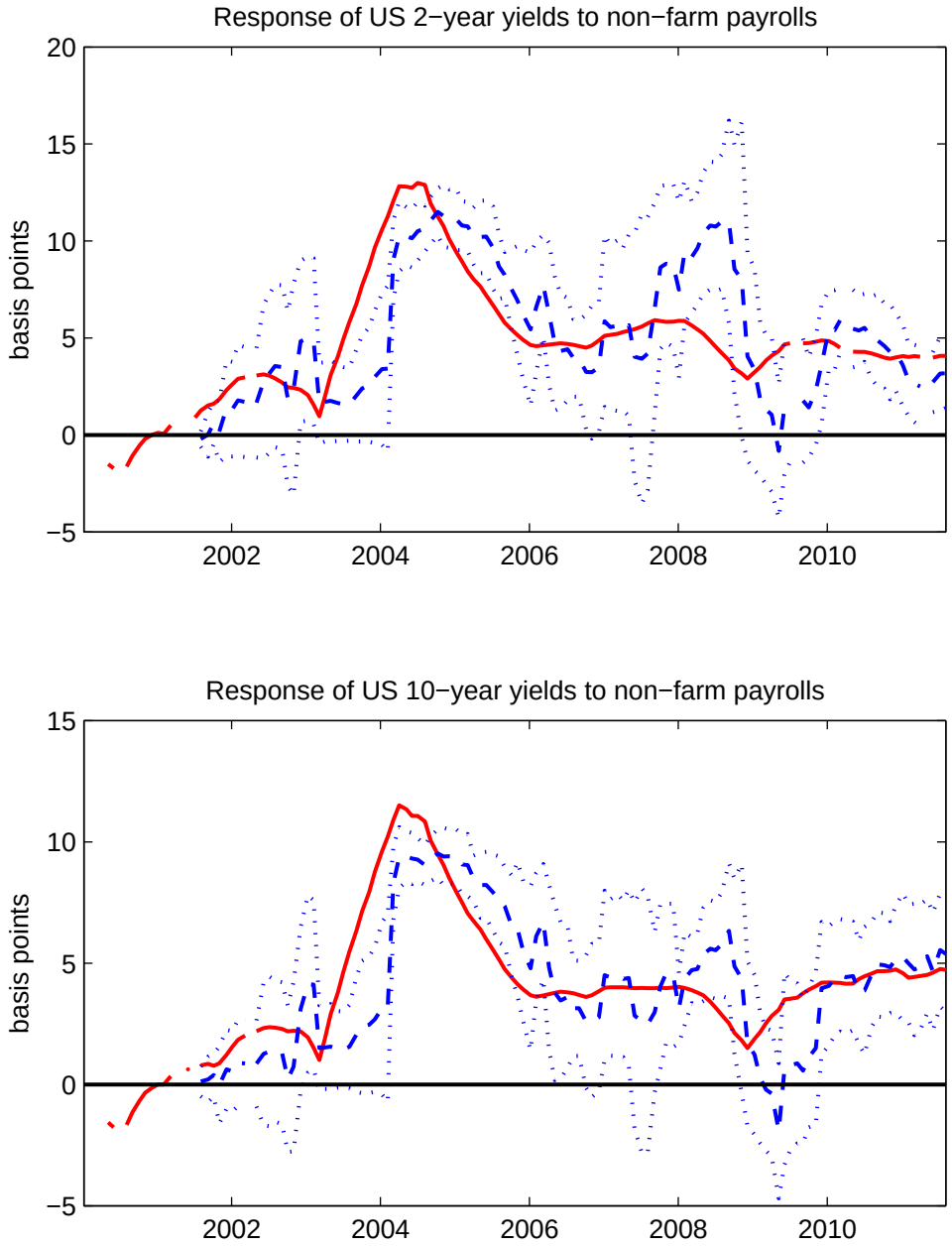

Figure 2: Response of US bond yields to non-farm payrolls surprises, 8:25-8:35am window. The parameter paths are computed following Müller and Petalas (2010) (red solid line), and using rolling regressions with a backward-looking window of 12 months (blue dashed line). Dotted lines represent 95% confidence bands for rolling regressions. The coefficients correspond to the time-varying effect of a one-standard deviation news surprise, in basis points.

