

Central Bank Communication and the Yield Curve*

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Abstract

Using the institutional features of ECB monetary policy announcements, we provide evidence for the risk premium channel of central bank communication. While central bank communication had a homogeneous effect across Euro-area sovereign bond yields before the European debt crisis, it drove a wedge between peripheral and core yields afterwards. Guided by the predictions of a theoretical model in which central bank communication reveals information about the state of the economy, we empirically link the periphery-core wedge to break-up and credit risk premia, and show that equity response to shocks can identify the strength of this risk premium channel.

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There is a growing consensus that monetary policy has surprisingly large effects on mid- and long-term interest rates; however, the literature disagrees on whether the dominant mechanism is via driving short rate expectations or risk premia, and whether these effects are short- or long-lived.¹ In this paper, we provide new evidence that monetary policy in the form of central bank communication affects risk premia and that this effect can be persistent. We identify the risk premium component of monetary policy communication by exploiting two points: (i) the protocol for European Central Bank (ECB) meetings allows us to decompose monetary policy surprises into target (short) rate and communication shocks, and (ii) current and future expected short rates are common across Euro-area countries, so shocks to yield spreads on ECB days must be due to shocks to risk premia.

To motivate our approach, Figure 1 displays cumulative changes in two-year sovereign bond yields for core and peripheral countries *only* on ECB meeting days from 2001 to 2015.² The plot shows that between 2001 and 2009 core and peripheral yields moved one-for-one on these days, but since the financial crisis yield changes have become disconnected, often moving in opposite directions and resulting in a significant yield spread. Moreover, this spread emerged during a period when unconventional measures were being implemented to reduce it. This paper shows both theoretically and empirically how such a spread can arise and provides new insights to understand the transmission mechanism of monetary policy on asset prices.

Our analysis is guided by a theoretical framework that highlights how central bank communication can command a risk premium. We consider a currency union of two countries, representing the Eurozone, and study the impact of monetary policy shocks that change the perceived probability of a credit event (a default or the breakup of this union), and hence, impact the risk premia investors demand on risky assets such as sovereign bonds and equity.

Within the model, when the central bank announces changes to the intended path of monetary policy, bond yields can be affected in two ways. First, monetary policy operates through the expectation channel: a negative target rate shock (lower current short rate than what market participants expected) or a negative communication shock (lower suggested future rates than what the market expected) provide information about future rates and thus decrease bond yields, and the magnitude is identical for bonds of the two countries. Second, monetary policy also works via the risk premium channel: a negative target rate or communication shock can be interpreted as bad news about the probability of the credit event and make investors less willing to hold risky assets. Thus, equilibrium risk premia go up on all sovereign debt, which dampens the effect of the expectation channel. If, in addition,

¹Hanson and Stein (2015) (among others) argue that monetary policy primarily works by affecting term premia, while Nakamura and Steinsson (2018) assert that yield reactions to policy surprises is due to strong nominal rigidities. Hanson, Lucca, and Wright (2018) argue that ‘excess sensitivity’ of long-term nominal interest rates to short-rate movements is transitory at low frequencies, while Brooks, Katz, and Lustig (2018) argue policy shocks generate permanent effects because they induce flows to fixed-income mutual funds.

²Throughout the paper the term ‘core’ refers to Germany and France, and ‘periphery’ to Italy and Spain. These countries account for about 76% of the total GDP of the Eurozone.

investors suffer larger losses on peripheral bonds conditional on the credit event, peripheral bond risk premia are larger in absolute terms, and core country bond yields are overall more responsive to monetary policy shocks than peripheral bonds.

Finally, we show that equity reaction to monetary policy shocks can provide information about the strength of the risk premium channel. In fact, even if stock and bond markets are segmented, equilibrium risk premia across asset classes are naturally correlated through the common credit event factor. Using the policy shock-equity covariance as a proxy for the magnitude of the risk premium channel can help explain the difference in the peripheral-core spread reaction to monetary policy shocks.

To extract monetary policy shocks around ECB announcement days, we rely on high-frequency data on money market rates with different maturities. Since target rate decisions and the press conference take place at different times, we can decompose intraday changes in Euro-area rates into surprises related to the level of the ECB policy interest rate (target rate shocks) and surprises related to the future path of monetary policy more generally (communication shocks). With the two ECB shocks in hand, we test the model predictions and document a number of novel results regarding Eurozone yields. First, target rate shocks affect yields almost one-for-one at the short end of the yield curve but have little impact on long-term yields. Communication shocks, however, have large effects on bond yields, being most pronounced for intermediate maturities, but also having significant impact at the long end. Importantly, while target shocks can have a significant impact on bond yields in the statistical sense, almost all explained variability in bond yields on ECB days is due to communication. Moreover, while the effect of target shocks on bond yields is short-lived, the effect of communication is more permanent and even increasing over time.

For our main result, we split our sample into pre- and post-crisis periods. We find that before 2009 monetary policy shocks affected the bond yields of Euro-area countries uniformly. After 2009, however, a differential effect of communication shocks arose between core and peripheral yields, which increased yield spreads at a time when unconventional measures were implemented to reduce them. Specifically, we show that post crisis peripheral yields' response to communication shocks became muted, whereas core country reactions remained the same. Using rolling regressions, we confirm that the effect of central bank communication on peripheral bond yields began to decline in early 2011, becoming insignificant by 2013. Combining this observation with the fact that communication was mostly dovish post 2009, we show that yields went down in core countries considerably whereas peripheral countries' yields did not react. As a result, communication is responsible for a significant wedge that, at its peak around the end of 2011, represented 20% of the total two-year yield spread.

We attribute the heterogeneous effect of communication shocks on core and peripheral yields to a risk premium differential across countries. In fact, by promising to keep interest rates low longer than previously expected (negative communication shocks), central bank decisions can signal bad news to the market, which implies agents require higher risk premia

on more vulnerable, i.e., peripheral, bonds.³ Motivated by our theoretical model, to identify days when communication shocks had a particularly strong risk premium effect, we rely on high-frequency movements of stock returns in a tight window around the ECB press conference. Standard theory predicts that tighter monetary policy should lead to a stock price decline, i.e., negative co-movement of shocks and equity; see, e.g., [Bernanke and Kuttner \(2005\)](#). In turn, tighter monetary policy that is accompanied by an increase in stock returns (positive co-movement) must indicate significantly improved economic or financial conditions either via positive cash flow news or lower risk premia. Thus, if risk premia on stocks and bonds are positively correlated, the sign of high-frequency co-movement of stocks and communication shocks can help disentangle days with (strong) communication risk premia versus no (or weak) risk premia on sovereign bonds.

Using this indicator, we find that while communication shocks affect yield spreads between peripheral and core countries on average, the effect is significantly larger on days with positive equity-shock co-movement. In other words, on these days future accommodating monetary policy was interpreted as an expression of the ECB's pessimistic view, which lead to an increase in the yield spread. A natural candidate for the cause of this wedge is the fear of a Eurozone breakup and sovereign default, as alluded to by ECB President Draghi's famous 'whatever it takes' speech that related peripheral countries' high borrowing costs to the emergence of liquidity, credit, and redenomination risk. To test this hypothesis, we explore the effect of monetary policy shocks on proxies of bond market illiquidity (bid-ask spreads), credit default swaps (CDS), and CDS quanto spreads.⁴ Using linear regressions, we find that the ECB's communication significantly increased the credit and redenomination risk spread between peripheral and core countries on positive equity-shock co-movement days. We take this result as evidence against a pure cash flow news spread, and conclude that communication dampened the effect of accommodating monetary policy on peripheral bonds post 2009 via the risk premium channel.

The rest of the paper is organized as follows. After a literature review, [Section 1](#) provides a theoretical framework to study the impact of monetary policy on sovereign yields. [Section 2](#) describes the institutional settings of ECB monetary policy days and outlines the identification of monetary policy shocks. We present our main empirical findings in [Section 3](#), and provide an explanation in [Section 4](#). Finally, [Section 5](#) examines the robustness of our results. An Online Appendix gathers additional results omitted from the main paper.

³A large literature studies whether and how monetary policy affects risk premia. For example, most of the unconventional monetary policy measures undertaken during the financial crisis by the U.S. Fed have compressed term premia and directly targeted other risky assets. However, monetary policy also affects risk premia in 'normal times'; see, e.g., [Yellen \(2011\)](#).

⁴CDS quanto spreads are the difference between two otherwise identical CDSs denominated in different currencies; in case of the Euro-area, these are CDS in U.S. dollars and Euros. A potential default of a Eurozone country would be expected to immediately trigger a devaluation of the Euro vis-à-vis the dollar and hence Euro-area CDS denominated in dollars trade at a higher spread (and are in general also more liquid). Therefore, CDS quanto spreads do not capture just credit risk of a country per se, but rather the expected devaluation of the Euro as well as the correlation between default and currency risk.

Related literature: This paper contributes to the asset pricing literature that explores the effect of monetary policy through demand and supply on the term structure of interest rates. Closest to us are [Hanson and Stein \(2015\)](#) and [Hanson, Lucca, and Wright \(2018\)](#), who document strong effects from short-rate changes on real and nominal U.S., as well as international bond yields. These authors interpret their results within a framework where ‘reaching-for-yield’ investors inelastically demand more long-term bonds as short rates decline and thereby affect term premia. Moreover, since capital is assumed to be slow-moving, shifts in term premia are transitory. The excess sensitivity of long-term rates in corporate and TIPS markets is the focus of [Brooks, Katz, and Lustig \(2018\)](#), who argue that target rate changes induce flows to fixed-income mutual funds and thereby increase the supply that has to be absorbed in equilibrium. Different from these papers, which focus on changes in short rates, we are interested in how communication about the future path of monetary policy affects long-term interest rates, and provide novel evidence that communication drives changes in credit and break-up risk premia.

Our theoretical model builds on the framework developed by [Vayanos and Vila \(2009\)](#), in which risk-averse arbitrageurs demand higher risk premia on bonds if their exposure to interest-rate risk increases due to shifts in the net supply of bonds. [Greenwood and Vayanos \(2014\)](#) use this model to study the implications of a change in the maturity structure of government debt supply, and [Hanson \(2014\)](#) and [Malkhozov, Mueller, Vedolin, and Venter \(2016\)](#) extend the framework to include mortgage-backed securities. [Greenwood, Hanson, and Vayanos \(2016\)](#) study forward guidance in rates and bond supply to evaluate the impact of QE announcements in the U.S and [Greenwood, Hanson, and Liao \(2018\)](#) model asset price dynamics in segmented markets to assess the impact of recent large-scale asset purchases by central banks. In these papers, which only consider a single country, risk premia are driven by shocks to net supply and its future path. Thus, the impact of conventional monetary policy tools on bond yields, via the expectation channel only, concentrates at the very short end of the yield curve and becomes negligible for longer maturities. In contrast, our framework highlights the impact of a risk premium news channel, therefore communication can have a significant impact on long-maturity bond yields, too. Further, our multi-country setting allows us to study cross-sectional differences in yield reactions between core and peripheral countries.

Second, our paper is related to the literature that explores the information channel of monetary policy whereby policy actions communicate information about the state of the economy to an imperfectly informed public: the policymaker has more information about economic fundamentals, hence her action taken in response to these fundamentals provides information to private agents. In the words of [Campbell, Fisher, Justiniano, and Melosi \(2016\)](#), monetary policy surprises “have a Delphic component.” In support of this, [Nakamura and Steinsson \(2018\)](#) find that FOMC forward guidance conveys the FOMC’s private information to market participants and that this information transfer has large macroeconomic effects. [Gürkaynak, Sack, and Swanson \(2005b\)](#) show that one way to explain

the large effects of monetary policy on long-term forward rates is to assume that the private agents' views of long-term inflation are not well-anchored. [Tang \(2015\)](#) documents that surprises in the Federal funds rate are empirically linked to inflation expectations. Different from these papers, we argue for and are primarily interested in the effect of communication on risk premia in sovereign bond markets.

Third, a handful of papers have studied how central bank communication can affect asset prices. [Ehrmann and Fratzscher \(2005\)](#) compare the communication strategies of the Federal Reserve, the Bank of England, and the ECB by measuring the tone in speeches and statements. Their findings suggest that central bank communication is a key determinant of the market's ability to anticipate monetary policy decisions and the future path of interest rates. [Rosa and Verga \(2008\)](#) examine the effect of ECB communication on the price discovery process in the Euribor futures market.

A set of studies have constructed wording indicators to classify the content of the statements of the ECB's or Fed's press conferences. [Lucca and Trebbi \(2011\)](#) construct a hawkish/dovish indicator from statements of Federal Open Committee Members and find longer-dated yields react to changes in communication around announcements. [Schmeling and Wagner \(2017\)](#) explore the effect of central bank tone on asset prices, where the tone measures the number of 'negative' words in the press statement following the target rate announcement. Different from these papers, we show that communication about monetary policy is not only the dominant factor driving interest rate changes on announcement days but also has significantly differential effects in the cross-section of Euro-area bond yields.

The construction of our shocks follows [Brand, Buncic, and Turunen \(2010\)](#), who study the effect of monetary policy on Eurozone money market rates. Different from the authors, whose data sample ends in 2007, our paper focuses on the heterogeneous cross-sectional effect of monetary policy communication on sovereign bonds after the financial crisis, particularly on days with strong risk premia effects.

Finally, the recent unconventional policies of central banks around the world spurred a plethora of literature on their impact on asset prices. For example, [Krishnamurthy, Nagel, and Vissing-Jorgensen \(2018\)](#) study three different ECB policies and argue that the reduction in peripheral yields is due to a compression of default and redenomination risk premia, as well as reduced segmentation effects. [Kojen, Koulischer, Nguyen, and Yogo \(2018\)](#) find that portfolio rebalancing due to the ECB's asset purchases led to a 13bps decline in yields on average. We contribute to this literature by focussing exclusively on conventional monetary policy and how communication can induce risk premia via investors' demand shocks.

1 Theoretical framework

To illustrate the mechanism of how monetary policy affects bond and stock returns, we propose a two-period overlapping-generations equilibrium model. Time is indexed by $t = 0, 1$ and 2. Agents, described below, make investment decisions at dates 0 and 1, and by date 2

all assets pay out. Our main interest lies in the date-0 relationship between monetary policy shocks and stock and bond prices.

