Time variation in asset price responses to macro announcements

Linda S. Goldberg and Christian Grisse

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

2013-11

Swiss National Bank Working Papers

The views expressed in this paper are those of the author(s) and do not necessarily represent those of the Swiss National Bank. Working Papers describe research in progress. Their aim is to elicit comments and to further debate.

ISSN 1660-7716 (printed version)
ISSN 1660-7724 (online version)

Time variation in asset price responses to macro announcements*

Linda S. Goldberg
Federal Reserve Bank of New York and NBER

Christian Grisse
Swiss National Bank

November 2013

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. Significant time variation in news effects is present for those announcements that have the largest effects on asset prices. The time variation in effects is explained by economic conditions, including the level of policy rates at the time of the release, and risk conditions: government bond yields increase in response to "good news", but less so when risk is elevated. Risk conditions matter since they can 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.

JEL classification: E43, E44, E52, F31, G12, G14, G15
Keywords: macroeconomic news announcements, high-frequency data, bond yields, exchange rates, monetary policy, risk

*The views expressed in this paper are those of the individual authors and do not necessarily reflect the position of the Federal Reserve Bank of New York, the Federal Reserve System, or the Swiss National Bank. Address correspondences to Linda S. Goldberg, e-mail: Linda.Goldberg@ny.frb.org, or Christian Grisse, e-mail: Christian.Grisse@snb.ch. Address: Federal Reserve Bank of New York, Research Department, 33 Liberty St, New York, N.Y. 10045; Swiss National Bank, Börsenstrasse 15, P.O. Box, 8022 Zürich, Switzerland. We thank Katrin Assenmacher, Rolf Scheufele, an anomymous referee of the SNB working paper series, and participants at the SNB's brown bag seminar and the 2012 annual meeting of the American Economic Association (Chicago) for their comments, and Leslie Shen and Diego Gilsanz for excellent research assistance.

1 Introduction

A rich literature explores the consequences of economic news announcements, such as inflation releases and employment payrolls reports, for asset prices, risk premia, and exchange rates. These consequences are measured within windows that cover minutes or hours after the economic data release, as in Andersen, Bollerslev, Diebold, and Vega (2003), and sometimes are assessed in relation to the predictions of basic economic models containing interest parity conditions and Taylor-rules for monetary policy, as in Gürkaynak, Swanson and Sack (2005) or Faust, Rogers, Wang, and Wright (2007). When the economic news effects are assessed in light of these models, they are viewed as informing how market participants view future interest rate paths conditioned on updated views of trajectories of inflation and the output gap. In the international setting, the news inform the relative trajectories of yields across countries, as well as informing exchange rates and risk premia.

The magnitudes of such effects of economic news are often discussed as if rules-of-thumb underlie the relationships. Yet, there is little reason to expect that the relationships between economic news and asset prices should be stable over time. Some studies provide relevant insights, for example showing that the effects of Federal Reserve policy announcements change in a zero lower bound environment (as in Kiley (2013) and Swanson and Williams (2013a, 2013b)). Policy regimes also play a role as central banks convince markets of the relative importance of inflation and output priorities in a policy reaction function, as Goldberg and Klein (2011) show: variation in economic news effects on European asset prices and on the euro/dollar exchange rate are indicative of market participants having evolving perceptions of the relative inflation aversion reflected in ECB policymaking.

In this paper, we argue that time-variation in the effects of news on bond yields and exchange rates should be viewed as an empirical regularity. 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 arises as the policy outcomes of news change due to a perceived reweighing of inflation and output preferences within reaction functions, due to changing implications of a unit of news for forecasts of output or inflation as the state of the economy shifts closer to or further from targets, due to changing risk preferences in the economy, or due to the importance of financial stability conditions leading to a (short run) shift of priorities of central banks. 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. Using econometric methods developed by Müller and Petalas (2010) and Elliott and Müller (2006), we show that persistent time variation is present to differing degrees in the high frequency data. We relate the observed time-variation patterns to macroeconomic conditions, the level of the Federal Funds rate, and to measures of risk. The level of interest rates and risk conditions have the greatest explanatory power for changes observed in asset price responsiveness to news. In particular, while US bond yields usually increase in response to "positive" US macroeconomic news, the increase is smaller when policy rates and 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 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. The bulk of that variation is explained by the level of the policy rate and the VIX index.

Section 2 provides a brief review of the related literature. Section 3 describes our data and empirical methods, and section 4 reports our baseline results for asset price responses to 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 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 papers 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. (2010)).

Several studies have also considered time variation in the effect 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, a number of papers 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

[1] See also Fischer (1989).

regressions and random effects models applied to data that span the period from 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 expected 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) argue that time variation in euro area bond yield responses to news evolved in the years after the introduction of the euro. 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. 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 argue that time variation should be viewed as the default condition and that asset price responses to news should change with risk conditions and macroeconomic context, as well as with (likely less frequent) changes policy reaction functions. Third, we test these propositions using a rich set of data 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. The asset prices we examine in depth are bond yields and exchange rates for the United States, Germany, France, and United Kingdom.

[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 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.[3] 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.[4]

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 2, 5, and 10 year bond yields for the United States, United Kingdom, Germany, and France.[5] The exchange rates examined are euros (EUR) and UK pounds (GBP), measured as US dollars (USD) per foreign currency.

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

[4]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.

[5]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. Bond yields are constructed using the formula

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

[Table 2 about here]

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

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.

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.[6] US announcements made at t =8.30am Eastern time and the alternative time windows $t^+ - t^-$ have $t^- = \{8\text{am}, 8{:}25\text{am}\}$ and $t^+ = \{8{:}35\text{am}, 9\text{am}, 4\text{pm}\}$. 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.

We conjecture that the standard assumption that the slope coefficient β_k in model (1) is constant over time is likely to be unrealistic. This is especially the case over periods containing business cycle variation and in periods of economic turmoil such as the recent global financial crisis. The second step of our analysis tests whether β_k is time-varying. 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 asymptotically (in large samples) equivalent to the optimal test for a particular process of time variation.[7]

[6] 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.

[7] Elliott and Müller (2006) report simulations that show that using the small-sample efficient test rather than

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.[8] 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. In Section 5 we turn to sources of time variation.

4 Baseline results

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 bond yields and exchange rates to US macroeconomic data announcements using the standard specification of equation (1) with coefficients assumed to be stable over time. Tables 3 and 4 summarize the results for the 8:25-8:35am and 8:25am-4pm windows. The reported coefficients correspond to the average change in bond yields or the log return in exchange rates over the window, expressed in basis points, associated with a one-standard deviation news surprise. We expect the coefficients for exchange rates to be negative (so that positive US surprises are associated with an appreciation of the USD), while the corresponding coefficients for bond yields should be positive. The ex ante sign of the effect of US inflation surprises is ambiguous, although one would expect a negative coefficient for exchange rates and a positive coefficient for bond yields 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]
[Table 4 about here]

The results are interesting. Consistent with earlier studies, most macroeconomic data announcements have highly significant effects on US bonds yields, across all maturities. By the far

the asymptotically equivalent quasi-local level test does not result in a significant loss of power in finite samples.

[8] 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}.

the strongest effects are due to news in non-farm payrolls. Where responses of US bond yields to real activity announcements are statistically significant, they always have the expected sign: announcements which show that real economic 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. Such a pattern of results could arise if market participants expect the Federal Reserve to raise interest rates in response to increases in core inflation, without a response to the more volatile CPI. 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 to US macro news documented by Faust et al. (2007).

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), most news announcements are not associated with a statistically significant effect on foreign bond markets, with the exception of non-farm payrolls. For GDP announcements some of the effects are significant, but positive: stronger than expected US real activity is associated with a US dollar depreciation within 5 minutes of the data release.

Instead, Table 4 shows broader patterns of significant asset price responses over the longer 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. Furthermore, 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. Non-farm payrolls have the expected significant effect on exchange rates only over the longer window. 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. A potential interpretation is that foreign exchange markets may take somewhat longer to interpret the international implications of US data announcements.

4.2 Time variation in the effects of news

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 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 5 about here]
[Table 6 about here]

Tables 5 and 6 report the test statistics for alternative time windows. The null that the responses of US bond yields over the 8.25-8:35am window to non-farm payrolls 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 responses. For core consumer prices and GDP announcements parameter stability can be rejected at least at the 5% level. Strong evidence also exists for time variation in the responses of foreign interest rates to non-farm payrolls and unemployment announcements over the 8:25-9am and 8:25am-4pm windows. For US dollar exchange rates there is some indication of time variation in the responses to non-farm payrolls over the 8:25am-4pm window. Overall, our results suggest that 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, the effects of those announcements that are associated with the largest market movements – in particular, the non-farm payrolls announcements, core CPI and GDP – exhibit significant time variation.[9]

4.3 Estimated parameter paths

In order to provide more in depth analysis of the magnitude and drivers of time variation, we narrow both the set of asset prices and news announcements. In particular, we narrow the set of asset prices to US 2- and 10-year government bond yields, comparable German bond yields, and the EURUSD exchange rate. We focus mainly 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.

Figures 1 and 2 present estimated parameter paths for the responses of US 2- and 10-year yields to payrolls surprises, computed using the Müller and Petalas (2010) method, together with

[9]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. 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. In the alternative regression

$$q_{t^+} - q_{t^-} = \sum_{k=1}^{K} \left(\mathbb{1}_{s_{k,t}>0} \beta_{1kt} s_{k,t} + \mathbb{1}_{s_{k,t}>0} \beta_{2kt} s_{k,t}^2 + \mathbb{1}_{s_{k,t}<0} \beta_{3kt} s_{k,t} + \mathbb{1}_{s_{k,t}<0} \beta_{4kt} s_{k,t}^2 \right) + \varepsilon_t$$

typically not all coefficients are statistically significant. However we still find evidence for significant time variation in the coefficients β_{jkt} for those macroeconomic announcements that have the largest effects on markets. Details can be obtained from the authors upon request. Reasons for such asymmetry could be posited. For example, policy itself may be asymmetric, with fast rate cuts and slow, smoothed rate increases. 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. Observationally, central banks do seem to be behaving this way and the asset price responses to policy may be capturing that.

an indication of the uncertainty associated with the estimates.[10] The effect of news in non-farm payrolls on US bond yields ranges between -2 and +13 basis points for a 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.[11] 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]
[Figure 2 about here]

While we provide a formal econometric decomposition below, this time variation is consistent with intuitive arguments about the state-dependency and the roles of risk. One interpretation of the 2004 peak is that investors expected that positive payrolls surprises would be followed by further 25 basis point policy rate hikes. Their enhanced certainty about the policy path, contingent on the state of output and inflation, facilitated investor willingness to trade on this expectation given the news, leading to larger price reactions.