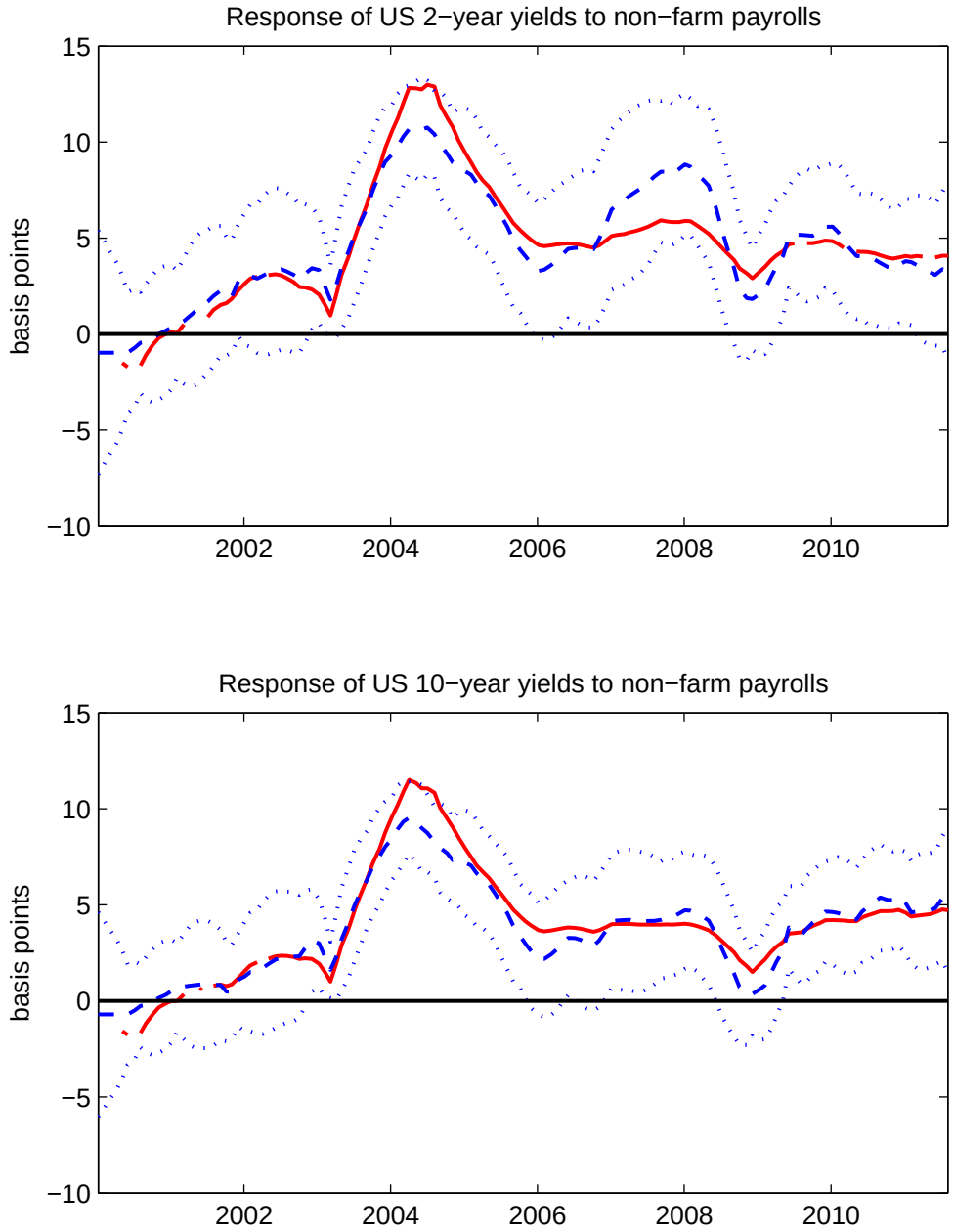

Figure 3: Response of US bond yields to non-farm payrolls surprises, 8:25-8:35am window. The parameter paths are computed following Müller and Petalas (2010) (red solid line), and using a random coefficients model (blue dashed line). Dotted lines represent ±2 standard error bands for the random coefficients model. The coefficients correspond to the time-varying effect of a one-standard deviation news surprise, in basis points.