We consider a world economy with two countries of a currency union, e.g. the Eurozone, referred to as core and peripheral and indexed by c and p . There are four assets in this economy that agents can invest in. First, at $t = 0$ and 1 , agents have access to a global riskless asset, akin to one-period risk-free bonds of the two countries, and this asset pays a net return of r_t at time $t + 1$. Further, there exist (long-term) zero-coupon bonds of both countries that mature at $t = 2$. The log price of the bond of country i , $i = c, p$, with date-2 face value of one Euro, the currency unit, is denoted by $p_{i,t}$, $t = 0, 1$, the yield-to-maturity by $y_{i,t} = -p_{i,t}/(t - 2)$, and the (risky) one-period net return on this bond, between t and $t + 1$, by $r_{i,t+1} = p_{i,t+1} - p_{i,t}$. We assume the country- i bond is in net Euro supply $S_{i,t} = S_i \geq 0$ for $i = c, p$. Finally, at date 0 there exists an asset that represents an aggregate stock index of the Eurozone, with a risky terminal log dividend d_1 paid out at date 1, in fixed Euro supply $S_{s,t} = S_s \geq 0$. We denote the date-0 log price of the stock by $p_{s,0}$, and the one-period net return by $r_{s,1} = d_1 - p_{s,0}$.^{5,6}

The risk-free rate r_t is assumed to be exogenously given, and its dynamics under the physical probability measure follows

$$r_{t+1} = r_t + \kappa_r (\theta_t - r_t) + Z_{r,t+1}, \quad (1)$$

where

$$\theta_{t+1} = \theta_t + \kappa_\theta (\bar{\theta} - \theta_t) + Z_{\theta,t+1}, \quad (2)$$

$\kappa_r, \kappa_\theta \in (0, 1)$ constants, and $Z_{r,t+1}$ and $Z_{\theta,t+1}$ are i.i.d. random variables with mean zero and variances σ_r^2 and σ_θ^2 , respectively. We interpret r_t as the target short rate set by the central bank and θ_t as information provided by the central bank about future short rates. Thus, $Z_{r,t}$ are changes to the target rate unexpected by investors, and $Z_{\theta,t}$ stand for communication shocks that provide new information about the future path of interest rates.

We assume that at the beginning of date 1, i.e. between the two trading rounds, a credit event can happen in the economy that we interpret as either the default of the peripheral country and/or the breakup of the Eurozone. Formally, this is triggered by the random variable $Z_{b,1}$ that takes the value of 1 with conditional probability π_0 and is zero otherwise, independent of all $Z_{r,t}$ s and $Z_{\theta,t}$ s. From its definition, $E_0 [Z_{b,1}] = E_0 [Z_{b,1}^2] = \pi_0$ and $\text{Var}_0 [Z_{b,1}] = \pi_0 - \pi_0^2$. To keep the calculations simple, we make the linear approximation $\text{Var}_0 [Z_{b,1}] \approx \pi_0$, which would be exact in a continuous-time framework, and is approximately true when π_0

⁵Assuming that the equity payoff happens at date 2 would lead to a slightly longer analysis without any further economic insight.

⁶It would be straightforward to introduce time-varying or even stochastic supply into the model for bonds and equity alike; see, e.g., [Greenwood and Vayanos \(2014\)](#). Moreover, our framework could accommodate country-specific credit risk for a more realistic modelling. These generalizations, however, would increase the technical complexity without any significant additional insight. Further, our framework could introduce stock indices of both countries, but our empirical identification regarding the strength of monetary policy news, presented in Section 4, does not depend on whether we look at an aggregate Eurozone stock index or country-level indices separately.

is close to zero. We allow π_0 to be random; in particular, we want to capture that monetary policy shocks provide news about the future of the Eurozone and hence affect the perceived probability of the credit event:⁷

$$\pi_0 = \bar{\pi} - Z_{\pi,0} - \eta_r Z_{r,0} - \eta_\theta Z_{\theta,0}, \quad (3)$$

with a constant $\bar{\pi}$ and a random variable $Z_{\pi,0}$ that has mean zero and variance σ_π^2 , and is independent of all $Z_{r,t}$, $Z_{\theta,t}$, and $Z_{b,1}$. The constant coefficients η_r and η_θ are crucial variables of the model as having non-zero η_r and η_θ implies that monetary policy decisions and communications can provide information about the state of the economy to market participants. In particular, having $\eta_r, \eta_\theta > 0$ captures that in turbulent times market participants can interpret negative target rate shocks (i.e., target rates lower than what the market expects) and negative communication shocks (i.e., future rates staying low longer than the market expects) as bad news. For example, the central bank that might have superior information believes rates must be held low for a prolonged period, so market participants increase their estimate regarding the probability of the credit event. If instead $\eta_r = \eta_\theta = 0$, the probability of a credit event is independent of monetary policy.

In case of the credit event, e.g. if the Eurozone breaks up, terminal payoffs on sovereign bonds and equity are affected; we consider this an event after which agents cannot capture the full intrinsic value of assets due to an actual default and the subsequent credit auction, or, e.g., search or transaction costs, lower liquidity, or a change in monetary policy by the now independent central banks.⁸ For sovereign bonds, we model this outcome as a drop in the face value from one Euro to $e^{-\gamma_i}$, measured by the non-negative coefficients γ_i , $i = c, p$.

Our interpretation distinguishes two main regimes for model parameters. One regime corresponds to the view that since the financial crisis there is a significant disconnect between the strength of core and peripheral economies, and in case of a peripheral default or the Eurozone breakup bonds issued by peripheral countries would be more exposed to credit losses, potential redenomination, and liquidity risks, and hence less valuable than bonds issued by core countries. This scenario corresponds to losses being larger on peripheral bonds: $\gamma_p \geq \gamma_c \geq 0$. A second regime is one featuring such sound financial conditions of the Eurozone that no significant difference between core and peripheral bonds exist, $\gamma_p = \gamma_c$, and/or a very small informational asymmetry between central banks and market participants such that monetary policy decisions and communications do not contain significant new information: $\eta_r = 0$. We think about the latter as close to the pre-financial-crisis view.⁹

⁷We have in mind a setting where the central bank has superior information about the fundamentals of the economy, and through its decisions, can affect some important macro variables, including the probability of breakup. If the central bank picks r_t and θ_t as solutions to an optimization problem subject to their information set, changes to r_t and θ_t will provide information to market participants. In Section OA-8 of the Online Appendix we provide a simple model as a micro foundation for this assumption.

⁸See also http://www.markit.com/cds/documentation/resource/credit_event_auction_primer.pdf.

⁹The specific assumption on the level and nature of losses at date 2 is not crucial for our results. First, we could also allow for core country bonds to have higher payout when peripheral countries exit the Eurozone in the form of $\gamma_c < 0$. This would only shift the level of equilibrium yields, but would not affect our qualitative

For equity, we allow monetary policy shocks and the credit event to affect the terminal log dividend:

$$d_1 = g_1 - \gamma_s Z_{b,1}, \quad (4)$$

where the random variable g_1 , with conditional mean $E_0[g_1] = \bar{g} + \phi_r Z_{r,0} + \phi_\theta Z_{\theta,0}$ and variance $\text{Var}_0[g_1] = \sigma_g^2$, has a standard risky equity payout component that is independent of monetary policy and breakup, the constant coefficients ϕ_r and ϕ_θ capture the effect of monetary policy signalling in terms of cash flow news, and the coefficient $\gamma_s \geq 0$ captures that the credit event can affect equity dividends, too.

Assets are held by overlapping generations of identical competitive investors that comprise a representative agent.¹⁰ Investors live for one period; they choose optimal bond and equity holdings at time t to trade off the mean and variance of their terminal wealth at $t + 1$. If $x_{i,t}$, $i = c, p, s$, denotes the Euro amount that period- t agents borrow to invest in core and peripheral bonds and in the stock, respectively, their budget constraint is written as

$$w_{t+1} = \sum_{i=c,p,s} x_{i,t} (r_{i,t+1} - r_t), \quad (5)$$

and the optimization problem is given by

$$\max_{\{x_{i,t}\}_{i=c,p,s}} E_t [w_{t+1}] - \frac{\alpha}{2} \text{Var}_t [w_{t+1}], \quad (6)$$

where $\alpha \geq 0$ is the coefficient of risk aversion. Finally, the market-clearing conditions are $x_{i,t} = S_i$ for $i = c, p, s$.¹¹

1.1 Equilibrium

At the date-1 investment phase agents know whether the credit event has happened, i.e., whether the date-2 payoff of the country- i bond is one or $e^{-\gamma_i}$. Hence, sovereign bonds by this time reduce to one-period riskless investment opportunities: by no arbitrage, bond returns between dates 1 and 2 must be r_2 , and date-1 log bond prices are $p_{i,1} = -r_1 - \gamma_i Z_{b,1}$.

predictions regarding the cross-section of yields. Second, our approach could also be extended to uncertain losses given the credit event happening. One sufficient condition for our results to remain valid is that the peripheral loss γ_p first-order stochastically dominates the core loss γ_c .

¹⁰Investors populating core and peripheral countries might be heterogeneous in terms of the potential losses suffered on certain assets. Hence, in Section OA-9 of the Online Appendix, we construct a model that allows for investor heterogeneity in the γ_i s. Under an additional mild assumption we obtain that upon negative monetary policy shocks, holdings also exhibit home bias, i.e., agents sell (short) foreign bonds and purchase home-country bonds instead, in line with the findings of, e.g., [Gennaioli, Martin, and Rossi \(2014\)](#), [Chari, Dovis, and Kehoe \(2016\)](#), and [Becker and Ivashina \(2018\)](#). See also [Farhi and Tirole \(2018\)](#).

¹¹To maintain tractability, we must assume that yields and expected returns are linear functions of a vector of state variables. Although stylized, this linearity assumption is common in asset pricing models. In particular, we substitute log returns for simple returns throughout our analysis, and use a [Campbell and Shiller \(1988\)](#) linearization of log returns. This modelling approach is also used in [Hanson and Stein \(2015\)](#), among other discrete-time models, and would be exact in continuous time.

From here, bond returns between dates 0 and 1 can simply be written as

$$r_{i,1} = p_{i,1} - p_{i,0} = 2y_{i,0} - r_1 - \gamma_i Z_{b,1}, \quad (7)$$

whereas the equity return is given by

$$r_{s,1} = d_1 - p_{s,0} = g_1 - \gamma_s Z_{b,1} - p_{s,0}. \quad (8)$$

Introducing the notation $\mu_{i,0} \equiv 2y_{i,0} - E_0[r_1]$, $i = c, p$, and $\mu_{s,0} \equiv E_0[g_1] - p_{s,0}$ for expected returns conditional on no credit event, and combining (5)-(8), the optimization problem at date 0 becomes

$$\begin{aligned} & \max_{\{x_{i,0}\}_{i=c,p,s}} \sum_{i=c,p,s} x_{i,0} (E_0[r_{i,1}] - r_0) - \frac{\alpha}{2} \text{Var}_0 \left[\sum_{i=c,p,s} x_{i,0} r_{i,1} \right] \\ & = \sum_{i=c,p,s} x_{i,0} (\mu_{i,0} - r_0 - \gamma_i \pi_0) - \frac{\alpha}{2} \left[(x_{c,0} + x_{p,0})^2 \sigma_r^2 + x_{s,0}^2 \sigma_g^2 + \left(\sum_{i=c,p,s} \gamma_i x_{i,0} \right)^2 \pi_0 \right], \end{aligned}$$

which leads to the following first-order conditions:

$$\mu_{i,0} - r_0 = \alpha \sigma_r^2 (x_{c,0} + x_{p,0}) + \gamma_s [1 + \alpha (\gamma_c x_{c,0} + \gamma_p x_{p,0} + \gamma_s x_{s,0})] \pi_0 \quad (9)$$

for $i = c, p$, and

$$\mu_{s,0} - r_0 = \alpha \sigma_g^2 x_{s,0} + \gamma_s [1 + \alpha (\gamma_c x_{c,0} + \gamma_p x_{p,0} + \gamma_s x_{s,0})] \pi_0. \quad (10)$$

Equations (9)-(10) highlight that expected excess returns on assets must compensate agents for the risk they hold, which is the interest rate and breakup risk for bonds, and the cash flow and breakup risk for stocks, respectively. Imposing market clearing, we obtain that equilibrium expected excess returns satisfy

$$\mu_{i,0} - r_0 = \alpha \sigma_r^2 (S_c + S_p) + \alpha \gamma_i [1 + (\gamma_c S_c + \gamma_p S_p + \gamma_s S_s)] \pi_0 \quad (11)$$

for $i = c, p$ and

$$\mu_{s,0} - r_0 = \alpha \sigma_g^2 S_s + \alpha \gamma_s [1 + (\gamma_c S_c + \gamma_p S_p + \gamma_s S_s)] \pi_0. \quad (12)$$

Combining (11) and (12) with the definition of bond and stock returns, (7) and (8), leads to the following result:

Theorem 1. *In the model described above, date-0 equilibrium bond yields are given by*

$$y_{i,0} = \frac{E_0[r_{i,1}] + E_0[r_1] + \gamma_i \pi_0}{2} = \underbrace{\frac{1}{2} [(2 - \kappa_r) r_0 + \kappa_r \theta_0]}_{\text{expectation component}} + \underbrace{\frac{1}{2} \alpha \sigma_r^2 (S_c + S_p) + \frac{1}{2} \gamma_i \lambda_\pi \pi_0}_{\text{risk premium components}}, \quad (13)$$

and the date-0 equilibrium stock price is

$$p_{s,0} = \underbrace{\bar{g} + \phi_r Z_{r,0} + \phi_\theta Z_{\theta,0}}_{\text{expected dividend } E_0[d_1]} - \underbrace{\left(r_0 + \overbrace{\alpha \sigma_g^2 S_s + \gamma_s \lambda_\pi \pi_0}^{\text{risk premium components}} \right)}_{\text{expected stock return } E_0[r_{s,1}]}, \quad (14)$$

with $\lambda_\pi \equiv 1 + \alpha (\gamma_c S_c + \gamma_p S_p + \gamma_s S_s) > 0$.