As a second example, the 2008 episode illustrates how elevated risk conditions and macroeconomic conditions could induce time variation. At the height of the financial crisis measures of risk were elevated, with several potentially off-setting implications for asset price responses to news. First, the central bank could have been seen as less likely to raise rates (relative to the prior path) following good news due to existing concerns about financial stability and growth, and unable to cut rates following bad news due to the zero lower bound. Second, elevated risk could have signalled that the relationship between macro announcements and subsequent macroeconomic outcomes was more uncertain, leading markets to place less weight on the macro news when updating their expectations. These first two effects would imply that US bond yields rise less in response to good news when risk is elevated, and fall less in response to bad news. Third, positive macro news could lead to a smaller risk premium and therefore to higher yields on "safe-haven"assets such as US government bonds. Fourth, positive macro news should imply an improvement of financial stability, raising the likelihood of tighter policy relative to the prior path. These last two effects magnify the standard reaction of US bond yields to data announcements.

[10]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 5 and 6. 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.

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

Similar effects are likely to be at play for foreign 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.[12] Finally, the response of US dollar bilateral exchange rates to macro announcements during the crisis should reflect the movements of US and foreign interest rates, as discussed above, 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.[13]

[Figure 3 about here]
[Figure 4 about here]

Figures 3 and 4 report parameter paths for responses of German 2-year yields and the EURUSD exchange rate to non-farm payrolls announcements. Responses over the shorter 8:25-8:35am window are very small in magnitude throughout the sample. In contrast, over the longer 8:25am-4pm window the response of German yields mostly mirrors that of US yields – most notably, the effects on both US and German yields exhibit a sharp peak in early 2004 – but with two differences. First, the responses are smaller in magnitude than those of US yields, consistent with the observations of prior studies; and second, while the responses of US yields to non-farm payrolls surprises declined in 2008, the response of German yields increased over the same period. The movements of the EURUSD response and the responses of US and German interest rates over the 8:25am-4pm window are consistent with uncovered interest parity. Quantitatively, the response of US 2-year yields to non-farm payrolls increased from close to 0 basis points in 2003 to about 13 basis points in 2004. Over the same period the response of German yields over the 8:25am-4pm window rose from around 1 to 4 basis points. Consequently, in 2002-2004 payrolls surprises were increasingly associated with a widening of the interest rate differential in favor of US yields. This is in line with the decline in the EURUSD response to payrolls, so that between 2002 and 2004 positive payrolls surprises were associated with a stronger appreciation of the dollar. In contrast, in mid-2008 payrolls surprises were associated with lower yields on US 2-year bonds but higher yields on German 2-year bonds. This is again consistent with the response of the EURUSD exchange rate, which briefly peaked in 2008.

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

[13] 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).

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 captures 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 are modelled as some version of the Taylor rule. We include risk as one determinant of interest rates to capture three separate effects. First, the central bank could have a financial stability mandate and could 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 $\phi_t \left(\cdot \right)$ allows for the possibility that the central bank reaction function changes over time.

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

$$\frac{di_t}{ds_t} = \sum_{i=1}^{3} \frac{\partial \phi_t}{\partial Z_{it}} \frac{dZ_{it}}{ds_t} \tag{4}$$

where $Z_{it} \in \{ \mathbb{E}_t \left(y_t \right), \mathbb{E}_t \left(\pi_t \right), \mathbb{E}_t \left(R_t \right) \}$. This equation presents 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

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

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.

We explore how asset price responses to news depend on Z_{it} by estimating two types of specifications. First, we consider the regression

$$\widehat{\beta}_{kt} = \gamma_0 + \sum_{i=1}^{3} \gamma_i Z_{i,t} + \varepsilon_t \tag{5}$$

where $\widehat{\beta}_{kt}$ is the Müller-Petalas estimate of the coefficient on announcement k at time t from regression (2). In this regression 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).[16] This specification 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. Alternatively we generate results by directly including these measures within the original regression framework:

$$q_{t^+} - q_{t^-} = \sum_{k=1}^{K} \delta_k s_{k,t} + \sum_{k=1}^{K} \sum_{i=1}^{3} \tau_k s_{k,t} Z_{it} + \varepsilon_t \tag{6}$$

These specifications allow for a differential impact of news surprises depending on the value of Z_{it}. The coefficients γ_k in (5) and τ_k in (6) capture the joint influence of the three effects discussed in the previous paragraph. Note that since exchange rate returns can be decomposed into the interest rate differential and a risk premium it is useful to similarly analyze exchange rate movements following data announcements within these frameworks.

[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).

[16] 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 $\widehat{\gamma}$ as

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

Müller and Petalas (2010) show how to compute the $T \times T$ variance-covariance matrix $Var\left(\widehat{\beta}_k\right)$, whose (t,t)th entry is the variance of $\widehat{\beta}_{kt}$. For σ_ε^2 we use the Newey-West corrected estimate of the variance of the residuals of (5).

5.2 Data on US macroeconomic and financial conditions

We employ 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.[17] As the VIX index trades from 9:15-4:15pm (EST), the regressions use prior day close values. We also use the target federal funds rate as a measure of the monetary policy stance.

We measure (expected) US macroeconomic conditions using data from three alternative sources. First, we obtain real-time data for real GDP growth, PCE inflation and the unemployment rate from the Alfred database at the Federal Reserve Bank of St. Louis. We compute the US output gap for month t as the difference between real GDP for the last available quarterly observation, say for quarter t', and potential output as of month t measured as HP-filtered real GDP, filtered over quarters up to and including t'.[18]

Second, we measure the macroeconomic outlook using the survey of professional forecasters, published by the Federal Reserve Bank of Philadelphia. In particular, 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 the real economy as the mean survey response for real GDP growth between quarters $t'-1$ and $t'+3$, and the outlook for inflation as the mean response for CPI inflation over the same quarters (growth and inflation rates are computed from the mean survey responses for the individual quarters). We also use forecasts for the unemployment rate in quarter $t'+3$, as well as the forecast for the change in the unemployment rate between $t'-1$ and $t'+3$.

Third, we use the Citi Economic Surprise Index for the US as an aggregated measure of whether US economic data announcements have been on average favorable or not over the weeks preceding the release. This index is available daily, and we use the $t-1$ value in the regression where the dependent variable is as of day t. For each day, the index aggregates a wide variety of US macroeconomic data surprises (actual data releases versus Bloomberg survey median prior to the release) of macroeconomic data announcements over the past three months, with declining weights for older releases. The weights are derived from relative high-frequency spot FX impacts of one standard deviation data surprises.[19] A positive reading of the index indicates that economic releases have on balance been above the consensus.

[Figure 5 about here]

Each of these alternative measures of US macroeconomic conditions has advantages and drawbacks for the purpose of explaining time variation in financial market responses to news.

[17] See `http://www.cboe.com/spx`. Alternatively we use Libor-OIS spreads as a measure of risk, with similar results. These results can be obtained from the authors upon request.

[18] We filter out only long-term trends, setting the smoothing factor of the HP-filter to the relatively high value of $\lambda = 40000$. This ensures that the US output gap is estimated to be positive at the end of the sample, as is commonly thought.

[19] See James and Kasikov (2008) for details.

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 the current situation. Finally, the Citi Economic Surprise index is available daily and therefore most accurately describes how the macroeconomic outlook has changed recently, without capturing the actual level of economic activity and inflation. Time series for these explanatory variables are reported in Figure 5. The VIX index and measures of forecast dispersion tend to move together over the medium term. The VIX index in our regressions may capture both the importance of risk or financial stability concerns and the role of investors' uncertainty about the macroeconomic outlook.

5.3 Results

The sources of time variation in the responses to US payrolls announcements are similar regardless of whether we estimate specification (5) or specification (6). For brevity, specification (5) results are reported in Tables 9 and 10 in the appendix. Below, we focus the exposition on specification (6) decompositions, which directly nests the effects of state variables on the impact of 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. The econometric results are reported in Table 7 using the outlook for inflation and unemployment from the survey of professional forecasters and in Table 8 using real-time data for inflation and unemployment. We only report results for a baseline specification which includes year-over-year inflation, the unemployment rate as a measure of economic slack, the VIX index and the Federal Funds rate as explanatory variables. The results are robust to using alternative measures of inflation and real activity, as well as to using Libor-OIS spreads in place of the VIX index as an alternative measure of risk.[20]

[Table 7 about here]
[Table 8 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, macroeconomic conditions and financial stability considerations strongly influence the magnitude and potentially the sign of this effect both over the short and longer windows. In particular, taken together the results from specifications (5) and (6) suggest that the VIX index and the level of the Federal Funds rate are the most robust drivers of time-variation in the responses of US bond yields to macro

[20] We do not report results for the Citi Economic Surprise Index, which is only available from 2003 and is found not exhibit a statistically significant link with $\widehat{\beta}_{kt}$.

announcements. Yields rise in response to positive payrolls surprises, but the increase is smaller when risk and the Federal Funds rate are high.

Tables 7 and 8 show that risk conditions (proxied by the VIX index) are a highly statistically significant determinant of time variation in the responses of US government bond yields. US yields increase on average following positive payrolls surprises, but 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 maturities and across time windows. A second important driver of movements in US bond yield responses to payrolls announcements is the level of the Federal Funds target rate. When the level of interest rates is already high, bond yields increase less in response to positive payrolls surprises. The coefficient on the unemployment rate is negative across specifications, but not always statistically significant. Finally, a somewhat puzzling finding is that the coefficient on expected inflation is negative in Table 7, while the coefficient on observed current inflation is positive in Table 8. Together these factors explain almost 7% percent of the time-variation in responses of US yields.

This broad pattern of findings carries over to German bond yields. Recall that German yields show a statistically significant response to US payrolls announcements only over the 8:25am-4pm window. Over this longer window the coefficient on the VIX index is negative and typically statistically significant. Where significant, the coefficient on the interaction term of payrolls and the federal funds rate is negative as well. Finally, over the 8:25am-4pm window the US dollar appreciates versus the euro on average, 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.[21]

To illustrate these results further Figures 6 (for the 8:25-8:35am window) and 7 (for the 8:25am-4pm window) decompose the estimated coefficients $\widehat{\beta}_k$ for the response of US bond yields from regression (2) into the contributions from the constant term, inflation, unemployment, the risk proxy and the Federal Funds rate according to regression (5). The decomposition shows that the 2002-2004 increase in US bond yield responses to payrolls mainly reflected a gradual decline in the VIX index, while conversely the 2008 drop in the coefficient was mainly driven by the sharp increase in the VIX. The effect of the jump in the VIX index in 2008 was large enough to more than offset the simultaneous fall in the policy rate to zero.

[Figure 6 about here]

[21] As a robustness check, we also ran the same regression specifications with the 2003-2005 data excluded from the sample. For the 8:25 to 8:35 window, the VIX interaction term remains negative and significant and FFR remains negative but not necessarily significant. For the 8:25 to 4pm window, the effect of the VIX interaction term is still negative, but with SPF data not significant anymore; the FFR coefficient sometimes turns negative, but it is still negative when significant. The 2004 episode partly drives the results; but most results are robust to excluding this episode (VIX and FFR remain mostly negative and significant; where significant the sign is negative).

[Figure 7 about here]

Alternative channels for risk may be driving these results. Markets might expect the Fed to react less strongly to positive macro news when risk is elevated potentially because of financial stability concerns. Markets might place less weight on announcement surprises when the relationship between news announcements and the economic outlook is more uncertain. Note that with $\delta_k > 0$ and $\tau_k < 0$ in specification (6) it is possible for US government bond yields to fall following a positive US macro announcement surprise if the VIX index is sufficiently elevated. On the forecast accuracy side, two preliminary but not conclusive pieces of evidence are that the gap between real time GDP and inflation series and later revised actual data does appear to be positively correlated with risk measures. In addition, the disagreement of macroeconomic forecasters also tends to move together with the VIX index.

6 Conclusion

Time variation in the responses of government bond yields and US dollar exchange rates to US macroeconomic news announcements is the default characteristic of these relationships. We have made three main contributions to underscore this point. First, using high-frequency data from 2000 to 2011 we provide evidence that asset price responses to news is time-varying both in regular economic conditions and in more stressed periods, as reflected in our sample by the global financial crisis. For those macro announcements that have the largest impact on markets, asset price responses significantly vary over time. Time variation in news effects can be economically important. For example, the response of US 2-year government bond yields to a 1 standard deviation surprise in payrolls announcements varies over our 2000-2011 sample between -2 and +13 basis points. Second, using recently developed econometric methods, we efficiently test for and demonstrate gradual and large quantitative time variation in news effects. Third, we show that time variation in news effects is related to changes in macroeconomic and financial conditions. US bond yields usually increase in response to "good news", but less so when risk is elevated. We interpret this result as reflecting 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. Spillovers to foreign markets are consistent with results along the US yield curve. However, these are evident mainly in longer windows of time, for example hours after the announcement takes place.

These findings leave a number of questions open for future study. The combination of time variation in asset price responses to news for exchange rates, bond yields, and risk premia, along the lines of Faust et al. (2007), remains a promising avenue for future research. In particular, if foreign exchange risk premia could be measured directly – e.g. by exploiting news effects on FX volatility implied by options prices – we could better relate the results on asset price responses and risk to exchange rate determination, building also on work of Engel, Mark and West (2007).

In addition, disentangling the channels through which risk conditions enter the time varying responses of markets will be a potentially fruitful avenue for further analysis.

References

[1] Andersen, Torben G., Tim Bollerslev, Fancis X. Diebold and Clara Vega (2003), "Micro effects of macro announcements: real-time price discovery in foreign exchange", *American Economic Review* 93(1), 38-62.

[2] Andersen, Torben G., Tim Bollerslev, Fancis X. Diebold and Clara Vega (2007), "Real-time price discovery in global stock, bond and foreign exchange markets", *Journal of International Economics* 73(2), 251-277.

[3] Assenmacher-Wesche, Katrin (2006), "Estimating central banks' preferences from a time-varying empirical reaction function", *European Economic Review* 50(8), 1951-1974.

[4] Bartolini, Leonardo, Linda S. Goldberg and Adam Sacarny (2008), "How economic news moves markets", *Current Issues in Economic and Finance* 14(6), August 2008.

[5] Boyd, John H., Jian Hu and Ravi Jagannathan (2006), "The stock market's reaction to unemployment news: why bad news Is usually good for stocks", *Journal of Finance* 65(2), 649-672.

[6] Brunnermeier, Markus K., Stefan Nagel and Lasse H. Pedersen (2009), "Carry trades and currency crashes", *NBER Macroeconomics Annual 2008*, 313-347.

[7] Clarida, Richard, Jordi Gali and Mark Gertler (2000), "Monetary policy rules and macroeconomic stability: evidence and some theory", *Quarterly Journal of Economics* 115(1), 147-180.

[8] Cocco, Flavio and Andreas Fischer (1989), "Are announcement effects time dependent?" *Economics Letters* 30(2), 157-159.

[9] Conrad, Jennifer, Bradford Cornell and Wayne R. Landsman (2002), "When is bad news really bad news?" *Journal of Finance* 57(6), 2507–2533.

[10] Dumont, Michel, Glenn Rayp, Olivier Thas and Peter Willemé (2005), "Correcting standard errors in two-stage estimation procedures with generated regressands", *Oxford Bulletin of Economics and Statistics* 67(3), 421-433.

[11] Ehrmann, Michael and Marcel Fratzscher (2005), "Exchange rates and fundamentals: new evidence from real-time data", *Journal of International Money and Finance* 24(2), 317-341.

[12] Ehrmann, Michael, Marcel Fratzscher, Refet S. Gürkaynak and Eric T. Swanson (2011), "Convergence and Anchoring of Yield Curves in the Euro Area", *Review of Economics and Statistics* 93(1), 350-364.

[13] Elliott, Graham and Ulrich K. Müller (2006), "Efficient tests for general persistent time variation in regression coefficients", *Review of Economic Studies* 73(4), 907-940.

[14] Engel, Charles and Kenneth West (2005), "Exchange Rates and Fundamentals", *Journal of Political Economy* 113(3), 485-517.

[15] Engel, Charles, Nelson Mark, and Kenneth West (2007), "Exchange rate models are not as bad as you think", *NBER Macroeconomics Annual 2007*, 381-441.

[16] Faust, Jon, John H. Rogers, Shing-Yi B. Wang and Jonathan H. Wright (2007), "The high-frequency response of exchange rates and interest rates to macroeconomic announcements", *Journal of Monetary Economics* 54(4), 1051-1068.

[17] Fischer, Andreas (1989), "Policy regime changes and monetary expectations", *Journal of Monetary Economics* 24(3), 423-436.

[18] Fleming, Michael J. and Eli M. Remolona (1999), "Price formation and liquidity in the U.S. treasury market: the response to public information", *Journal of Finance* 54(5), 1901-1915.

[19] Fratzscher, Marcel (2009), "What explains global exchange rate movements during the financial crisis?" *Journal of International Money and Finance* 28(8), 1390-1407.

[20] Gilbert, Thomas, Chiara Scotti, Georg Strasser and Clara Vega (2010), "Why do certain macroeconomic news announcements have a big impact on asset prices", working paper.

[21] Goldberg, Linda S. and Deborah Leonard (2003), "What moves sovereign bond markets? The effects of economic news on U.S. and German yields", *Current Issues in Economics and Finance*, Federal Reserve Bank of New York, September 2003.

[22] Goldberg, Linda S. and Michael W. Klein (2011), "Evolving perceptions of central bank credibility: the ECB experience", *NBER International Seminar on Macroeconomics 2010*, 153-182.

[23] Gürkaynak, Refet S., Brian Sack and Eric Swanson (2005), "The sensitivity of long-term interest rates to economic news: evidence and implications for macroeconomic models", *American Economic Review* 95(1), 425-436.

[24] Gürkaynak, Refet S. and Justin Wolfers (2007), "Macroeconomic derivatives: an initial analysis of market-based macro forecasts, uncertainty and risk", *NBER International Seminar on Macroeconomics 2005*, 11-50.

[25] Gürkaynak, Refet S. and Jonathan H. Wright (2013), "Identification and Inference Using Event Studies", *The Manchester School* 81, 48-65.

[26] Habib, Maurizio M. and Livio Stracca (2012), "Getting beyond carry trade: what makes a safe haven currency?" *Journal of International Economics* 87(1), 50-64.

[27] Hamilton, James D., Seth Pruitt and Scott Borger (2011), "Estimating the market-perceived monetary policy rule", *American Economic Journal: Macroeconomics* 3(3), 1-28.

[28] Hautsch, Nikolaus and Dieter Hess (2007), "Bayesian learning in financial markets: testing for the relevance of information precision in price discovery", *Journal of Financial and Quantitative Analysis* 42(1), 189-206.

[29] James, Jessica and Kristjan Kasikov (2008), "Impact of economic data surprises on exchange rates in the inter-dealer market", *Journal of Quantitative Finance* 8(1), 5-15.

[30] Kiley, Michael T. (2013), "Monetary policy statements, treasury yields, and private yields: before and after the zero lower bound", Finance and Economics Discussion Series 2013-16, Board of Governors of the Federal Reserve System.

[31] Kohler, Marion (2010), "Exchange rates during financial crises," *BIS Quarterly Review*, March 2010, 39-50.

[32] Markov, Nikolay and Carlos de Porres (2012), "Is the Taylor rule nonlinear? Empirical evidence from a semi-parametric modeling approach", working paper.

[33] McCauley, Robert N. and Patrick McGuire (2009), "Dollar appreciation in 2008: safe haven, carry trades, dollar shortage andoverhedging", *BIS Quarterly Review*, December 2009, 85-92.

[34] Müller, Ulrich K. and Philippe-Emmanuel Petalas (2010), "Efficient estimation of the parameter path in unstable time series models", *Review of Economic Studies* 77(4), 1508-1539.

[35] Newey, Whitney K. and Kenneth West (1987), "A simple, positive semi-definite, heteroskedasticity and autocorelation consistent covariance matrix", *Econometrica* 55(3), 703-708.

[36] Nyblom, Jukka (1989), "Testing for the constancy of parameters over time", *Journal of the American Statistical Association* 84(405), 223-230.

[37] Sims, Christopher A. and Tao Zha (2006), "Were there regime switches in U.S. monetary policy?" *American Economic Review* 96(1), 54-81.