Equation (13) shows that the yield on a long-term bond equals the average expected short rate over the lifetime of the bond plus the average risk premium components for interest rate risk and the risk of the credit event. In turn, stock prices can be described by a textbook dividend discounting formula: the log price is the difference of the log expected next period cash flow and the discount rate, which in turn is the current risk-free rate plus the risk premium. Importantly, the equilibrium market price of default risk, $\lambda_\pi \pi_0$, shows up in both bond yields and stock returns, because all assets are subject to the risk of the credit event and are priced by the same representative investor.¹²

1.2 Model predictions

We summarize our model predictions about the effect of target and communication shocks on sovereign bond yields and the relationship of bond and stock prices in a series of propositions that form the basis of our baseline empirical tests. For this, we start with model-implied unconditional multivariate regressions of country- i bond yield changes on the target rate and communication shocks in the form¹³

$$\Delta y_{i,0} = \alpha_i + \beta_{i,r} Z_{r,0} + \beta_{i,\theta} Z_{\theta,0} + \varepsilon_{i,0}, \quad (15)$$

where $\Delta y_{i,0} \equiv y_{i,0} - E[y_{i,0}]$ is the surprise in yields compared to the ex ante expectation, before the date-0 shocks are realized, and a regression of the periphery-core yield spread on the two shocks:

$$\Delta (y_{p,0} - y_{c,0}) = \alpha_{pc} + \beta_{pc,r} Z_{r,0} + \beta_{pc,\theta} Z_{\theta,0} + \varepsilon_{pc,0}. \quad (16)$$

Equation (13) implies that in our model regression coefficients become:

$$\beta_{i,r} = \frac{1}{2} [(2 - \kappa_r) - \eta_r \gamma_i \lambda_\pi] \quad \text{and} \quad \beta_{i,\theta} = \frac{1}{2} [\kappa_r - \eta_\theta \gamma_i \lambda_\pi], \quad (17)$$

¹²Our model assumes that there is a representative investor who prices all assets and is not subject to any constraints. While introducing some form of explicit market segmentation, e.g. following Greenwood, Hanson, and Liao (2018), would lead to different equilibrium prices, it would not affect the result that bond and stock risk premia co-move positively, as all assets would be still subject to a common risk factor π_0 .

¹³As the target and communication shocks are uncorrelated in the model, univariate regressions of yield changes on either the target or the communication shocks would lead to the same regression coefficients as the multivariate one. Moreover, running the theoretical regressions on the actual variables, e.g. on r_t instead of the shock $Z_{r,t}$, would not affect coefficients.

and the spread regression coefficients are

$$\beta_{pc,r} = \beta_{p,r} - \beta_{c,r} = \frac{1}{2}\eta_r (\gamma_c - \gamma_p) \lambda_\pi \text{ and } \beta_{pc,\theta} = \beta_{p,\theta} - \beta_{c,\theta} = \frac{1}{2}\eta_\theta (\gamma_c - \gamma_p) \lambda_\pi. \quad (18)$$

The above results lead to the following testable predictions:

Proposition 1. *The impact of target shocks in regression (15) is uniform across countries, $\beta_{c,r} = \beta_{p,r}$ or $\beta_{pc,r} = 0$, as long as the news channel is absent, $\eta_r = 0$, and/or there is no heterogeneity in losses, $\gamma_c = \gamma_p$. For $\gamma_p > \gamma_c$ and $\eta_r > 0$, we have $\beta_{c,r} > \beta_{p,r}$ and $\beta_{pc,r} < 0$. Moreover, there exists a constant $\bar{\eta}_r > 0$ such that regression betas are negative if $\eta_r > \bar{\eta}_r$.*

Proposition 2. *The impact of communication shocks in regression (15) is uniform across countries, $\beta_{c,\theta} = \beta_{p,\theta}$ or $\beta_{pc,\theta} = 0$, as long as the news channel is absent, $\eta_\theta = 0$, and/or there is no heterogeneity in losses, $\gamma_c = \gamma_p$. For $\gamma_p > \gamma_c$ and $\eta_\theta > 0$, we have $\beta_{c,\theta} > \beta_{p,\theta}$ and $\beta_{pc,\theta} < 0$. Moreover, there exists a constant $\bar{\eta}_\theta > 0$ such that regression betas are negative if $\eta_\theta > \bar{\eta}_\theta$.*

Propositions 1 and 2 state that if monetary policy action and communication provide information about the state of the economy, and the peripheral economy is weaker than the core, shocks have higher impacts on core country yields than on peripheral yields.

Bond yields are the average expected returns earned through the lifetime of bonds, which in turn depend on expected future risk-free rates and risk premia. Therefore, when the central bank announces changes to either the current target rate or the intended future path of monetary policy, bond yields can be affected via two channels.

A direct effect operates through the expectation channel, and it is uniform across all countries, because they share the same target rate process. A negative current target rate shock decreases all future expected target rates. Thus, as a response, bond yields go down. Similarly, communication shocks provide information about intended future target rates: a negative communication shock implies that future target rates are lower than previously expected, also decreasing all yields.

The second, indirect effect, works through the risk premium channel as monetary policy shocks affect the equilibrium price of risk of the credit event. In our model, a negative target or communication shock is also interpreted as bad news about the state of the economy as long as η_r or $\eta_\theta > 0$: it makes investors less willing to hold risky assets such as long-term bonds and equity compared to the risk-free investment. Hence, agents, who still have to hold them in equilibrium, demand a higher risk premium. Overall, negative monetary policy shocks lower rates via the expectation channel but raise them via the risk premium channel; the direct and indirect effects go in opposite directions, as captured by the negative signs of the $\gamma_i \lambda_\pi$ terms in (17).

The heterogeneity in the impact of monetary policy shocks on bond yields across countries is driven by the fact that agents expect to suffer larger losses on peripheral long-term bonds than on core ones, so the risk premium they demand must be higher. Given that the expectation channel is identical for bonds of the two countries, and that the risk

premium channel goes the opposite direction as the expectation channel, we obtain that core country bonds are more responsive to communication shocks than peripheral bonds. Finally, as Propositions 1 and 2 suggest, the news channel can be strong enough to dominate the expectation channel and lead to negative overall regression coefficients.

Next we study the model-implied relationship of stock returns and monetary policy shocks in the form of the theoretical regression

$$\Delta p_{s,0} = \alpha_s + \beta_{s,r} Z_{r,0} + \beta_{s,\theta} Z_{\theta,0} + \varepsilon_{s,0}, \quad (19)$$

where $\Delta p_{s,0} \equiv p_{s,0} - E[p_{s,0}]$ is return surprise at time of the announcement. From (14) we obtain

$$\beta_{s,r} = \phi_r + \eta_r \gamma_s \lambda_\pi - 1 \text{ and } \beta_{s,\theta} = \phi_\theta + \eta_\theta \gamma_s \lambda_\pi, \quad (20)$$

which prompt the following result:

Proposition 3. *As long as $\eta_r = \eta_\theta = \phi_r = \phi_\theta = 0$, we have $\beta_{s,r} = -1 < 0$ and $\beta_{s,\theta} = 0$. When either $\eta_\theta > 0$ or $\phi_\theta > 0$, we have $\beta_{s,\theta} > 0$. Moreover there exist $\bar{\eta}_r > 0$ and $\bar{\phi}_r > 0$ such that either $\eta_r > \bar{\eta}$ and $\phi_r \geq 0$, or $\eta_r \geq 0$ and $\phi_r > \bar{\phi}_r$, imply $\beta_{s,r} > 0$.*

According to Proposition 3, when both the cash flow and risk premium news channel of monetary policy are absent from the model, we obtain that an increase in target rates decreases contemporaneous stock returns—the standard monetary policy effect documented by Bernanke and Kuttner (2005). Moreover, communication shocks in this case do not move stock returns. If, on the other hand, monetary policy also signals something about the future state of the economy, which in our model either refers to news about the level of expected dividends or the probability of a credit event or Eurozone breakup, there is positive co-movement between communication shocks and contemporaneous stock returns. Further, an increase in the target rate can also lead to positive stock returns, if the news effect, either via cash flow news or risk premium news, is strong enough (see, e.g., Jarociński and Karadi (2018)).

Finally, our framework connects bond yield regression coefficients and the covariance between monetary policy shocks and stock returns. Using (17), (18), and (20), we obtain the following result.¹⁴

Proposition 4. *Holding all other coefficients fixed, $Cov[p_{s,0}, Z_{j,0}]$ is increasing, while $\beta_{c,j}$, $\beta_{p,j}$, and $\beta_{pc,j}$ are all decreasing in η_j for $j = r, \theta$. Assuming that all the variation is coming from η_j , we have $d\beta_{c,j}/dCov[p_{s,0}, Z_{j,0}]$, $d\beta_{p,j}/dCov[p_{s,0}, Z_{j,0}]$, $d\beta_{pc,j}/dCov[p_{s,0}, Z_{j,0}] < 0$.*

The reason for the tight relationship between the equity-shock correlation and the yield regression coefficients is that since equity is also subject to the risk of the credit event, its risk

¹⁴Note that the relationship between covariances and regression betas are simply given by $Cov[p_{s,0}, Z_{j,0}] = \beta_{s,j} \sigma_j^2$ for $j = r, \theta$. Therefore, the covariance is positive if and only if the beta is positive.

premium is tied to bond risk premia through the term $\lambda_\pi \pi_0$.¹⁵ In fact, a higher sensitivity of the probability of the credit event to, for example, communication shocks, measured by η_θ , leads to a higher covariance and a higher risk premium, i.e., lower regression coefficient, on sovereign bonds. Thus, the equity-shock covariance can help explain the difference in the peripheral-core regression coefficients by being informative about the strength of the risk premium channel: on days when $\text{Cov}[p_{s,0}, Z_{j,0}]$ is higher, we should expect $\beta_{pc,j}$ to be lower.

It is important to point out, however, that while monetary policy news *only* via dividend expectations can generate positive covariance between equity returns and monetary policy shocks, as suggested by [Jarociński and Karadi \(2018\)](#), these covariances are uninformative about sovereign yields' reaction to shocks. Indeed, setting $\gamma_s = 0$, we obtain $\text{Cov}[p_{s,0}, Z_{r,0}] = (\phi_r - 1) \sigma_r^2$ and $\text{Cov}[p_{s,0}, Z_{\theta,0}] = \phi_\theta \sigma_\theta^2$, both independent of the yield regression betas. For this channel to work, a risk premium news channel must be present.

We conclude that our model provides an understanding of how monetary policy shocks affect the term structure of yields and the relationship of yields and equity, and highlights the importance of the risk premium channel. In what follows, we provide empirical tests suggested by Propositions 1-4.

2 ECB Governing Council meetings and policy shocks

2.1 Announcement dates

Our sample period runs from February 1, 2001, to December 31, 2014. During this period there is one ECB meeting per month, except for the years 2001 and 2008, with 20 and 13 meetings, respectively. From the 177 announcement days we exclude 16 that were either not followed by a press conference or were unscheduled. We also ignore other speeches done by the ECB President or Vice-President for identification reasons, as our focus is purely on capturing and disentangling target rate and communication shocks arising from official and pre-scheduled announcements, and studying their effects on asset prices.¹⁶ Our final sample thus consists of 161 announcement days: there are 19 days when the main refinancing rate was raised, 10 days when the interest rate was lowered, and 132 meetings with no change.

There are two noteworthy points regarding our sample. First, since 2010, the ECB has also announced so-called unconventional monetary policy measures such as the securities market program (SMP), long-term refinancing operations (LTROs), outright market transactions (OMT), or asset purchase programs (APP). These announcements have been the focus of a recent literature. From the 161 announcements, there are six dates on which an unconventional measure was announced during the press conference, and we verify in Section OA-7 of the Online Appendix that these six announcements do not significantly

¹⁵The tight link between sovereign credit risk and stock returns is a well-documented fact; see, e.g., [Bocola \(2016\)](#) and [Hébert and Schreger \(2017\)](#) for Italy and Argentina, respectively.

¹⁶The exclusion dates are summarized in Section OA-1 of the Online Appendix.

affect our results. Second, since January 2015, the press release refers to current and future unconventional policy measures, too. Our period of interest thus ends in December 2014 to keep our identification clean.¹⁷

2.2 Estimation

A large empirical literature extracts monetary policy shocks from money market rates.¹⁸ We follow the approach in [Brand, Buncic, and Turunen \(2010\)](#) based on high-frequency identification, which exploits the fact that the ECB conducts the target rate announcement and the press conference at different points in time. This allows a simple yet clean separation of the target vis-à-vis the communication channel.

The ECB publishes a brief press release announcing its policy rate decision at 13:45 CET. In our sample, the press release only contains information about the ECB's policy rates. From 14:30 CET, the ECB President and Vice-President hold a press conference that starts with an introductory statement, whose structure has remained the same since the very beginning: it contains (i) a summary of the ECB's monetary policy decision and balance of risks to price stability, and, since July 2013, an open-ended forward guidance; (ii) a discussion of both real and monetary developments in the Euro area; and (iii) a conclusion with some considerations on fiscal policy and structural reforms. The press conference then continues with a Question-and-Answer session.

The target rate window is defined as a 45-minute window bracketing the 13:45 CET announcement, starting at 13:40 and ending at 14:25 CET. The communication window starts at 14:25 CET, and ends at 15:30 CET, 40 minutes after the press conference is over. We refer to the entire window, which encompasses both the target rate and communication windows, as the monetary policy window; see [Figure 2](#).¹⁹

¹⁷The ECB also started to publish its monetary policy deliberations in January 2015.