[38] Swanson, Eric T. and John C. Williams (2013a), "Measuring the effect of the zero lower bound on medium- and longer-term interest rates", Working Paper 2012-02, Federal Reserve Bank of San Francisco.

[39] Swanson, Eric T. and John C. Williams (2013b), "Measuring the effect of the zero lower bound on yields and exchange rates in the U.K. and Germany", Working Paper 2013-21, Federal Reserve Bank of San Francisco.

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	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
Spot Exchange Rate	EURUSD	Thomson-Reuters	1/2000	8/2011
	GBPUSD	Thomson-Reuters	1/2000	8/2011
Bond Yields[1]	France	Thomson-Reuters	1/2000	8/2011
	Germany	Thomson-Reuters	1/2000	8/2011
	United Kingdom	Thomson-Reuters	1/2000	8/2011
	United States	BrokerTec, 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 asset prices: constant coefficient estimation for the 8:25-8:35am window

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire	PCEcore
FX Spot											
EURUSD	0.54	0.74	0.36	0.58	-0.43	0.68	2.15**	1.21***	-0.37	0.87	-0.12
GBPUSD	0.13	0.16	-0.59	-0.63	0.38	0.07	0.64	0.89**	-0.16	0.05	-0.08
2-year yields											
US	4.83***	1.88***	1.49***	1.41***	0.02	0.30**	1.80***	-0.16	0.31***	0.59***	0.31**
DE	-0.05	-0.03	-0.06	-0.08	0.06	-0.02	-0.17*	-0.06	0.03	0.09	0.03
FR	0.15**	0.04	0.05	-0.16**	0.09	0.02	-0.13	-0.10**	0.02	0.12**	-0.01
GB	0.13**	-0.04	-0.01	-0.06	0.07	-0.06	-0.05	-0.13***	-0.02	-0.03	0.04
5-year yields											
US	5.25***	1.74***	1.56***	1.49***	-0.03	0.30**	1.87***	-0.15	0.33***	0.69***	0.37***
DE	0.06	-0.04	0.00	-0.04	0.04	-0.02	-0.09	-0.04	-0.02	0.07	0.05
FR	0.07*	-0.03	0.02	-0.10	0.16	-0.04	-0.14	-0.01	-0.03	0.09	0.05
GB	0.10**	-0.07	0.03	-0.11	0.08	-0.05	0.07	-0.09**	-0.02	-0.01	-0.00
10-year yields											
US	4.01***	1.16***	1.33***	1.33***	-0.06	0.31***	1.53***	-0.01	0.26***	0.49***	0.36***
DE	0.04	-0.00	0.02	-0.01	0.02	-0.02	-0.07	-0.04	0.01	0.02	0.06
FR	0.03	-0.05	-0.02	0.04	0.03	-0.01	-0.06	0.01	0.01	0.01	0.11*
GB	0.09**	-0.05	0.06	-0.10	0.09	-0.05	0.03	-0.11***	0.02	-0.02	-0.01

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. Yields refers to benchmark government bond yields.

Table 4: Effects of news on asset prices: 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	-24.53***	-12.18***	-2.94	-0.70	-4.54	3.14	-16.85**	0.02	-9.83***	-5.39	-1.03
GBPUSD	-17.56***	-9.25**	-2.29	-3.84	0.52	1.45	-7.19	3.79	-6.40**	1.91	-4.70
2-year yields											
US	5.92***	1.30*	1.72***	1.47**	-0.11	0.39	2.52**	-0.30	0.74	0.98**	0.84
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											
US	4.60***	1.00	2.21***	1.29*	0.14	0.10	2.32**	-0.29	0.76	1.14**	0.86
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											
US	3.57***	0.78	1.49***	1.42**	-0.46	0.19	1.82*	-0.27	0.39	1.02**	0.96
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. Yields refers to benchmark government bond yields.

Table 5: Tests for time variation in effects of news on asset prices, 8:25-8:35am window

	Payrolls	Unemp	Retail	CPI-XFE	CPI	H-starts	GDP	PIncome	Pspend	Empire	PCEcore
FX Spot											
EURUSD	-6.22	-3.77	-3.37	-3.61	-4.55	-4.78	-5.99	-4.54	-4.76	-7.79*	-7.21*
GBPUSD	-6.36	-3.60	-3.14	-3.50	-6.82	-5.37	-6.76	-4.16	-4.31	-8.57**	-4.85
2-year yields											
US	-14.58***	-5.97	-8.85**	-12.81***	-2.85	-7.58*	-8.55**	-2.63	-4.12	-4.33	-2.63
DE	-3.90	-6.23	-7.60*	-6.92	-5.00	-3.51	-3.23	-3.23	-5.16	-4.75	-4.64
FR	-6.20	-4.96	-3.20	-6.16	-3.38	-5.05	-8.01*	-2.76	-3.74	-6.12	-2.63
GB	-3.50	-3.35	-2.67	-3.34	-5.78	-4.49	-2.77	-7.85*	-4.79	-4.78	-5.34
5-year yields											
US	-14.68***	-5.36	-5.51	-11.62***	-3.27	-7.25*	-9.87**	-2.01	-5.16	-3.64	-2.82
DE	-5.10	-6.45	-5.80	-7.36*	-4.92	-5.27	-6.15	-2.48	-4.52	-3.96	-7.99*
FR	-6.36	-7.99*	-4.43	-6.30	-7.17*	-3.02	-7.08	-2.75	-5.03	-4.02	-6.58
GB	-3.68	-2.11	-2.56	-4.01	-5.71	-5.15	-5.90	-4.21	-7.49*	-5.11	-6.12
10-year yields											
US	-15.36***	-5.73	-4.69	-9.89**	-3.94	-8.19*	-10.25**	-0.98	-6.12	-4.68	-4.03
DE	-4.57	-8.66**	-4.23	-6.11	-7.27*	-4.45	-5.96	-3.32	-6.54	-3.22	-5.30
FR	-5.72	-4.91	-4.59	-8.97**	-4.13	-5.51	-5.85	-3.27	-4.09	-4.60	-5.95
GB	-3.84	-3.12	-2.68	-4.08	-8.51**	-2.41	-7.89*	-2.40	-6.87	-4.88	-4.70

Notes: This table reports test statistics for the Elliott and Mller (2006) *quasi-local level* test. The null hypothesis 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 6: Tests for time variation in effects of news on asset prices, 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											
US	-8.42**	-3.26	-2.43	-5.02	-5.60	-7.58*	-8.35*	-4.30	-4.78	-5.11	-4.16
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											
US	-10.54**	-3.61	-5.03	-3.36	-6.14	-10.38**	-8.45**	-2.90	-4.57	-4.13	-3.68
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											
US	-11.46***	-3.88	-2.53	-3.91	-5.39	-6.48	-8.55**	-3.27	-5.17	-2.89	-5.70
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 Mller (2006) *quasi-local level* test. The null hypothesis 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 7: Sources of time variation in responses to non-farm payrolls: regression specification (6) using data from the survey of professional forecasters

	US yields			DE yields			FX
	2-year	5-year	10-year	2-year	5-year	10-year	EURUSD
8:25am-8:35am							
Payrolls	32.10***	30.35***	25.06***	1.43*	0.60	-0.05	7.11
Unemp	2.23***	2.16***	1.51***	-0.03	-0.04	-0.01	0.66
Payrolls × inflation	-5.12***	-4.39***	-3.62***	-0.48**	-0.21*	0.05	-1.62
Payrolls × UR	-1.12***	-0.83**	-0.74**	-0.10	-0.03	-0.01	-0.63
Payrolls × VIX index	-0.32***	-0.36***	-0.29***	0.01	0.00	-0.00	0.02
Payrolls × FFR	-0.88**	-1.07***	-0.92***	0.00	0.03	0.00	0.10
$\overline{R}^2$	0.67	0.70	0.70	0.03	0.07	0.01	0.06
Durbin-Watson	1.97	1.96	1.96	2.03	2.40	2.28	2.06
observations	128	130	131	128	135	136	140
8:25am-4pm							
Payrolls	20.96***	28.80***	28.22***	15.37***	14.19***	10.72***	-213.30***
Unemp	1.50**	1.55**	1.27**	1.06**	1.15**	0.90**	-15.40***
Payrolls × inflation	-1.85	-4.59**	-4.21***	-4.04***	-3.30**	-2.62**	41.60***
Payrolls × UR	-0.46	-0.34	-0.77*	-0.24	-0.03	0.01	5.01
Payrolls × VIX index	-0.30***	-0.47***	-0.41***	-0.13***	-0.18***	-0.13***	2.66***
Payrolls × FFR	-0.51	-0.42	-0.50	0.09	0.07	0.11	1.87
$\overline{R}^2$	0.52	0.47	0.43	0.23	0.30	0.27	0.29
Durbin-Watson	2.05	2.13	2.16	2.25	2.28	2.26	1.82
observations	105	115	112	129	134	137	140

Notes: This table reports coefficients from regression (5). ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. Inflation and UR are expected year-over-year CPI inflation and the expected one-year ahead unemployment rate from the survey of professional forecasters. VIX index is the CBOE VIX index on the day prior to the news release. FFR is the federal funds target rate.

Table 8: Sources of time variation in responses to non-farm payrolls: regression specification (6) using real-time data

	US yields			DE yields			FX
	2-year	5-year	10-year	2-year	5-year	10-year	EURUSD
8:25am-8:35am							
Payrolls	16.14***	16.46***	14.06***	1.29	0.12	0.21	2.69
Unemp	2.22***	2.13***	1.47***	-0.03	-0.05	-0.01	0.62
Payrolls × inflation	4.21***	3.42**	2.08*	-0.89	0.08	0.05	1.46
Payrolls × UR	-1.01**	-0.69*	-0.58*	-0.10	-0.04	-0.03	-0.66*
Payrolls × VIX index	-0.30***	-0.33***	-0.26***	0.03	0.00**	-0.00	0.02
Payrolls × FFR	-2.13***	-2.10***	-1.67***	-0.04	-0.04**	-0.03	-0.43
$\overline{R}^2$	0.66	0.69	0.68	0.07	0.06	0.01	0.06
Durbin-Watson	1.87	1.90	1.87	2.17	2.48	2.32	2.03
observations	126	128	129	121	128	129	133
8:25am-4pm							
Payrolls	14.38***	14.41***	16.05***	5.00	4.53	2.34	-120.66**
Unemp	1.47**	1.36*	1.05	0.86*	1.01**	0.82**	-14.47***
Payrolls × inflation	5.24**	3.67*	1.24	0.39	1.05	1.36	12.10
Payrolls × UR	-0.74*	-0.22	-0.49	-0.12	0.12	0.15	3.33
Payrolls × VIX index	-0.35***	-0.44***	-0.36***	-0.05	-0.12***	-0.09***	1.73***
Payrolls × FFR	-1.66***	-1.62***	-1.33***	-0.59*	-0.51	-0.42	5.98
$\overline{R}^2$	0.55	0.46	0.40	0.19	0.28	0.24	0.28
Durbin-Watson	1.81	1.99	1.98	2.20	2.19	2.14	1.90
observations	103	113	110	122	127	130	133

Notes: This table reports coefficients from regression (5). ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on White standard errors. Yields refers to benchmark government bond yields. Inflation and UR are real-time data on year-over-year core PCE inflation and the unemployment rate. VIX index is the CBOE VIX index on the day prior to the news release. FFR is the federal funds target rate.

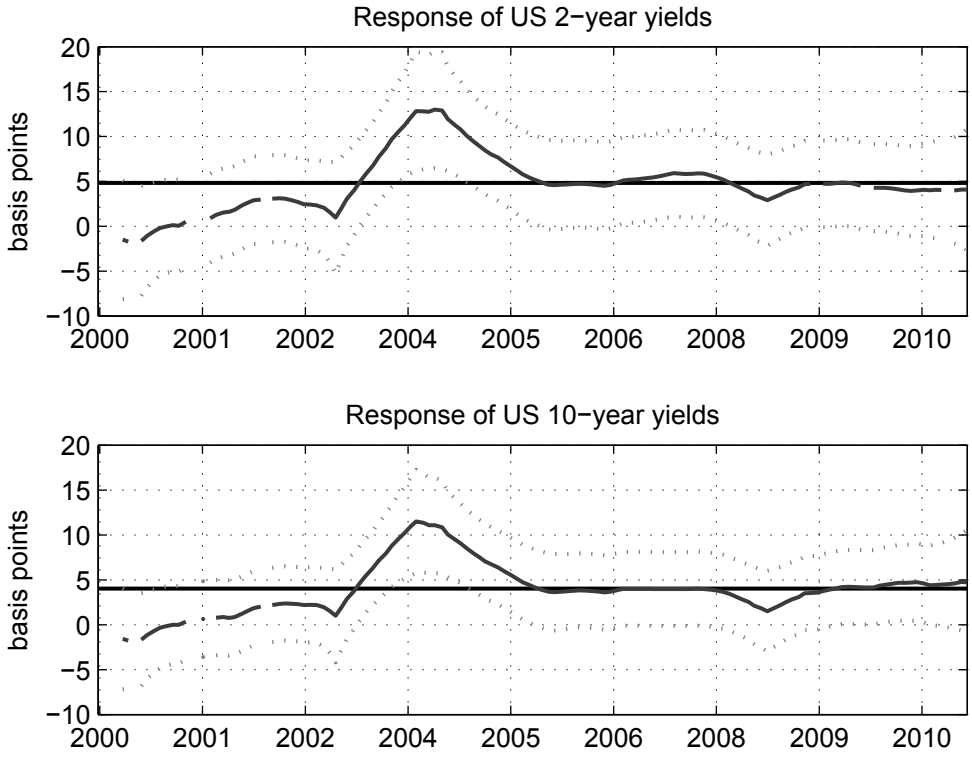

Figure 1: Response of US bond yields to non-farm payrolls surprises, 8:25-8:35am window. The parameter paths are computed following Müller and Petalas (2010). The coefficients correspond to the time-varying effect of a one-standard deviation news surprise, in basis points. Dotted lines represent the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

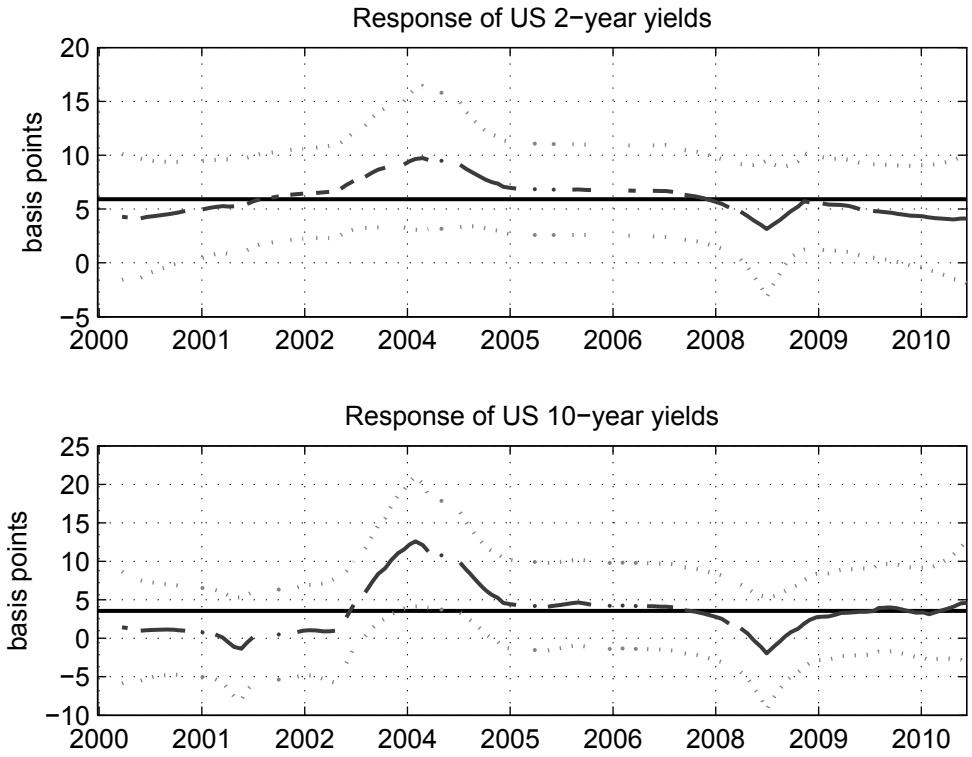

Figure 2: Response of US bond yields to non-farm payrolls surprises, 8:25am-4pm window. The parameter paths are computed following Müller and Petalas (2010). The coefficients correspond to the time-varying effect of a one-standard deviation news surprise, in basis points. Dotted lines represent the 95% equal-tailed posterior interval. Black solid lines indicate the baseline estimate in specification (1).

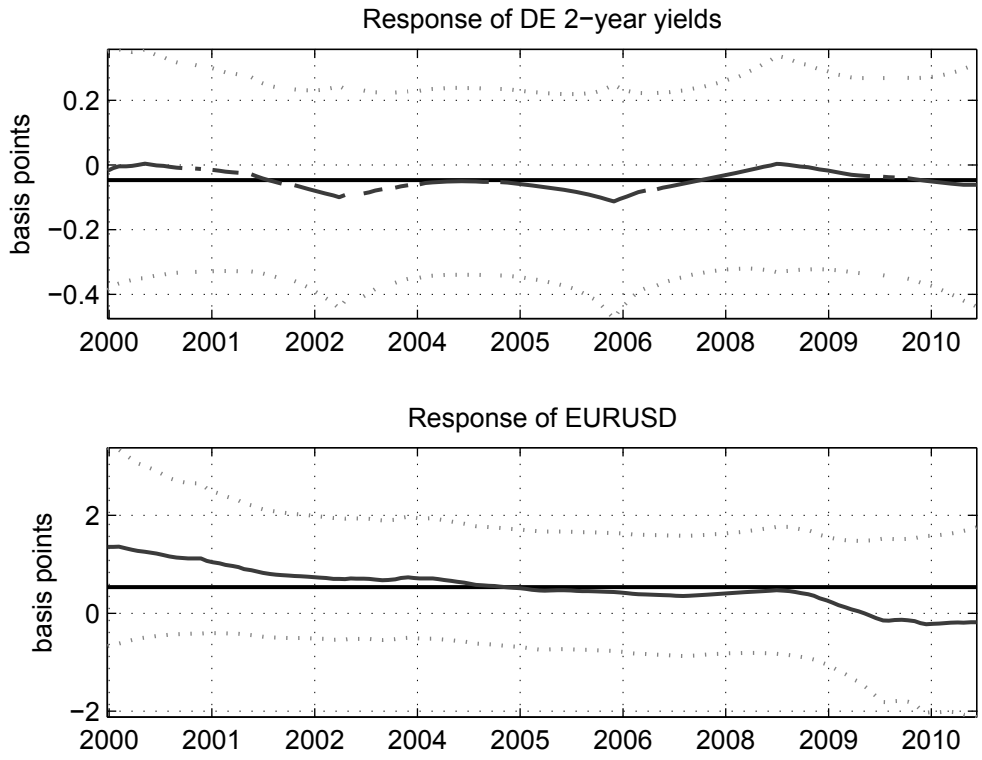

Figure 3: Responses of German 2-year bond yields and the EURUSD exchange rate to non-farm payrolls surprises, 8:25-8:35am window. The parameter paths are computed following Müller and Petalas (2010). The coefficients correspond to the time-varying effect of a one-standard deviation news surprise, in basis points. Dotted lines represent the 95% equal-tailed posterior interval. Black solid lines indicate the baseline estimate in specification (1).