¹⁸A seminal paper in this field is [Kuttner \(2001\)](#), who proposes measuring the unexpected change in the current policy rate with changes in the price of Federal Funds futures that settles in the month containing the meeting. Other examples include the use of structural vector autoregressions ([Christiano, Eichenbaum, and Evans \(1999\)](#)), using changes in interest rates orthogonal to the information contained in internal Federal Reserve forecasts ([Romer and Romer \(2004\)](#)), a heteroskedasticity approach on the variance-covariance matrix of daily yields ([Rigobon and Sack \(2003\)](#), [Boyarchenko, Haddad, and Plosser \(2017\)](#)), and identification using high-frequency changes to interest rates around announcements ([Cochrane and Piazzesi \(2002\)](#), [Faust, Swanson, and Wright \(2004\)](#), [Gertler and Karadi \(2015\)](#), and [Nakamura and Steinsson \(2018\)](#)). To separate the effect of target rate changes from any other communication, [Gürkaynak, Sack, and Swanson \(2005a\)](#) propose extracting latent factors using high-frequency yield changes in a narrow window around FOMC announcements but need to impose identifying assumptions in order to disentangle the role of target rate shocks versus so-called 'path' shocks. [Swanson \(2018\)](#) extends this approach to include a third, 'quantitative easing-related' factor. For a recent survey article on this literature see [Buraschi and Whelan \(2016\)](#).

¹⁹All our results remain the same, both quantitatively and qualitatively, when shrinking the target and communication windows, or introducing a gap of 10 minutes between the target rate and communication windows. Additionally, while there are no other important Eurozone macro announcements during these windows, U.S. jobless claims take place every Thursday at 08:30 ET which corresponds to 14:30 CET. Controlling for the surprise component of these announcements from Bloomberg surveys does not alter our findings. Detailed results are gathered in Section QA-2 of the Online Appendix.

The policy shocks we extract are a composite measure of high-frequency changes in interest rates with different maturities, which allows us to capture changes in monetary policy beyond the shortest maturity. Moreover, our identification is based on the premise that changes in the policy indicators in these tight windows are dominated by the information about monetary policy contained in the ECB press release and press conference.

Let ΔY denote a $N \times T$ matrix of interest rate changes described by the dynamics

$$\Delta Y = F\Omega' + \eta, \quad (21)$$

where N denotes the number of announcements and T the different maturities; F is an $N \times k$ matrix of $k < T$ number of latent factors that drive the variation of rate changes in the relevant period, Ω is a $T \times k$ matrix of factor loadings, and η is an $N \times T$ matrix of idiosyncratic error terms. We estimate the latent factors within target and communication windows separately using principal components analysis on the 161 (number of announcements) \times 13 (maturities) matrices of rate changes. As it is well-known, for each window, the matrix Ω then contains the eigenvectors of the covariance matrix of ΔY , and F is computed as $F = \Delta Y\Omega$.²⁰

The intra-day interest rate data that we employ consist of real-time quotes from Reuters TickHistory. The data are unsmoothed and we filter for mispriced quotes and sample the data at the one-minute interval. We estimate our monetary policy shocks from ΔY 's that include overnight index swap rates with maturities ranging between one and twelve months, and swap rates (written on the six-month Euribor) with a two-year maturity.²¹

We find that for both the target and communication windows, the first PC explains more than 86%, and the first two PCs explain more than 93% of the variation. To assess the economic significance of these factors, we can regress zero-coupon rate changes, bootstrapped from the swap rate changes of the whole monetary policy window, on the first and second PC of each windows. Our regression results reveal that literally almost all of the variation in bond yields is captured by the first PC and that the second factor has very little impact on yield changes both in the target and communication window. To save space, we report detailed regression results in Section OA-1 of the Online Appendix.

Based on our analysis, in the following, we label PC1 of the target rate window our target rate shock, denoted by $Z_{r,t}$, and interpret it as the surprise component in the short rate, $r_t - E_{t-1}[r_t]$. Further, we label PC1 of the communication window the communication shock, denoted by $Z_{\theta,t}$, and think about it as one that provides information about short rates in the future, $E_t[r_{t+\tau}] - E_{t-1}[r_{t+\tau}]$. In addition, we recognize that both shocks can reveal some

²⁰We normalize the eigenvectors such that the factor loadings sum to one and are therefore interpreted as weights. The first principal component is then a variance-maximizing average of interest-rate changes.

²¹While the primary objective of the ECB is price stability over the medium term, and they state that "it is not advisable to specify ex-ante a precise horizon for the conduct of monetary policy, since the transmission mechanism spans a variable, uncertain period of time," a two-year cutoff can be justified by the ECB implicitly hinting to have a horizon of two to three years by publishing forecasts (including interest rates) with a projection horizon of up to two years (extended to three years as of December 2016). See, e.g., <http://www.ecb.europa.eu/pub/projections/html/index.en.html>.

information about the state of the economy from the ECB to market participants.

2.3 Target and communication shocks

We present summary statistics of the target rate and communication shocks in Table 1. Both shocks are approximately mean zero, i.e., there is no surprise on average. At the same time, the volatility of communication shocks is almost twice as large as that of target shocks. We also note that while target rate shocks feature a negative skewness, the skewness for communication shocks is slightly positive, and both shocks exhibit significant excess kurtosis.

Figure 3 plots the time-series of the target rate and communication shocks. Our first salient observation is that target rate shocks are close to zero most of the time except for some large outliers, including in the post-2009 period. Communication shocks, however, display more variation, especially starting in mid 2008 when shocks are mostly negative, indicating future dovish monetary policy.

The figure also contains brief annotations that help to explain some of the larger observations. The first one coincides with the May 10, 2001, meeting when the ECB surprisingly cut the refinancing rate by 25bps; reasons for the surprise easing were the disappointing unemployment and industrial production numbers from Germany, published on May 8 and 9, 2001. Our target shock on this day is measured at -18.55 bps, implying that the rate cut on this day was largely unanticipated. The second event corresponds to June 5, 2008, when President Trichet hinted at a rate hike at the following meeting; the communication shock is 18.08bps. The third event corresponds to March 3, 2011, when Trichet hinted at a tightening at the next meeting by saying at the press conference that “strong vigilance is warranted.” On August 4, 2011 rates were kept constant but the market expected an announcement of bond purchases for Italy and Spain, the communication shock is -14.33 bps. On November 3, 2011, President Draghi surprised the market by a 25bp cut at his first meeting, identified as a -10.65 bp target rate shock. Finally, on July 5, 2012, the ECB cut interest rates by 25bps to an all-time low; our target shock is -8.16 bps.

3 Empirical analysis

In the following, we study the effect of target rate and communication shocks on bond yield changes for different maturities on ECB monetary policy announcement days. Our two main empirical findings are as follows: First, while before the 2009 crisis monetary policy had a uniform effect on bond yields of core and peripheral countries, peripheral countries’ bond yield reaction to monetary policy became muted and even insignificant after 2009. As a consequence, ECB monetary policy, especially communication, drove a wedge between peripheral and core countries’ yields in this period. Second, we link the wedge between

core and peripheral bond yields to an emergence of a credit and redenomination risk-related premium.

3.1 Additional data

We use data from different sources. To save space, we report all summary statistics in the Online Appendix.

Sovereign bond yields: We use daily bond yields of Germany, France, Italy, and Spain, with maturities ranging between three months and 10 years, available from Bloomberg, and bootstrap zero-coupon bond yields from the data.²² To keep the number of results tractable, we refer to ‘core yields’ (‘periphery yields’) as simple averages of the bond yields of Germany and France (Italy and Spain).²³

Inflation: We obtain daily mid-quotes on inflation-linked coupon yields for Germany, France, Italy, and Spain from Bloomberg, and, following Ermolov (2017), estimate a Nelson-Siegel model in order to back out constant-maturity zero-coupon real yields. Details of the estimation and maturity structure of real European debt are given in the Online Appendix.²⁴

Equity: We obtain daily returns on German (DAX), French (CAC 40), Italian (FTSE MIB), and Spanish (IBEX 35) equity market indices. In addition, we also use high frequency data on Eurostoxx futures obtained from Reuters Datascope. Futures returns are computed on the most liquid (highest volume) contract which is either the front month or the next to delivery (in expiration months).

Bond illiquidity: To measure bond market illiquidity, we use the bid-ask spread on government bond yields with two-year maturity available from Bloomberg. We refer to ‘core’ (‘periphery’) bond illiquidity as simple averages of the bid-ask spread on German and French (Italian and Spanish) government bonds.

Credit risk: To measure the credit risk of each country, we use Euro- and U.S. dollar-denominated credit default swaps (CDS) available from Markit. Sovereign CDS pay off in case of a sovereign default. Outright default, however, is only one of the possible scenarios that are considered a credit event. One important concern during the European debt crisis was that a redenomination of liabilities by one of the Eurozone members into a pre-Euro currency could trigger a CDS payout. There are two types of CDS contracts which define a credit event differently. Under the ISDA 2003 definition, redenomination does not trigger a credit event as long as it involves a G7 currency. The newer definition (ISDA 2014) limits this to the currencies of Canada, Japan, Switzerland, the United Kingdom, the United States, and the Eurozone. All our data are ISDA 2003 contracts.

Redenomination risk: U.S. dollar-denominated Eurozone CDS typically display higher

²²We focus on these four countries as both bond and CDS data coverage for these countries is reliable.

²³Our results remain qualitatively the same when we use a GDP-weighted average.

²⁴Ermolov (2017) estimates end-of-month real term structures excluding Italy and Spain since the focus of his paper is on default free real yields. We estimate daily yields and include both Italy and Spain.

spreads than Euro-denominated CDS.²⁵ The difference between U.S. dollar and Euro-denominated CDS is called a CDS quanto spread:

$$\text{CDS quanto}_{i,t} = \text{CDS}(\$)_{i,t} - \text{CDS}(\text{€})_{i,t}.$$

Upon default, buyers of CDS quantos are paid $(100 - \text{recovery rate}) \times \frac{\$}{\text{€}}$ % change, which means that buyers get compensated for any depreciation of the Euro against the U.S. dollar and the recovery value (see, e.g., [Lando and Nielsen \(2017\)](#)). The value of a quanto spread is hence determined by two factors: (i) the expected change in the exchange rate following a default, and (ii) the correlation between the exchange rate and the CDS spread (whether there is a default or not). We label the interaction between a country’s likelihood of default and an associated currency devaluation “redenomination risk” (see, e.g., [DeSantis \(2015\)](#)). Notice that in the data, before August 2010, there is no difference between CDS spreads denominated in USD and EUR, and hence the CDS quanto spread is zero. Spreads then start to increase and peak at around 100bps for peripherals and 75bps for core countries mid 2012.

3.2 Swap yields

Before moving to sovereign bond yields, we explore the impact of monetary policy shocks on changes in daily default-free zero-coupon bond yield and forward rates, bootstrapped from swap rates. We are mostly interested in whether monetary policy shocks, estimated from short-term yields, have an effect on long-maturity yields. Standard expectations hypothesis suggests that movements in short rates should only have a minor impact on long-maturity interest rates, unless shocks to short rates are extremely persistent.

To examine the effect of target and communication shocks on zero-coupon yields and forwards, we run multivariate regressions from rate changes on our proxies of policy shocks:

$$\Delta y_t^\tau = \alpha^\tau + \beta_r^\tau Z_{r,t} + \beta_\theta^\tau Z_{\theta,t} + \epsilon_t^\tau \quad \text{and} \quad \Delta f_t^\tau = \alpha^\tau + \beta_r^\tau Z_{r,t} + \beta_\theta^\tau Z_{\theta,t} + \epsilon_t^\tau, \quad (22)$$

where Δy_t^τ (Δf_t^τ) are daily zero-coupon yield (forward) changes with maturities $\tau = 3, \dots, 120$ ($\tau = 12, \dots, 120$) months. [Table 2](#) collects the results.

Target shocks have a significant effect on swap rate changes, especially at the short end, and the effect dies out as the maturity prolongs. Estimated coefficients for communication shocks are also highly statistically different from zero for all maturities, and the effect is largest for the one- and two-year maturities, and decreases with maturity afterwards. Economically, we find that for any 100bp change in the target shock, there is a 71bp change in the two-year yield, whereas communication shocks of the same size induce changes of

²⁵Imagine an investor bought an Italian CDS denominated in Euros. Upon Italy’s default, the Euro would immediately depreciate vis-à-vis the U.S. dollar. U.S. dollar-denominated CDS are hence a better hedge than an equivalent Euro-denominated CDS. [Mano \(2013\)](#) provides empirical evidence that currencies indeed tend to depreciate in sovereign defaults.

143bps to the one-year yield and 140bps to the two-year yield. For the ten-year rate, the effect of a 100bp target shock declines to 13bps; however, the effect of communication shocks is still statistically and economically large, with a yield response of 65bps.

To evaluate the importance of central bank communication on zero-coupon yields, the penultimate row of each panel in Table 2 reports the adjusted R^2 s of our regressions when we include both monetary policy shocks, while the last row reports the increase in the R^2 s compared to a univariate regression that only uses the target rate shock as right-hand-side variable. Our findings suggest that, except for very short maturities, communication shocks are an order of magnitude more important than target rate shocks to explain the variation in yields: the change in the R^2 s ranges between 66% at the one-year maturity and 16% at the ten-year maturity, representing 80% and 100% of the variation in these bond yields, respectively.

Our results are comparable to earlier literature that documents a strong impact of U.S. monetary policy shocks on long-term nominal and real yields. For example, [Cochrane and Piazzesi \(2002\)](#) find that a 100bp increase in the one-month Eurodollar rate around FOMC announcements is associated with a 52bp increase in the ten-year nominal Treasury yield. Similarly, [Hanson and Stein \(2015\)](#) find that a 100bp change in the two-year nominal yield measured on FOMC announcement days leads to a 42bp change in ten-year forward real interest rates. [Hanson, Lucca, and Wright \(2018\)](#) document strong effects for ten-year bond yield changes in the U.S., United Kingdom, Germany, and Canada in response to monetary policy shocks.

Zero-coupon bond yields are the average of one-year forward rates over the maturity of a bond, while forward rates are the risk-neutral expectation of future short rates, so it is interesting to translate our results to the space of forward rates. The lower panel of Table 2 shows that the reaction of forward rate changes to both types of monetary policy shocks are significant up to a maturity of seven years. For example, the one-year forward rate five years ahead moves by almost 50bps as a response to a 100bp communication shock. To summarize, we find that changes in short-term rates have significant effects on long-term interest rates.