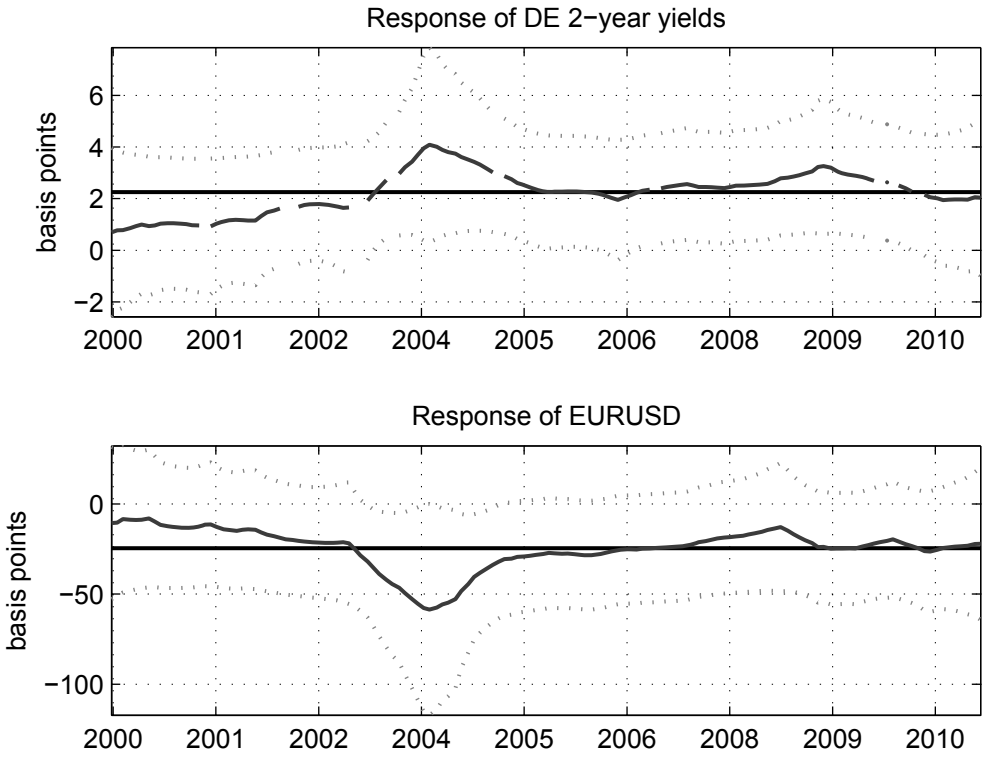

Figure 4: Responses of German 2-year bond yields and the EURUSD exchange rate to non-farm payrolls surprises, 8:25am-4pm window. The parameter paths are computed following Müller and Petalas (2010). The coefficients correspond to the time-varying effect of a one-standard deviation news surprise, in basis points. Dotted lines represent the 95% equal-tailed posterior interval. Black solid lines indicate the baseline estimate in specification (1).

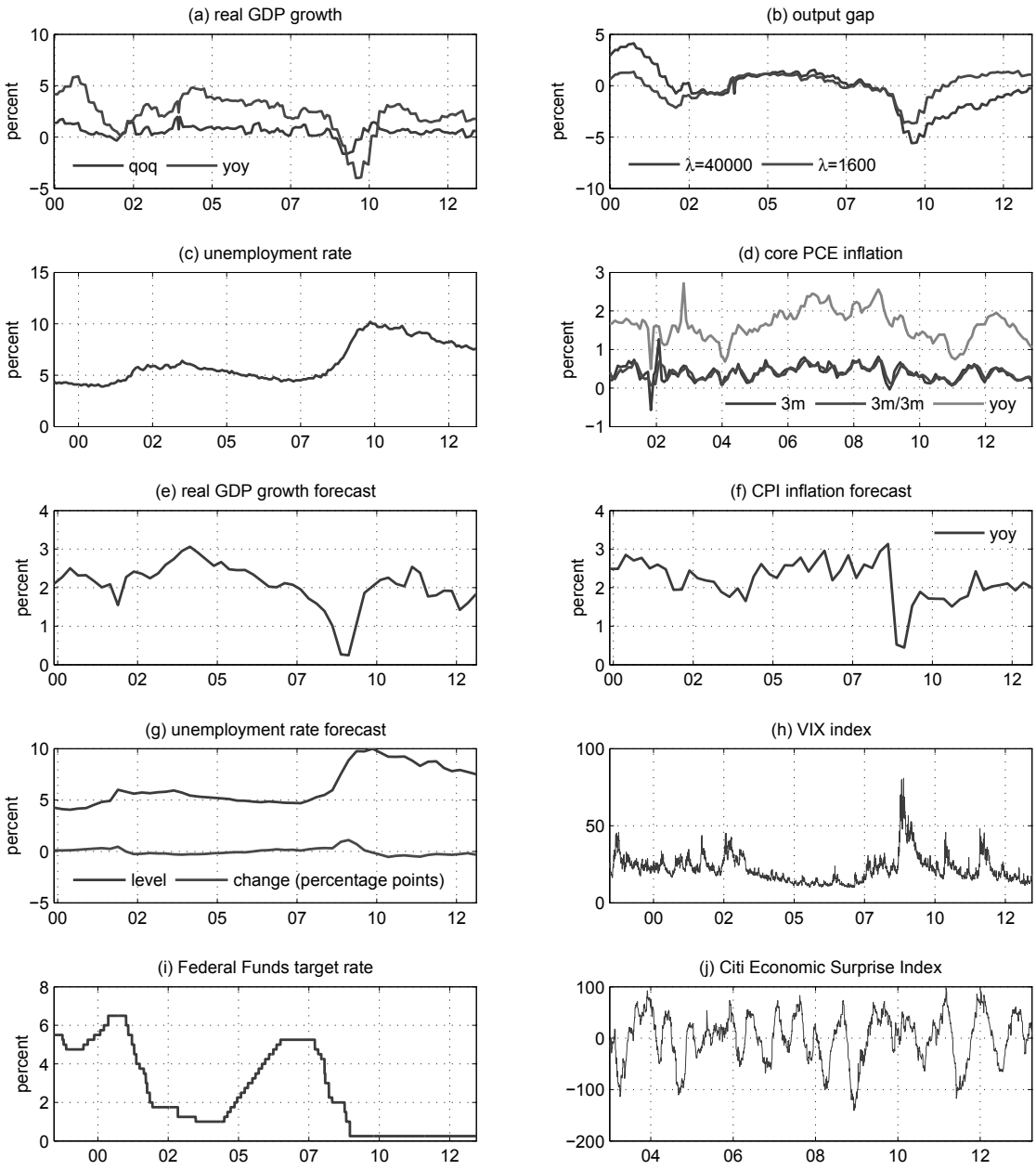

Figure 5: Explanatory variables used in section 5. Panels (a) to (c) use US real-time data from the Alfred database at the Federal Reserve Bank of St. Louis. Panels (d) to (g) use data from the survey of professional forecasters.

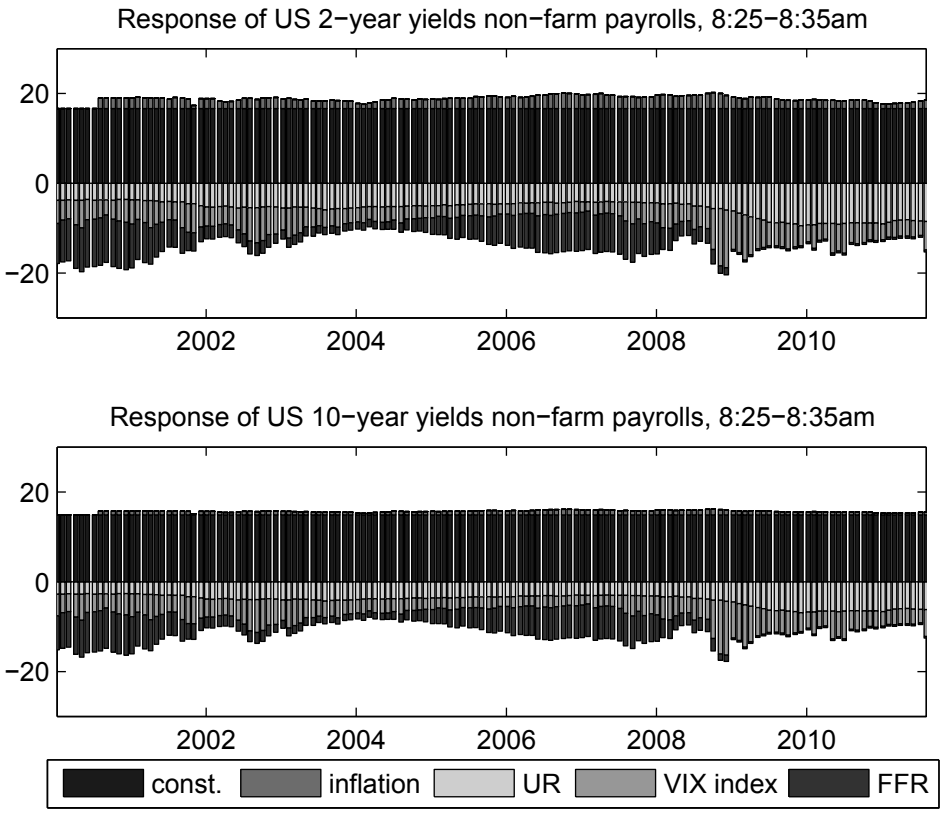

Figure 6: This chart shows contributions to $\beta_{k,t}$ from model (5), for the response of US government bond yields over the 8:25-8:35am window.

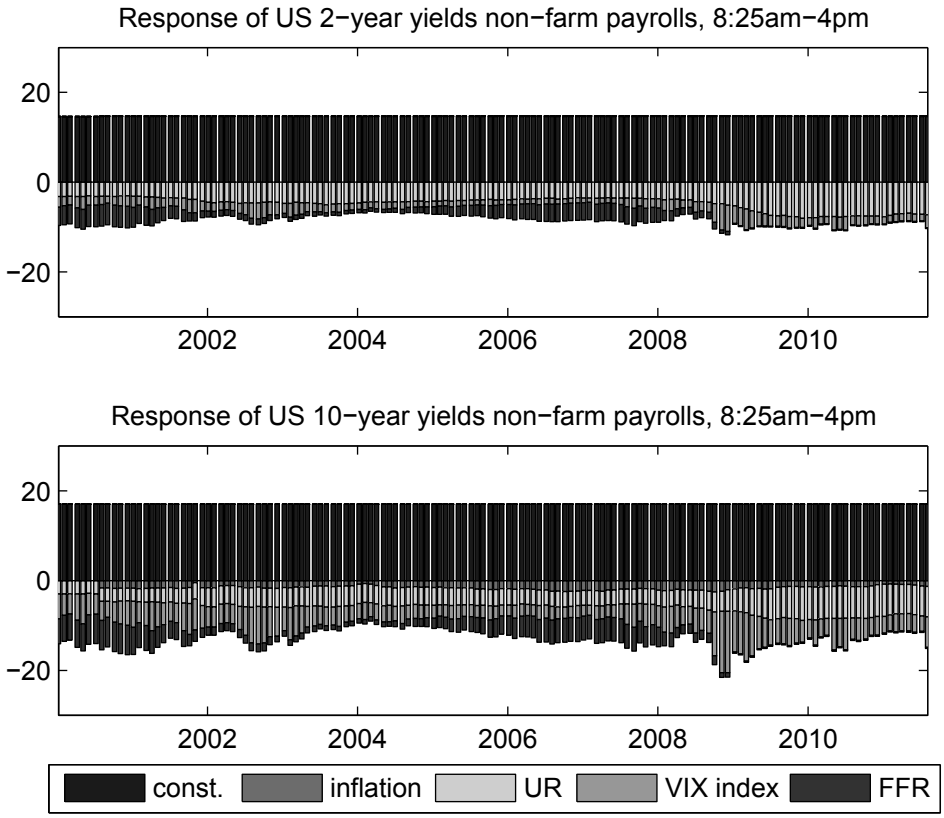

Figure 7: This chart shows contributions to $\beta_{k,t}$ from model (5), for the response of US government bond yields over the 8:25am-4pm window.

Appendix: results for specification (5)

Table 9: Sources of time variation in responses to non-farm payrolls: regression specification (5) using data from the survey of professional forecasters

	US yields			DE yields			FX
	2-year	5-year	10-year	2-year	5-year	10-year	EURUSD
8:25am-8:35am							
const.	20.75***	20.73***	17.76***	-0.13	0.10	0.11*	1.83**
inflation	-0.98	-0.88	-0.76	-0.00	-0.01	-0.01	-0.16
UR	-1.06*	-0.88	-0.82*	0.01	-0.01	-0.01*	-0.20***
VIX index	-0.18***	-0.21***	-0.18***	0.00	0.00	0.00	0.01
FFR	-1.31**	-1.42***	-1.24***	0.01	0.00	0.00	0.01
$\overline{R}^2$	0.49	0.54	0.58	0.32	0.62	0.58	0.66
Durbin-Watson	0.22	0.25	0.29	0.14	0.23	0.08	0.11
observations	128	130	131	128	135	136	140
8:25am-4pm							
const.	16.73***	16.99**	19.33**	4.87**	6.19**	5.07**	-92.87***
inflation	-0.78	-1.06	-1.16	-0.25	-0.37	-0.35	5.37
UR	-0.90***	-0.52	-0.92	-0.12	-0.10	-0.06	4.48*
VIX index	-0.09***	-0.21***	-0.23***	-0.03	-0.06**	-0.05**	0.73***
FFR	-0.62**	-0.87	-1.00*	-0.28*	-0.34	-0.27	5.05***
$\overline{R}^2$	0.63	0.46	0.55	0.40	0.39	0.41	0.61
Durbin-Watson	0.37	0.26	0.37	0.09	0.12	0.15	0.34
observations	105	115	112	129	134	137	140

Notes: This table reports coefficients from regression (5). ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on standard errors corrected to account for generated dependent variables as suggested by Dumont (2005). Yields refers to benchmark government bond yields. Inflation and UR are expected year-over-year CPI inflation and the expected one-year ahead unemployment rate from the survey of professional forecasters. VIX index is the CBOE VIX index on the day prior to the news release. FFR is the federal funds target rate.

Table 10: Sources of time variation in responses to non-farm payrolls: regression specification (5) using real-time data

	US yields			DE yields			FX
	2-year	5-year	10-year	2-year	5-year	10-year	EURUSD
8:25am-8:35am							
const.	16.64***	16.87***	14.86***	-0.10	0.09*	0.12***	1.99***
inflation	1.40	1.15	0.51	-0.01	0.00	-0.02	-0.32
UR	-0.93*	-0.73	-0.68	0.00	-0.01	-0.01**	-0.20***
VIX index	-0.20***	-0.23***	-0.19***	0.00	0.00	0.00	0.01
FFR	-1.62***	-1.65***	-1.38***	0.00	-0.00	-0.00	-0.01
$\overline{R}^2$	0.48	0.51	0.54	0.30	0.62	0.67	0.73
Durbin-Watson	0.27	0.28	0.30	0.15	0.17	0.24	0.26
observations	126	128	129	121	128	129	133
8:25am-4pm							
const.	14.64***	12.87*	17.00**	3.33*	4.01	3.18	-77.64***
inflation	0.06	0.83	-1.00	0.74*	0.94	0.72	1.25
UR	-0.79**	-0.33	-0.73	-0.09	-0.05	0.00	3.59
VIX index	-0.09***	-0.22***	-0.21***	-0.03*	-0.06**	-0.06**	0.71***
FFR	-0.74**	-1.08*	-1.01*	-0.39**	-0.47**	-0.38**	5.25**
$\overline{R}^2$	0.58	0.43	0.51	0.40	0.38	0.39	0.53
Durbin-Watson	0.29	0.26	0.30	0.19	0.19	0.20	0.25
observations	103	113	110	122	127	130	133

Notes: This table reports coefficients from regression (5). ***, **, and * denote significance at the 1%, 5% and 10% level, respectively, based on standard errors corrected to account for generated dependent variables as suggested by Dumont (2005). Yields refers to benchmark government bond yields. Inflation and UR are real-time data on year-over-year core PCE inflation and the unemployment rate. VIX index is the CBOE VIX index on the day prior to the news release. FFR is the federal funds target rate.

Swiss National Bank Working Papers published since 2004:

2004-1 Samuel Reynard: Financial Market Participation and the Apparent Instability of Money Demand

2004-2 Urs W. Birchler and Diana Hancock: What Does the Yield on Subordinated Bank Debt Measure?

2005-1 Hasan Bakhshi, Hashmat Khan and Barbara Rudolf: The Phillips curve under state-dependent pricing

2005-2 Andreas M. Fischer: On the Inadequacy of Newswire Reports for Empirical Research on Foreign Exchange Interventions

2006-1 Andreas M. Fischer: Measuring Income Elasticity for Swiss Money Demand: What do the Cantons say about Financial Innovation?

2006-2 Charlotte Christiansen and Angelo Ranaldo: Realized Bond-Stock Correlation: Macroeconomic Announcement Effects

2006-3 Martin Brown and Christian Zehnder: Credit Reporting, Relationship Banking, and Loan Repayment

2006-4 Hansjörg Lehmann and Michael Manz: The Exposure of Swiss Banks to Macroeconomic Shocks – an Empirical Investigation

2006-5 Katrin Assenmacher-Wesche and Stefan Gerlach: Money Growth, Output Gaps and Inflation at Low and High Frequency: Spectral Estimates for Switzerland

2006-6 Marlene Amstad and Andreas M. Fischer: Time-Varying Pass-Through from Import Prices to Consumer Prices: Evidence from an Event Study with Real-Time Data

2006-7 Samuel Reynard: Money and the Great Disinflation

2006-8 Urs W. Birchler and Matteo Facchinetti: Can bank supervisors rely on market data? A critical assessment from a Swiss perspective

2006-9 Petra Gerlach-Kristen: A Two-Pillar Phillips Curve for Switzerland

2006-10 Kevin J. Fox and Mathias Zurlinden: On Understanding Sources of Growth and Output Gaps for Switzerland

2006-11 Angelo Ranaldo: Intraday Market Dynamics Around Public Information Arrivals

2007-1 Andreas M. Fischer, Gulzina Isakova and Ulan Termechikov: Do FX traders in Bishkek have similar perceptions to their London colleagues? Survey evidence of market practitioners' views

2007-2 Ibrahim Chowdhury and Andreas Schabert: Federal Reserve Policy viewed through a Money Supply Lens

2007-3 Angelo Ranaldo: Segmentation and Time-of-Day Patterns in Foreign Exchange Markets

2007-4 Jürg M. Blum: Why 'Basel II' May Need a Leverage Ratio Restriction

2007-5 Samuel Reynard: Maintaining Low Inflation: Money, Interest Rates, and Policy Stance

2007-6 Rina Rosenblatt-Wisch: Loss Aversion in Aggregate Macroeconomic Time Series

2007-7 Martin Brown, Maria Rueda Maurer, Tamara Pak and Nurlanbek Tynaev: Banking Sector Reform and Interest Rates in Transition Economies: Bank-Level Evidence from Kyrgyzstan

2007-8 Hans-Jürg Büttler: An Orthogonal Polynomial Approach to Estimate the Term Structure of Interest Rates

2007-9 Raphael Auer: The Colonial Origins Of Comparative Development: Comment. A Solution to the Settler Mortality Debate

2007-10 Franziska Bignasca and Enzo Rossi: Applying the Hirose-Kamada filter to Swiss data: Output gap and exchange rate pass-through estimates

2007-11 Angelo Ranaldo and Enzo Rossi: The reaction of asset markets to Swiss National Bank communication

2007-12 Lukas Burkhard and Andreas M. Fischer: Communicating Policy Options at the Zero Bound

2007-13 Katrin Assenmacher-Wesche, Stefan Gerlach, and Toshitaka Sekine: Monetary Factors and Inflation in Japan

2007-14 Jean-Marc Natal and Nicolas Stoffels: Globalization, markups and the natural rate of interest

2007-15 Martin Brown, Tullio Jappelli and Marco Pagano: Information Sharing and Credit: Firm-Level Evidence from Transition Countries

2007-16 Andreas M. Fischer, Matthias Lutz and Manuel Wälti: Who Prices Locally? Survey Evidence of Swiss Exporters

2007-17 Angelo Ranaldo and Paul Söderlind: Safe Haven Currencies

2008-1 Martin Brown and Christian Zehnder: The Emergence of Information Sharing in Credit Markets

2008-2 Yvan Lengwiler and Carlos Lenz: Intelligible Factors for the Yield Curve

2008-3 Katrin Assenmacher-Wesche and M. Hashem Pesaran: Forecasting the Swiss Economy Using VECX* Models: An Exercise in Forecast Combination Across Models and Observation Windows

2008-4 Maria Clara Rueda Maurer: Foreign bank entry, institutional development and credit access: firm-level evidence from 22 transition countries

2008-5 Marlene Amstad and Andreas M. Fischer: Are Weekly Inflation Forecasts Informative?

2008-6 Raphael Auer and Thomas Chaney: Cost Pass Through in a Competitive Model of Pricing-to-Market

2008-7 Martin Brown, Armin Falk and Ernst Fehr: Competition and Relational Contracts: The Role of Unemployment as a Disciplinary Device

2008-8 Raphael Auer: The Colonial and Geographic Origins of Comparative Development

2008-9 Andreas M. Fischer and Angelo Ranaldo: Does FOMC News Increase Global FX Trading?