Finally, we study if monetary policy shocks have a lasting effect on bond yields beyond the one-day horizon, i.e., whether monetary policy shocks are transitory or permanent in nature. A recent debate discusses this question in the context of forward guidance (in the U.S.) and finds that these effects can be relatively short-lived (see, e.g., [Woodford \(2012\)](#) or [Swanson \(2018\)](#)). This is reinforced in [Hanson, Lucca, and Wright \(2018\)](#), who argue that in presence of slow-moving capital, the transmission of monetary policy is far more short-lived than one might conclude from high-frequency evidence. To assess the impact of target and communication shocks over longer horizons, we follow the approach of [Swanson \(2018\)](#) and estimate the yield regression (22) for horizons up to 30 days.²⁶ The corresponding results for the two-year yield are plotted on Figure 4. We note that for target shocks, swap rates are significantly affected up to a horizon of two weeks, after which confidence intervals become larger and estimates insignificant. Communication shocks have a more persistent effect as

²⁶We choose a horizon of 30 days as ECB announcements take place approximately every 30 days.

estimated coefficients are highly significant out to 30 days. Even more striking, the impact of communication slightly increases over time, with the point estimate rising from 1.5 for a one-day horizon to a level of 2.2 for 30 days; a 50% increase. This is an important result since, to the extent that communication shocks can be interpreted as a form of forward guidance, it suggests monetary policy can have long-lasting effects. These effects contrast to the results in [Hanson, Lucca, and Wright \(2018\)](#) who document that U.S. target shocks are very transitory but are in line with [Swanson \(2018\)](#) who finds that U.S. quantitative easing related shocks had permanent effects on a wide array of asset prices.

3.3 The cross section of Eurozone yields

We next turn to our main result and study two different aspects of ECB monetary policy that help us identify potential risk premium channels. We want to explore whether monetary policy has affected sovereign bond yields differently in the cross section, in core vs peripheral countries, and whether the effect has changed over time.²⁷

Formally, we run regressions of bond yield changes of core and peripheral countries for the pre-crisis (January 2001 to February 2009, 91 observations) and post-crisis (March 2009 to December 2014, 70 observations) periods separately, in the form of

$$\Delta y_{i,t}^\tau = \alpha_i^\tau + \beta_{i,r}^\tau Z_{r,t} + \beta_{i,\theta}^\tau Z_{\theta,t} + \epsilon_{i,t}^\tau, \quad (23)$$

where $\Delta y_{i,t}^\tau$ are daily zero-coupon yield changes for $i = c, p$ (core and periphery), with maturities $\tau = 3, \dots, 120$ months, and we compare the obtained core and peripheral coefficients.²⁸ Propositions 1 and 2 suggest that in such regressions $\beta_{c,j} \geq \beta_{p,j}$ for $j = r, \theta$. Moreover, when monetary policy does not provide any additional information to market participants beyond affecting the short rate, or countries are treated as equal, then $\beta_{c,j} = \beta_{p,j}$. In contrast, if monetary policy is informative about the future of the Eurozone economy and peripheral countries are considered more vulnerable, we should expect $\beta_{c,j} > \beta_{p,j}$.

The upper two panels of Figure 5 plot the effect of target rate (left panel) and communication shocks (right panel) when the sample ends in February 2009. We find that before the 2008-2009 global financial crisis, coefficients for both shocks are statistically different from zero for nearly all maturities, and estimated coefficients for core and peripheral countries are virtually the same, indicating that monetary policy did not have a differential effect. For example, for any 100bp communication shock, there is a 144bp change in two-year bond yields for both core and peripheral countries.

The lower two panels present results for the March 2009 to December 2014 period. We find that target rate shocks have a differential effect on core versus peripheral countries: estimated coefficients for core countries are similar for most maturities to the pre-2009

²⁷Our country-by-country results are available upon request.

²⁸We start our crisis sample in March 2009, as this was the time when yields of core and peripherals started to significantly diverge. All of our results also hold when we start the sample in January 2009, for example.

values, and even slightly larger at the long end of the yield curve, while peripheral countries' coefficients are now negative and significant out to three years. Regarding communication shocks, for core countries we find virtually the same hump-shaped pattern as in the first part of the sample, but peripheral countries are affected much less. For example, for a 100bp communication shock post 2009 there is a 142bp change in the two-year yield for core countries, just as in the pre-crisis period, whereas the effect on a two-year peripheral yield is only around 40bps. Moreover, peripheral point estimates of communication shocks are only borderline significant for maturities exceeding five years. These results confirm the prediction of our theoretical framework and imply a regime change from pre-2009 to post-2009 that lead to significantly different patterns in sovereign yields' reaction to monetary policy shocks.

In order to get a better understanding, the left panel of Figure 6 depicts adjusted R^2 s from rolling-window regressions of two-year bond yield changes of core and peripheral countries on target and communication shocks (bold lines) and for communication shocks only (dashed lines).²⁹ We note two interesting features. First, before the crisis, monetary policy shocks accounted for around 40% of the variation of bond yield changes of both core and peripheral countries. Mid 2008, the adjusted R^2 doubles to 80%, which coincides with the beginning of the ECB's dovish monetary policy and several cuts in the target rate as illustrated by the decreasing EONIA rate. While the high R^2 persists throughout the crisis for core countries, there is a complete breakdown in the effect of monetary policy on peripheral bond yields starting in 2010: the adjusted R^2 decreases from 80% to 40% in the first half of 2010 and then subsequently reaches zero in 2012. Second, we find that almost *all* of the variation is explained by the communication shocks themselves: the difference between the total R^2 and the R^2 from using communication shocks only is virtually zero.

We further explore these events in the right panel of Figure 6, where we plot rolling regression coefficients of communication for core and peripheral countries' two-year bond yield changes. Indeed, we find the effect on core countries' bond yields to remain very stable throughout the 2008 to 2015 period. Peripheral bond yields, however, become virtually insensitive to communication shocks starting in 2011 as the estimated coefficient starts to drift downwards and becomes insignificant at the end of 2012. Again, these patterns are in line with the results of Propositions 1 and 2 regarding the yield spread regression coefficient, and suggest a structural change sometime around the start of the Eurozone debt crisis.

One particularly large drop happened on August 4, 2011, when the Governing Council decided to keep interest rates unchanged, however, market participants expected an announcement about purchases of Italian and Spanish bonds that did not materialize.³⁰ On the same day, José Manuel Barroso, the President of the European Commission, warned of contagion from peripheral to core countries, and he called for Europe's leaders to re-assess

²⁹We use a rolling window of 50 months. Results look qualitatively the same with different window lengths.

³⁰This is best reflected in the Q&A session, when several questions are directly related to bond purchases of Italy and Spain.

the financial stability mechanisms designed to hold the Eurozone together.³¹

3.4 Communication effects

Since the onset of the crisis in 2008, the ECB has tried to ease distress in financial markets and to reduce sovereign spreads by (i) drastically lowering its target rate, (ii) providing unprecedented amounts of liquidity support against a broader set of assets used as collateral, and since January 2015, by (iii) introducing quantitative easing in the form of the Asset Purchase Programme. Our results so far suggest that conventional monetary policy in the form of central bank communication is also a driver of the yield spread as its impact is quantitatively larger on core countries than on peripheral countries.

To evaluate the exact effect and economic significance of this channel, we calculate the size and direction of the spread implied by monetary policy shocks, and compare it to the time-series of the yield spread between core and peripheral countries. The left panel of Figure 7 plots the cumulative target and communication shocks for the entire period. There are two noteworthy observations. First, the variation in target rate shocks is quantitatively much smaller than in communication shocks, in line with our observation from Figure 3. Second, until 2009, communication shocks cumulatively had a positive effect, while target rate shocks were on average slightly negative. The sign switches in the beginning of 2009, when target shocks become positive and communication shocks turn negative; that is, the target rate was set systematically higher than what the market expected, whereas communication about the future path of interest rates was lower than what had been expected.³² Combining this insight with the estimated regression coefficients for core and peripheral countries, we can derive the cumulative effect of monetary policy shocks on yield spreads during the crisis period.

The right panel of Figure 7 shows the impact of communication shocks for the two-year maturity. We calculate this implied spread by multiplying realized shocks with the difference in real-time policy loadings displayed in Figure 6, and add them up over time. Strikingly, we find that communication shocks had a positive effect on the yield spread; it increased from January 2009 to Spring 2011, when ECB President Trichet announced a rate hike for the following meeting, peaked at almost 50bps at the end of 2011, then slightly decreased until the end of 2014. Economically, this effect is large: in September 2011, the two-year

³¹This weekend was particularly eventful for the Eurozone. On August 5, ECB President Trichet, together with Mario Draghi, wrote a secret letter to the Italian government in which they pushed for structural reforms “to be implemented as soon as possible,” thereby implicitly tying the ECB’s support to the implementation of these measures (the letter was leaked in September). On the same day, the Italian Prime Minister announced new measures to reduce the deficit and hasten economic reform. Finally, on August 7, a Sunday, the ECB announced that the Securities Markets Programme would also include Spain and Italy.

³²The U.S. Federal Reserve lowered its policy interest rate from 5.25% in September 2007 to 0-0.25% in December 2008 and at the same time also initiated quantitative easing. The ECB’s first reaction, in July 2008, was to raise the main refinancing rate. After the Lehman bankruptcy in September 2008, the ECB joined an internationally coordinated rate reduction on 8 October. The ECB’s slow pace of rate cuts was interrupted by two more hikes—in April and July 2011. The policy rate was brought to near-zero only in November 2013, five years after the U.S. Federal Reserve.

core-periphery yield spread was 270bps, so at its peak the spread due to communication represented around 20% of the total yield spread.³³

4 Monetary policy news channels

Recent literature that studies central bank signalling argues that monetary policy affects asset prices via investors' beliefs about the real rate (see, e.g., [Campbell, Fisher, Justiniano, and Melosi \(2016\)](#) and [Nakamura and Steinsson \(2018\)](#)). To empirically pin down this expectations channel, these studies regress private-sector survey expectations about future economic activity and inflation on monetary policy shocks. Recall that monetary policy announcements can affect bond prices via two channels: expectations of future short rates and risk premia, both present in our model. In the following, we provide novel evidence supporting the risk premium channel of central bank communication.

4.1 Monetary policy shocks and equity

One way to test the central bank's information channel on investors' expectations is via surveys of professional forecasters about macroeconomic quantities such as output or inflation and their link to monetary policy shocks. Survey data from the Eurozone, however, does not react to policy shocks, which could be because of the delay between ECB days and when the surveys are conducted, or simply because policy shocks do not contain information about the level of macro variables, or more broadly, about asset cash flow.³⁴ Instead, we revisit [Rigobon and Sack \(2004\)](#) and [Bernanke and Kuttner \(2005\)](#) to identify the effect of monetary policy shocks on other asset prices, namely stock returns, in high frequency.

Proposition 3 states that as long as monetary policy does not provide information about future dividends or the required risk premium, an unexpected positive target rate shock leads to a stock price decline whereas communication shocks leave stock prices unaffected. If, on the other hand, a tightening of monetary policy also suggests a more optimistic outlook about economic conditions and/or an improvement of financial conditions, either in the form of 'cash flow news' or 'risk premium news', stock prices are expected to drop less or even increase, while they should increase as a response to positive communication shocks.

³³The 'regime switch' in terms of central bank communication can also be illustrated in Figure OA-8 of the Online Appendix, which plots the number of mentions of core and peripheral countries (left panel), as well as the number of mentions of 'crisis' words during the ECB press conference. For this, we use a web-scraping algorithm to download transcripts of ECB press conferences and use basic text analysis tools to count words. 'Peripheral' words include *Italy, Spain, Greece, Portugal, Ireland* and *periphery*. 'Core' words include *Belgium, France, Germany, Netherlands* and *core*. 'Crisis' words include *crisis* and *default*. According to the figure starting 2010 and in particular in the summer of 2011, peripheral countries are mentioned a multiple times more often than core countries. Moreover, we observe a large spike in default- or crisis-related mentions in the summer of 2011 as well.

³⁴In unreported results, using forecast data from Consensus Economics on macroeconomic quantities, we confirm the findings of [Andrade and Ferroni \(2018\)](#) that survey forecasts do not respond to ECB policy surprises.

We explore this channel by considering the fitted reaction of Eurostoxx equity futures returns to monetary policy shocks. Specifically, we compute realized log returns between 9:30 and time t for $t = 9:31, \dots, 17:30$ CET on all ECB days, and estimate multivariate regressions on target and communication shocks minute by minute.

Figure 8 displays our results for target (communication) results on the left (right) panels. In the pre-crisis period (top panels), we observe a significant negative reaction to target shocks around the announcement time, in line with the standard channel of monetary policy as discussed in previous literature (see, e.g., Rigobon and Sack (2004), Bernanke and Kuttner (2005), D’Amico and Farka (2011)). Communication, on the other hand, has little impact on equity, and the coefficients are statistically insignificant. In the post-crisis period equity also reacts negatively to target shocks, but its impact is not significantly different than zero by the end of the day. Post 2009, however, the reaction of equity to communication shocks is quite different: equity returns show a strong positive correlation with communication shocks, which is statistically significant throughout the trading day. Comparing the left panels of Figure 8 with the prediction of Proposition 3 suggests that target rate shocks affect equity mainly through the standard short rate channel of monetary policy, and the cash flow and risk premium effects are small both before and after the crisis. From the right-hand panels, on the other hand, we conclude that after 2009 either the cash flow or the risk premium content of communication became strong enough to overturn the short rate channel of monetary policy.

Since the explanatory power of target shocks is negligible for sovereign yields, in the following, we study the short rate versus the cash flow and risk premium effects of communication shocks only. For this, we stratify the post-2009 period based on whether communication shocks co-move negatively or positively with equity returns around the ECB press conference, and refer to the first type of days as short rate (SR) days. Co-movement is measured by $\text{sign}[\tilde{r}_{s,t} \times \tilde{Z}_{\theta,t}]$, where $\tilde{r}_{s,t}$ is the demeaned return of Eurostoxx futures over the monetary policy window and $\tilde{Z}_{\theta,t}$ is the demeaned communication shock.

4.2 Communication shocks and bond yields revisited

We revisit the sovereign yield reaction results of Figure 5 by re-estimating our baseline regression (23) separately on SR days and other days in the post-2009 period. Proposition 4 states that on SR days, when stock returns have negative or zero co-movement with equity, target and communication regression coefficients should be similar across countries, $\beta_{c,j} = \beta_{p,j}$ for $j = r, \theta$, whereas on days with positive equity-shock co-movement we should expect $\beta_{p,j} > \beta_{c,j}$. To study differences in the estimated coefficients, we also run regressions on the yield spread between peripheral and core bonds.