2008-10 Charlotte Christiansen and Angelo Ranaldo: Extreme Coexceedances in New EU Member States' Stock Markets

2008-11 Barbara Rudolf and Mathias Zurlinden: Measuring capital stocks and capital services in Switzerland

2008-12 Philip Sauré: How to Use Industrial Policy to Sustain Trade Agreements

2008-13 Thomas Bolli and Mathias Zurlinden: Measuring growth of labour quality and the quality-adjusted unemployment rate in Switzerland

2008-14 Samuel Reynard: What Drives the Swiss Franc?

2008-15 Daniel Kaufmann: Price-Setting Behaviour in Switzerland – Evidence from CPI Micro Data

2008-16 Katrin Assenmacher-Wesche and Stefan Gerlach: Financial Structure and the Impact of Monetary Policy on Asset Prices

2008-17 Ernst Fehr, Martin Brown and Christian Zehnder: On Reputation: A Microfoundation of Contract Enforcement and Price Rigidity

2008-18 Raphael Auer and Andreas M. Fischer: The Effect of Low-Wage Import Competition on U.S. Inflationary Pressure

2008-19 Christian Beer, Steven Ongena and Marcel Peter: Borrowing in Foreign Currency: Austrian Households as Carry Traders

2009-1 Thomas Bolli and Mathias Zurlinden: Measurement of labor quality growth caused by unobservable characteristics

2009-2 Martin Brown, Steven Ongena and Pinar Yeşin: Foreign Currency Borrowing by Small Firms

2009-3 Matteo Bonato, Massimiliano Caporin and Angelo Ranaldo: Forecasting realized (co)variances with a block structure Wishart autoregressive model

2009-4 Paul Söderlind: Inflation Risk Premia and Survey Evidence on Macroeconomic Uncertainty

2009-5 Christian Hott: Explaining House Price Fluctuations

2009-6 Sarah M. Lein and Eva Köberl: Capacity Utilisation, Constraints and Price Adjustments under the Microscope

2009-7 Philipp Haene and Andy Sturm: Optimal Central Counterparty Risk Management

2009-8 Christian Hott: Banks and Real Estate Prices

2009-9 Terhi Jokipii and Alistair Milne: Bank Capital Buffer and Risk Adjustment Decisions

2009-10 Philip Sauré: Bounded Love of Variety and Patterns of Trade

2009-11 Nicole Allenspach: Banking and Transparency: Is More Information Always Better?

2009-12 Philip Sauré and Hosny Zoabi: Effects of Trade on Female Labor Force Participation

2009-13 Barbara Rudolf and Mathias Zurlinden: Productivity and economic growth in Switzerland 1991-2005

2009-14 Sébastien Kraenzlin and Martin Schlegel: Bidding Behavior in the SNB's Repo Auctions

2009-15 Martin Schlegel and Sébastien Kraenzlin: Demand for Reserves and the Central Bank's Management of Interest Rates

2009-16 Carlos Lenz and Marcel Savioz: Monetary determinants of the Swiss franc

2010-1 Charlotte Christiansen, Angelo Ranaldo and Paul Söderlind: The Time-Varying Systematic Risk of Carry Trade Strategies

2010-2 Daniel Kaufmann: The Timing of Price Changes and the Role of Heterogeneity

2010-3 Loriano Mancini, Angelo Ranaldo and Jan Wrampelmeyer: Liquidity in the Foreign Exchange Market: Measurement, Commonality, and Risk Premiums

2010-4 Samuel Reynard and Andreas Schabert: Modeling Monetary Policy

2010-5 Pierre Monnin and Terhi Jokipii: The Impact of Banking Sector Stability on the Real Economy

2010-6 Sébastien Kraenzlin and Thomas Nellen: Daytime is money

2010-7 Philip Sauré: Overreporting Oil Reserves

2010-8 Elizabeth Steiner: Estimating a stock-flow model for the Swiss housing market

2010-9 Martin Brown, Steven Ongena, Alexander Popov, and Pinar Yeşin: Who Needs Credit and Who Gets Credit in Eastern Europe?

2010-10 Jean-Pierre Danthine and André Kurmann: The Business Cycle Implications of Reciprocity in Labor Relations

2010-11 Thomas Nitschka: Momentum in stock market returns: Implications for risk premia on foreign currencies

2010-12 Petra Gerlach-Kristen and Barbara Rudolf: Macroeconomic and interest rate volatility under alternative monetary operating procedures

2010-13 Raphael Auer: Consumer Heterogeneity and the Impact of Trade Liberalization: How Representative is the Representative Agent Framework?

2010-14 Tommaso Mancini Griffoli and Angelo Ranaldo: Limits to arbitrage during the crisis: funding liquidity constraints and covered interest parity

2010-15 Jean-Marc Natal: Monetary Policy Response to Oil Price Shocks

2010-16 Kathrin Degen and Andreas M. Fischer: Immigration and Swiss House Prices

2010-17 Andreas M. Fischer: Immigration and large banknotes

2010-18 Raphael Auer: Are Imports from Rich Nations Deskilling Emerging Economies? Human Capital and the Dynamic Effects of Trade

2010-19 Jean-Pierre Danthine and John B. Donaldson: Executive Compensation: A General Equilibrium Perspective

2011-1 Thorsten Beck and Martin Brown: Which Households Use Banks? Evidence from the Transition Economies

2011-2 Martin Brown, Karolin Kirschenmann and Steven Ongena: Foreign Currency Loans – Demand or Supply Driven?

2011-3 Victoria Galsband and Thomas Nitschka: Foreign currency returns and systematic risks

2011-4 Francis Breedon and Angelo Ranaldo: Intraday patterns in FX returns and order flow

2011-5 Basil Guggenheim, Sébastien Kraenzlin and Silvio Schumacher: Exploring an uncharted market: Evidence on the unsecured Swiss franc money market

2011-6 Pamela Hall: Is there any evidence of a Greenspan put?

2011-7 Daniel Kaufmann and Sarah Lein: Sectoral Inflation Dynamics, Idiosyncratic Shocks and Monetary Policy

2011-8 Iva Cecchin: Mortgage Rate Pass-Through in Switzerland

2011-9 Raphael A. Auer, Kathrin Degen and Andreas M. Fischer: Low-Wage Import Competition, Inflationary Pressure, and Industry Dynamics in Europe

2011-10 Raphael A. Auer and Philip Sauré: Spatial Competition in Quality, Demand-Induced Innovation, and Schumpeterian Growth

2011-11 Massimiliano Caporin , Angelo Ranaldo and Paolo Santucci de Magistris: On the Predictability of Stock Prices: a Case for High and Low Prices

2011-12 Jürg Mägerle and Thomas Nellen: Interoperability between central counterparties

2011-13 Sylvia Kaufmann: K-state switching models with endogenous transition distributions

2011-14 Sébastien Kraenzlin and Benedikt von Scarpatetti: Bargaining Power in the Repo Market

2012-01 Raphael A. Auer: Exchange Rate Pass-Through, Domestic Competition, and Inflation: Evidence from the 2005/08 Revaluation of the Renminbi

2012-02 Signe Krogstrup, Samuel Reynard and Barbara Sutter: Liquidity Effects of Quantitative Easing on Long-Term Interest Rates

2012-03 Matteo Bonato, Massimiliano Caporin and Angelo Ranaldo: Risk spillovers in international equity portfolios

2012-04 Thomas Nitschka: Banking sectors' international interconnectedness: Implications for consumption risk sharing in Europe

2012-05 Martin Brown, Steven Ongena and Pinar Yeşin: Information Asymmetry and Foreign Currency Borrowing by Small Firms

2012-06 Philip Sauré and Hosny Zoabi: Retirement Age across Countries: The Role of Occupations

2012-07 Christian Hott and Terhi Jokipii: Housing Bubbles and Interest Rates

2012-08 Romain Baeriswyl and Camille Cornand: Reducing overreaction to central bank's disclosures: theory and experiment

2012-09 Bo E. Honoré, Daniel Kaufmann and Sarah Lein: Asymmetries in Price-Setting Behavior: New Microeconometric Evidence from Switzerland

2012-10 Thomas Nitschka: Global and country-specific business cycle risk in time-varying excess returns on asset markets

2012-11 Raphael A. Auer, Thomas Chaney and Philip Sauré: Quality Pricing-to-Market

2012-12 Sébastien Kraenzlin and Thomas Nellen: Access policy and money market segmentation

2012-13 Andreas Kropf and Philip Sauré: Fixed Costs per Shipment

2012-14 Raphael A. Auer and Raphael S. Schoenle: Market Structure and Exchange Rate Pass-Through

2012-15 Raphael A. Auer: What Drives Target2 Balances? Evidence From a Panel Analysis

2012-16 Katja Drechsel and Rolf Scheufele: Bottom-up or Direct? Forecasting German GDP in a Data-rich Environment

2013-01 Andreas Kettemann and Signe Krogstrup: Portfolio balance effects of the SNB's bond purchase program

2013-02 Nicole Aregger, Martin Brown and Enzo Rossi: Transaction Taxes, Capital Gains Taxes and House Prices

2013-03 Simone Meier: Financial Globalization and Monetary Transmission

2013-04 Christian Grisse and Thomas Nitschka: On financial risk and the safe haven characteristics of Swiss franc exchange rates

2013-05 Matthias Gubler and Matthias S. Hertweck: Commodity Price Shocks and the Business Cycle: Structural Evidence for the U.S.

2013-06 Elisabeth Beusch, Barbara Döbeli, Andreas Fischer and Pınar Yeşin: Merchanting and Current Account Balances

2013-07 Victoria Galsband and Thomas Nitschka: Currency excess returns and global downside market risk

2013-08 Nikolay Markov and Thomas Nitschka: Estimating Taylor Rules for Switzerland: Evidence from 2000 to 2012

2013-09 Gregor Bäurle and Elizabeth Steiner: How do individual sectors respond to macroeconomic shocks? A structural dynamic factor approach applied to Swiss data

2013-10 Robert Oleschak and Thomas Nellen: Does SIC need a heart pacemaker?

2013-11 Linda S. Goldberg and Christian Grisse: Time variation in asset price responses to macro announcements

Swiss National Bank Working Papers are also available at www.snb.ch, section Publications/Research
Subscriptions or individual issues can be ordered at Swiss National Bank, Fraumünsterstrasse 8, CH-8022 Zurich,
fax +41 44 631 81 14, E-mail library@snb.ch