Figure 9 displays estimates for SR and other days. We find that, just as our theory predicts, there is no difference between peripheral and core coefficients on SR days, indicated by insignificant estimates for the yield spread throughout the entire term structure. On non-SR

days, however, estimated spread coefficients are significantly different from zero at almost all maturities. This implies that the wedge we observe in the peripheral and core bond yield reaction to communication shocks is driven exclusively by days on which the ECB reveals strong cash flow or risk premium-related information to the market.

To study the relative impact of communication shocks on the two types of days more formally, we run the following regression for the pre- and post-2009 periods separately:

$$\Delta y_{i,t}^{24} = \alpha_i + \beta_i Z_{\theta,t} + \underbrace{\gamma_i \text{Dummy}_t \times Z_{\theta,t}}_{\text{interaction}} + \delta_i \text{Dummy}_t + \epsilon_{i,t}, \quad (24)$$

where $\Delta y_{i,t}^{24}$, $i = c, p, pc$, are daily changes in two-year core and peripheral yields as well as their spread, and Dummy_t is a dummy variable which takes the value of zero on SR days, when the co-movement between the Eurostoxx return and the communication shock is negative, and one on all other days. In this regression, our main interest lies in parameter γ , which measures how much stronger the effect of central bank communication is on positive equity-shock co-movement days relative to negative ones.

The results are gathered in Table 3. Recall that when the dummy variable takes the value of one, accommodating monetary policy signals worse economic conditions in the future. Our results imply that while in the pre-crisis period there is no significant difference between the two types of announcement days, the estimated coefficients are significant and negative for the full sample period as well as in the post-crisis period, both for the peripheral yield and the peripheral-core yield spread at a two-year maturity. Moreover, for the post-crisis periods, the peripheral interaction coefficient γ_p is larger in absolute terms than the communication shock coefficient β_p . This implies that on days when the ECB signalled bad news to the public by loosening monetary policy, bond yields on peripheral bonds increased and so did the yield spread, in stark contrast with pre-crisis announcement days.

The observations that (i) almost all the yield spread sensitivity difference comes on positive stock-shock co-movement days, and (ii) survey forecasts of macro quantities are unresponsive to ECB communication together suggest that the positive co-movement is driven mainly by the risk premium effect of communication, and not by a cash flow news channel. Therefore, from this point on we label positive co-movement days as risk premia (RP) days.

4.3 The risk premium channel of central bank communication

Next, we want to pin down the specific risk premium channels through which central bank communication can impact bond yields. Standard textbook algebra reveals that nominal bond yields can be written as the sum of expected nominal short rates, inflation risk premia, and real risk premia, or as the sum of the real yield, expected inflation, and inflation risk

premia:

$$y_{i,t}^\tau = \underbrace{\text{E}_t \left[\frac{1}{\tau} \sum_{k=1}^{\tau} (r_{i,t+k}^r + q_{i,t+k}) \right]}_{\text{expected nominal short rates}} + \underbrace{\text{IRP}_{i,t}}_{\text{Inflation Risk Premia}_{i,t}} + \underbrace{\text{RRP}_{i,t}}_{\text{Real Risk Premia}_{i,t}} \quad (25)$$

$$= \underbrace{\text{E}_t \left[\frac{1}{\tau} \sum_{k=1}^{\tau} r_{i,t+k}^r \right]}_{\text{real yield } y_{i,t}^{r,\tau}} + \underbrace{\text{E}_t \left[\frac{1}{\tau} \sum_{k=1}^{\tau} q_{i,t+k} \right]}_{\text{expected inflation}} + \text{IRP}_{i,t}, \quad (26)$$

where $r_{i,t+k}^r$ denotes the real short rate and $q_{i,t+k}$ is the rate of inflation of country i , k periods ahead. For this reason, Eurozone bond markets provide a unique opportunity to test whether monetary policy communication can affect risk premia: observing a cross-section of changes in Euro-area yields around ECB announcements one can difference out expectation components since expected nominal short rates are the same for all countries. Specifically, using (25), we can write changes in the peripheral-core yield spread as follows:

$$\Delta(y_{p,t}^\tau - y_{c,t}^\tau) = \Delta(\text{IRP}_{p,t}^\tau - \text{IRP}_{c,t}^\tau) + \Delta(\text{RRP}_{p,t}^\tau - \text{RRP}_{c,t}^\tau),$$

where the first component on the right-hand side refers to changes in inflation risk premia and the second component to changes in real risk premia. These risk premia can arise from a number of alternative channels, as illustrated by ECB President Mario Draghi's speech at an investor conference in London on July 26, 2012, that became (in)famous for the sentence "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro." In this speech, he specifically mentions the divergence of peripheral and core bond yields, and ascribes the resulting risk premia to three drivers: "Then there's another dimension to this that has to do with the premia that are being charged on sovereign states borrowings. These premia have to do, as I said, with default, with liquidity, but they also have to do more and more with convertibility, with the risk of convertibility."³⁵

Motivated by these observations, we consider a set of alternative explanations to rationalize the wedge in monetary policy responses by running similar regressions to (24) but altering the left-hand side:

$$\Delta X_{i,t} = \alpha_i + \beta_i Z_{\theta,t} + \gamma_i \text{Dummy}_t \times Z_{\theta,t} + \delta_i \text{Dummy}_t + \epsilon_{i,t},$$

where $i = c, p$ and $X_{i,t}$ are proxies for (i) inflation risk; (ii) illiquidity risk; (iii) credit risk; and (iv) redenomination risk. The sample we consider runs from August 2010 to December 2014, determined by CDS quanto spreads, our proxy for redenomination risk, that were zero before August 2010.

³⁵See <http://www.ecb.europa.eu/press/key/date/2012/html/sp120726.en.html> for a full transcript of the speech.

To study the role of inflation risk, we estimate daily break-even inflation rates, defined as the difference between nominal and real yields. Table 4 reports estimates for Germany, Italy, and their spread, representing core and periphery, since real term structures for Spain are only available for a short period at the end of our sample.³⁶ We find that almost all the point estimates for the two countries and the break-even rate difference between the two are insignificant, including the interaction term, and the adjusted R^2 s remain low or even negative. Overall, our results are in line with evidence in Nakamura and Steinsson (2018), who find an insignificant response of U.S. break-even rates to monetary policy shocks.³⁷

Turning to real risk premium channels, in Table 5 we report results when $X_{i,t}$ are bid-ask spreads, CDS and CDS quanto spreads, as discussed in Section 3.1. First, regarding illiquidity, we find that the estimated coefficient on communication, β_i , is significant for core but not peripheral countries' bid-ask spreads: negative communication shocks increase the illiquidity of core but not peripheral bonds. However, the interaction term on the spread is not significant, therefore there is no differential effect of how communication affects illiquidity on SR and RP days.

Second, considering the effect on credit risk, we find a statistically significant response of CDS for both core and peripheral countries. The interaction term is negative for both, but economically much larger for peripheral countries. Importantly, the estimated coefficient on the credit spread is negative and significant, with an associated t -statistic of -4.03. Hence, post 2010 negative communication shocks increased the credit risk spread between peripheral and core countries in the Euro-area.

However, while important, the differential effect of communication is unlikely to be just a reflection of changes in credit risk. Therefore, we also explore the impact of monetary policy shocks on CDS quanto spreads. Recall that CDS quantos are defined as the difference between spreads on CDS denominated in different currencies, thereby capturing redenomination risk better than CDSs alone. Considering that redenomination happens when the Eurozone breaks up suggests that CDS quantos can be used as proxies for breakup risk.

To this end, the final columns of Table 5 report regression results from changes in CDS quantos on the communication shock and the interaction term. Again, we find the interaction term to be negative and highly statistically significant for both core and peripheral countries. The spread between peripheral and core countries' quantos is also highly statistically significant with an associated t -statistic of -3.64 and carries a negative sign. Thus, post 2010 ECB communication increased the breakup risk spread between core and peripheral countries.

³⁶We only report results for the five- and ten-year maturities. Other maturities look quantitatively the same. Real French yields are also available, and the results for this term structure are quantitatively similar to Germany. Results are reported in the Online Appendix.

³⁷One limitation of this analysis is that without a model we cannot separate the effect of monetary policy shocks on inflation expectations and inflation risk premia, which together add up to breakeven inflation; see (26). But as we find no significant cross-sectional difference for break-even inflation for the five- and ten-year horizons, we conclude that the yield wedge is unlikely to come from inflation risk premia.

Overall, our findings demonstrate that financial markets interpret some dimension of central bank communication in terms of risk premia, default likelihoods, and a potential break up of the Euro-area, which has important policy implications. In line with ECB President Draghi’s assertion that the divergence between peripheral and core yields is due to risk premia, we demonstrate that some of the risk premia are actually induced on days the ECB announces its future monetary policy.

5 Robustness

One might worry that our main results are driven by the way we construct the monetary policy shocks, or that outliers could unduly affect our main result. To address these concerns, we use two alternative approaches to construct the target and communication shocks and find our results confirmed. We also check the validity of our main result when excluding outliers and find the results to be intact.

Alternative Monetary Policy Shocks: In their seminal paper, [Gürkaynak, Sack, and Swanson \(2005a\)](#) identify policy shocks using principal component analysis on futures rates with maturities up to one year in a tight window bracketing FOMC target rate announcements. In the setup of [Gürkaynak, Sack, and Swanson \(2005a\)](#), the principal components have no structural interpretation a priori since, for example, both factors are correlated with changes in the Federal funds rate. As rate announcements and other potential dimensions of monetary policy (e.g., forward guidance) happen at the same time in the U.S., the authors propose an identification strategy by restricting the second factor to have no effect on the short-end of the yield curve after a rotation. In other words, their second factor moves interest rates for the upcoming year without changing the current Federal funds rate.

Our approach allows for a separate identification of target rate and communication shocks by making use of an institutional feature of ECB policy announcements, namely that the target rate announcement and press conference take place separately. Our latent factors, F , are estimated from (21) separately around the target rate announcement and the press conference, and our approach does not rely on imposing any restrictions. To save space, Section OA-3 of the Online Appendix presents a comparison between the approach in [Gürkaynak, Sack, and Swanson \(2005a\)](#) and our identification strategy. Interestingly, we find that when using the [Gürkaynak, Sack, and Swanson \(2005a\)](#) “path” shocks instead of our communication shocks, results are very similar to the ones presented here. We view this results as an external validation for the rotated latent factor approach of [Gürkaynak, Sack, and Swanson \(2005a\)](#).

Alternatively, one could construct target and communication shocks from the short-end and the slope of the term structure of money market rates directly. To this end, we define target shocks as changes in the OIS one-month rate sampled in the monetary policy window, i.e. from 13:40 to 16:10 CET and communication shocks are defined as changes in the difference between the OIS 12-month and one-month rate sampled in the monetary

policy window. All results are collected in the Online Appendix, and we re-confirm our main findings.

Impact of Outliers: Finally, Section OA-4 of the Online Appendix studies the validity of our results when excluding large observations. To this end, we exclude 5% of the largest observations in the target and communication window from the post-crisis period. We find that regardless of whether we drop outliers or not, the results look virtually the same. We therefore conclude that our main result is unlikely to be driven by large outliers.

6 Conclusion

Central bank communication has taken centre stage in both popular and academic literature since the advent of the 2008 financial crisis. In this paper, we exploit high-frequency asset price movements to provide novel evidence on the risk premium channel of monetary policy.

Our findings can be summarized as follows. While monetary policy had a uniform effect on core and peripheral bond yields pre-crisis, we document dramatic differences post-2009. In particular, while communication shocks significantly lowered yields of core countries, peripheral countries' bond yields were immune against communication, which led to a significant increase in the periphery-core wedge. Guided by a theoretical framework, we show that this wedge mainly emerges on days when the ECB reveals information related to their pessimistic outlook of the Eurozone economy. We then link this wedge to credit and breakup risk premia. This finding shows that communication shocks offset some of the effects of the ECB's monetary policy tools that aimed at easing the funding squeeze of peripheral countries.

Our paper documents that central bank communication can have large effects on asset prices but remains agnostic about the specific contents of the communication. In our model, investors adjust the risk premia they demand to hold risky assets depending on the monetary policy signal they receive. At the same time, it is well known that central banks rely on asset prices to steer the economy. The two-way interaction between the central bank and the bond market is the focus of [Stein and Sunderam \(2018\)](#), who model optimal target setting when the central bank has private information. Studying in more detail the type of communication and the feedback between asset prices and communication in the data and theory remains a challenging topic that we leave for future research.

Figures

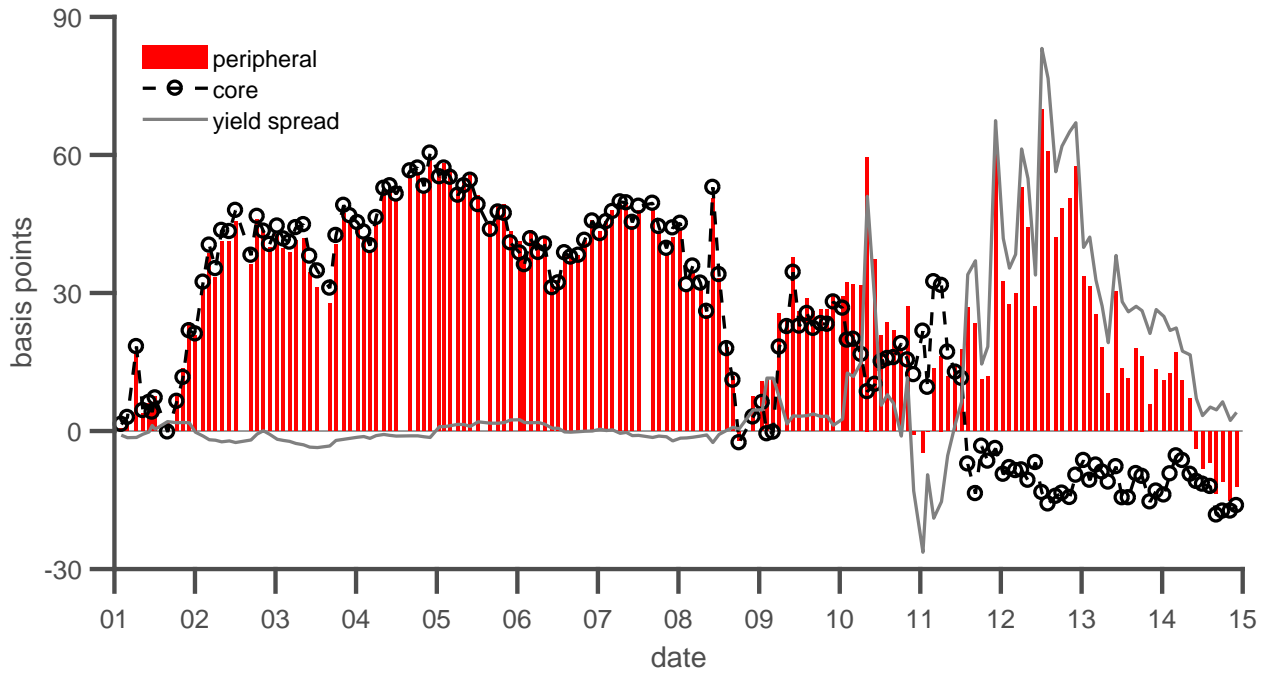


Figure 1. European sovereign bond yield changes on ECB days

This figure displays cumulative changes in two-year yields for core (average of Germany and France) and peripheral (average of Italy and Spain) bonds, as well as the spread between peripheral and core bonds only on European Central Bank meeting days.

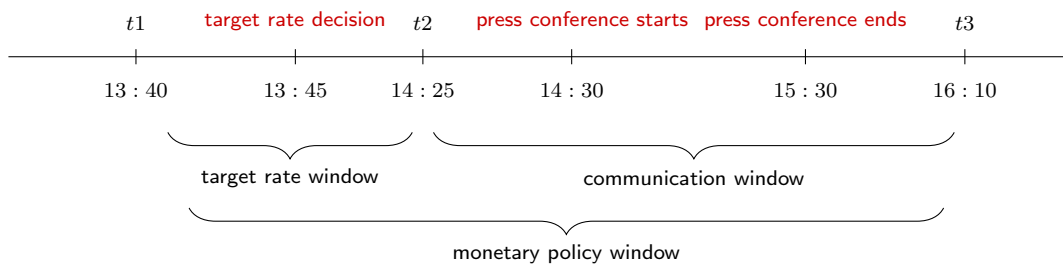


Figure 2. Monetary policy decision window

The figure illustrates the timeline of ECB announcements. All times are in Central European Time.

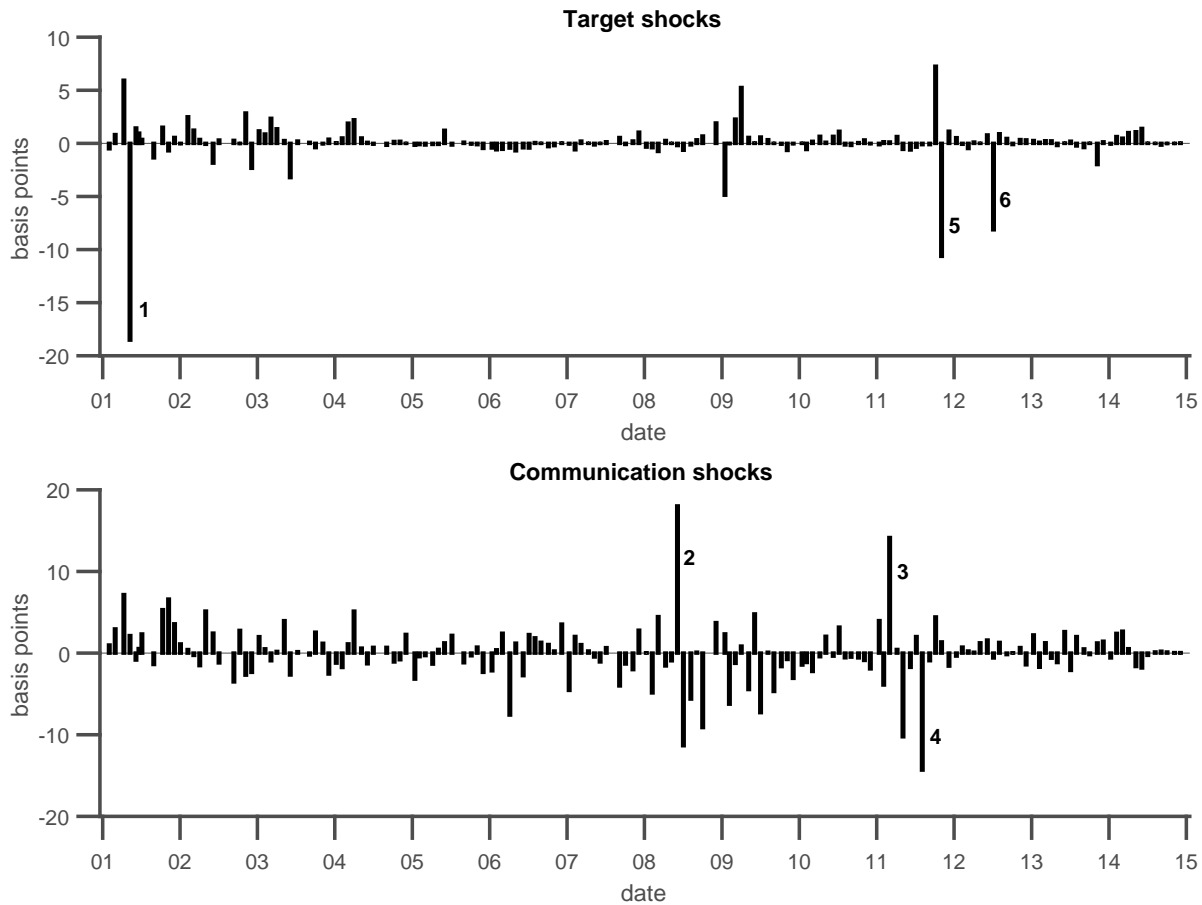


Figure 3. Time series of target and communication shocks

This figure plots target (upper panel) and communication (lower panel) shocks between 2001 and 2015. 1) May 10, 2001: surprise 25bps cut after dismal industrial production and unemployment numbers from Germany. 2) June 5, 2008: President Trichet announces rate hike for next meeting. 3) March 3, 2011: President Trichet announces interest rate hike at next meeting. 4) August 4, 2011: Rates were kept constant but market expected announcement of bond purchases for Italy and Spain. 5) November 3, 2011: Surprise 25bps cut at President Draghi's first meeting. 6) July 5, 2012: 25bps cut to an all-time low to 0.75%.

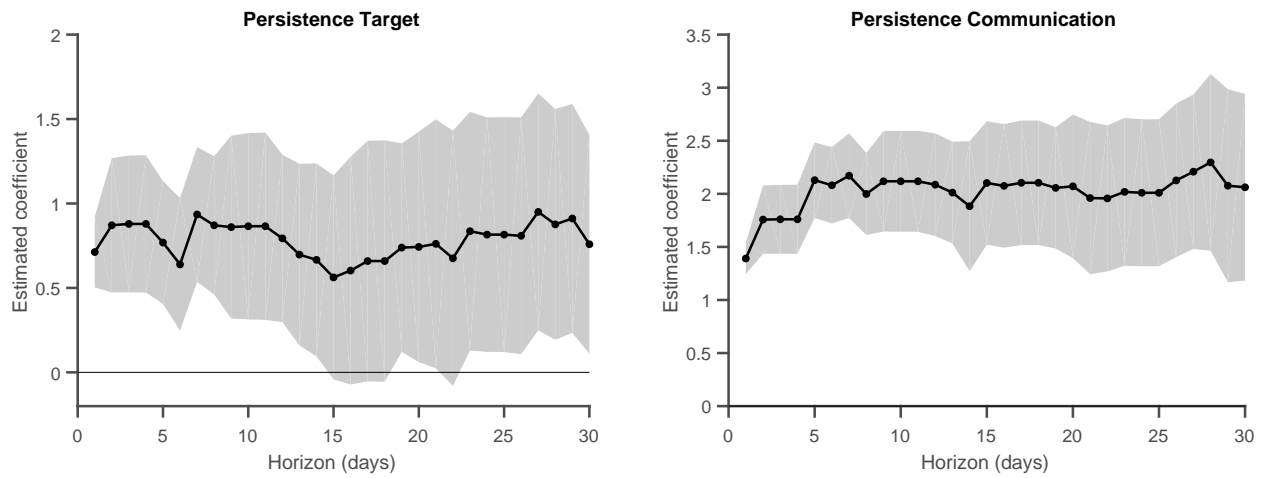


Figure 4. Two-year swap yield response to monetary policy shocks at different horizons
 This figure plots the response of two-year swap rates at horizons ranging from 1 to 30 days for the target rate (left panel) and communication (right panel) shock on ECB announcement days. 90% confidence intervals are based on [Newey and West \(1987\)](#) standard errors. Data run between 2001 and 2014.

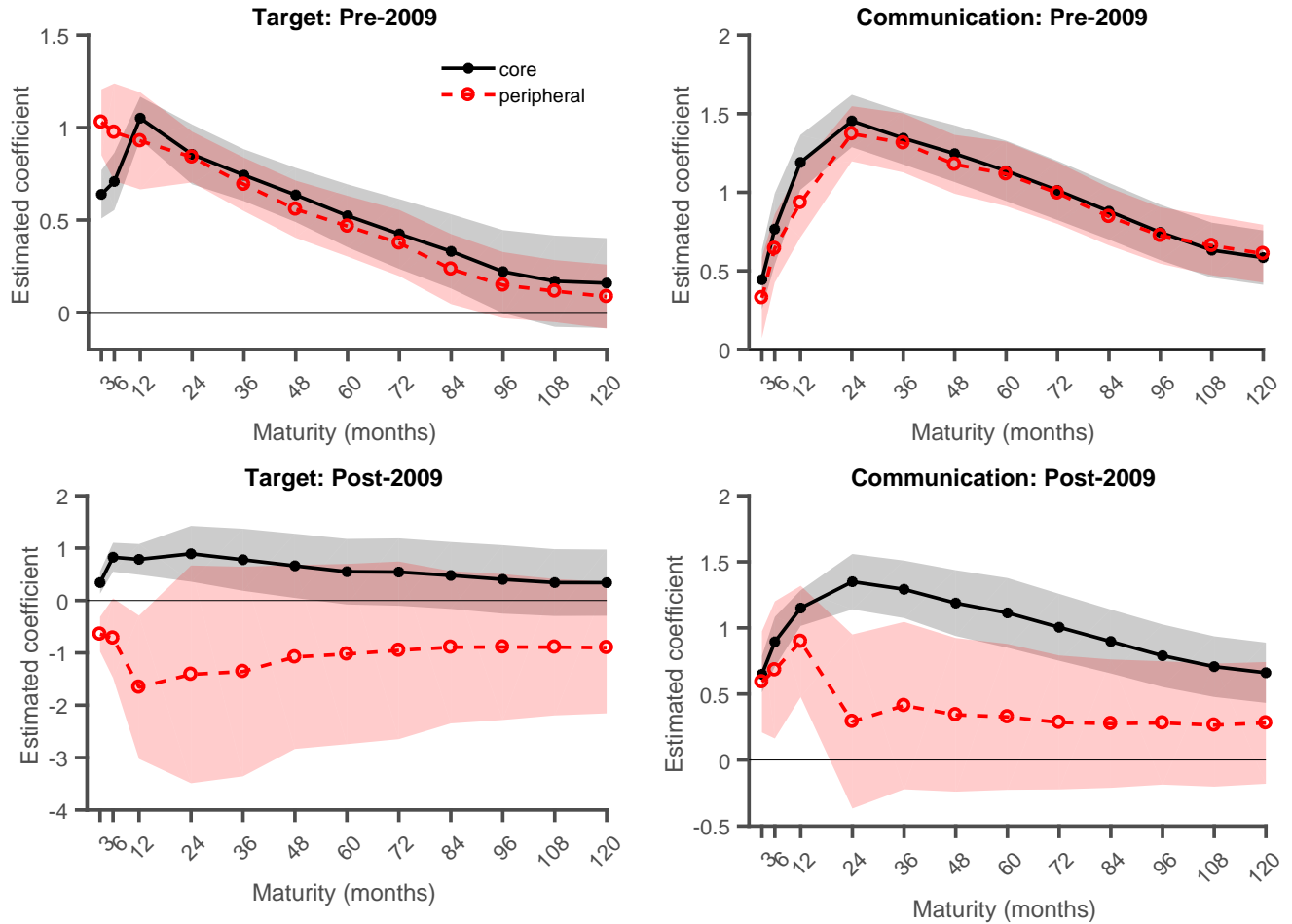


Figure 5. Core and peripheral yield response before and after the onset of the crisis

This figure plots the response of core (solid) and peripheral (dashed line) countries' bond yields at different maturities for target (left) and communication (right) shocks on ECB announcement days:

$$\Delta y_{i,t}^{\tau} = \alpha_i^{\tau} + \beta_{i,r}^{\tau} Z_{r,t} + \beta_{i,\theta}^{\tau} Z_{\theta,t} + \epsilon_{i,t}^{\tau}, \quad \tau = 3, \dots, 120 \text{ months.}$$

90% confidence intervals are based on [Newey and West \(1987\)](#) standard errors. Data run from January 2001 to February 2009 on the upper panels and from March 2009 to December 2014 on the lower panels.

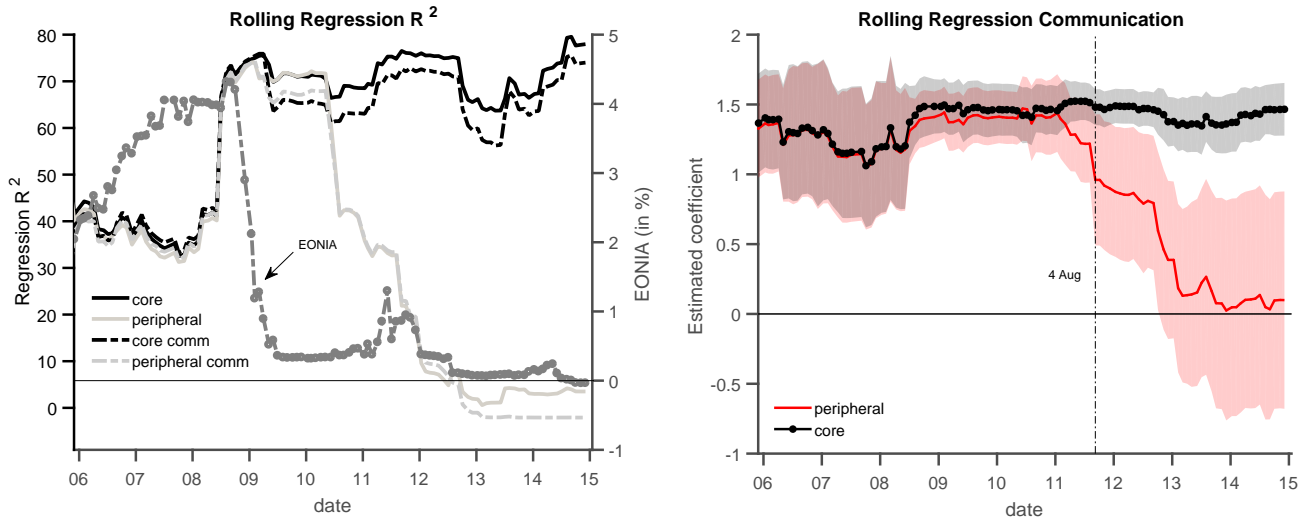


Figure 6. Rolling R^2 and regression coefficients

The left panel plots the rolling adjusted R^2 from regressing core and peripheral two-year bond yields on the target and communication shock (bold lines). The dashed lines present the adjusted R^2 when controlling only for communication shocks. The right axis depicts the EONIA rate (in percent). The right panel plots regression coefficients from rolling regressions of core and peripheral bond yields on the communication shock. The window size for the rolling window is set to 50 months.

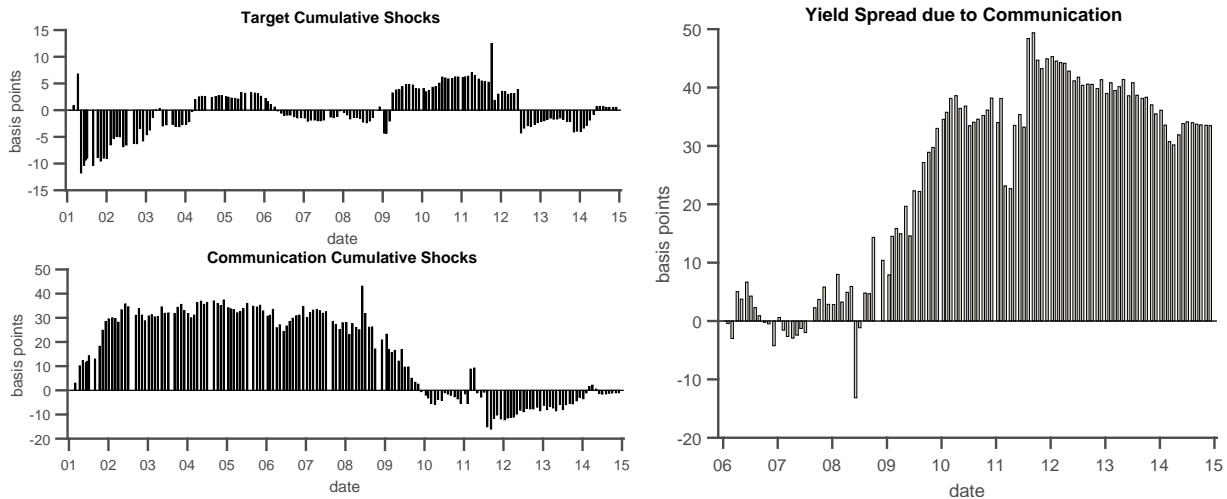


Figure 7. Cumulative monetary policy shocks and the effect on the yield spread

The left figure plots cumulative target and communication shocks from January 2001 to December 2014. The right panel plots the product of the cumulative communication shock and the rolling regression coefficient for the yield spread between peripheral and core bond yield changes on communication shocks from Figure 6.

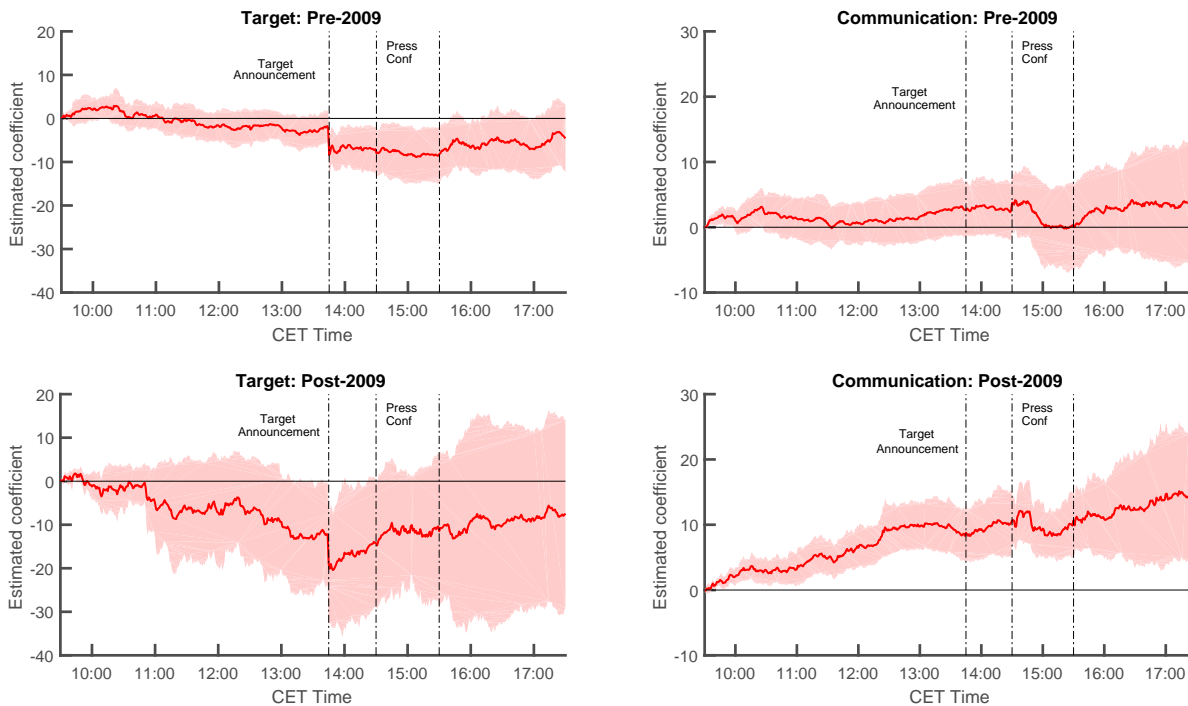


Figure 8. High frequency equity response to policy shocks

We estimate a minute-by-minute regression of equity returns on policy shocks on ECB days by computing realized returns, $\log(P_t/P_{09:30})$, between 09:30 and time t for $t = 09:31, \dots, 17:30$ CET on all ECB days, and regressing them on both target and communication shocks. The loadings on target shocks are displayed on the left panels and the loadings on communication shocks are displayed on the right panels; the top panels refer to pre-2009 and the bottom panels refer to the post-crisis period.

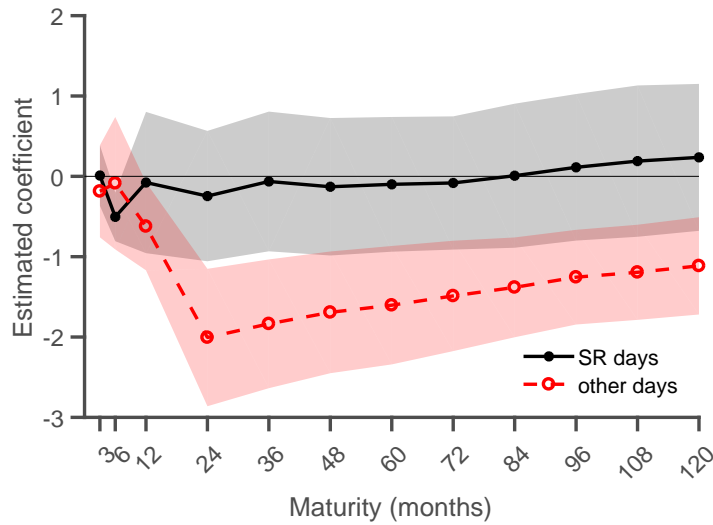


Figure 9. Post-crisis yield responses on short rate and other days

This figure plots the response of bond yield spreads at different maturities for communication shocks on short rate versus other days:

$$\Delta(y_{p,t}^\tau - y_{c,t}^\tau) = \alpha_{pc}^\tau + \beta_{pc,\theta}^\tau Z_{\theta,t} + \epsilon_{pc,t}^\tau, \quad \tau = 3, \dots, 120 \text{ months.}$$

Short rate days versus other days are determined by whether the sign of the co-movement between monetary policy shocks and the Eurostoxx equity return is negative or positive. 90% confidence intervals are based on [Newey and West \(1987\)](#) standard errors. Data run from March 2009 to December 2014.

Tables

	Mean	Std Dev	Min	Max	Skew	Kurtosis	AR(1)
Z_r	0.01	2.18	-18.52	7.27	-4.49	39.13	-0.29
Z_θ	-0.11	3.51	-14.44	17.91	0.34	10.12	-0.16

Table 1. Summary statistics of target and communication shocks

This table presents summary statistics for target and communication shocks in basis points (bp). Target (Z_r) (communication (Z_θ)) shocks are calculated from a principal component analysis applied to swap rate changes with maturities ranging between one month and two years, sampled between 13:40 and 14:25 CET (14:25 and 16:10 CET) on days the ECB announces its monetary policy. Data are in basis points, and run between 2001 and 2014.

	3	6	12	24	60	72	84	96	108	120
Swap Rates										
Z_r	1.07	1.01	1.01	0.71	0.46	0.32	0.25	0.18	0.10	0.13
t -stat	(17.33)	(15.77)	(8.67)	(5.70)	(3.16)	(2.08)	(1.65)	(1.14)	(0.61)	(0.72)
Z_θ	0.62	0.96	1.43	1.40	1.19	1.08	0.92	0.74	0.64	0.65
t -stat	(8.25)	(13.37)	(20.22)	(15.82)	(10.34)	(9.78)	(9.09)	(5.85)	(5.25)	(4.68)
R^2	72.16	80.89	81.15	63.17	43.52	38.61	30.45	22.93	17.85	16.96
ΔR^2	31.97	54.48	65.98	56.08	40.34	36.80	29.14	22.14	17.54	16.53
Forward Rates										
Z_r		1.01	0.41	0.25	-0.41	-0.11	-0.36	-0.57	0.40	
t -stat		(8.67)	(2.60)	(1.03)	(-1.77)	(-0.36)	(-1.02)	(-1.88)	(0.68)	
Z_θ		1.43	1.36	0.84	0.53	-0.05	-0.49	-0.14	0.67	
t -stat		(20.22)	(10.06)	(5.26)	(2.50)	(-0.09)	(-0.86)	(-0.37)	(1.16)	
R^2		81.15	41.15	13.02	6.76	0.09	2.73	1.74	2.36	
ΔR^2		65.98	39.16	12.40	5.66	0.03	2.19	0.23	2.02	

Table 2. Swap and forward rate response to target and communication shocks

This table reports the results of multivariate regressions of zero-coupon one-day changes in swap rates (upper panel) and forward rates (lower panel) across different maturities on target (Z_r) and communication (Z_θ) shocks on days when the ECB announces their monetary policy. t -statistics are calculated using [Newey and West \(1987\)](#). ΔR^2 indicates the change in the adjusted R^2 when we add communication shocks, Z_θ , to the regression. Data run between 2001 and 2014.

	Full			Pre			Post		
	Core	Peripheral	Spread	Core	Peripheral	Spread	Core	Peripheral	Spread
Z_θ	1.47	1.30	-0.16	1.49	1.36	-0.13	1.44	1.19	-0.25
t-stat	(14.58)	(6.95)	(-0.84)	(12.54)	(11.17)	(-2.89)	(8.94)	(2.82)	(-0.45)
interaction	-0.11	-0.94	-0.84	-0.01	0.16	0.17	-0.08	-1.84	-1.76
t-stat	(-0.87)	(-1.84)	(-1.59)	(-0.05)	(0.85)	(2.26)	(-0.60)	(-2.46)	(-2.28)
dummy	0.01	0.00	-0.00	-0.01	-0.01	-0.00	0.02	-0.00	-0.02
t-stat	(0.72)	(0.23)	(-0.41)	(-0.56)	(-0.85)	(-2.05)	(1.69)	(-0.19)	(-1.26)
R^2	58.53	11.24	4.11	61.08	57.80	11.95	55.33	1.45	8.04

Table 3. Bond yield response dummy regressions

This table reports estimated coefficients from the regression

$$\Delta y_{i,t}^{24} = \alpha_i + \beta_i Z_{\theta,t} + \gamma_i \underbrace{\text{Dummy}_t \times Z_{\theta,t}}_{\text{interaction}} + \delta_i \text{Dummy}_t + \epsilon_{i,t},$$

where $\Delta y_{i,t}^{24}$ are one-day changes in core and peripheral two-year bond yields as well as the spread between peripheral and core bond yields on days that the ECB announces its monetary policy and Dummy is a dummy variable that takes the value of one on days with positive co-movement between the Eurostoxx and the monetary policy shock and zero otherwise. t -statistics are calculated using [Newey and West \(1987\)](#). R^2 reports the adjusted R-squared. Data run from January 2001 to December 2014 (full sample), January 2001 to February 2009 (pre crisis) and March 2009 to December 2014 (post crisis).

	Germany		Italy		Spread	
	60	120	60	120	60	120
Z_θ	0.47	0.13	-0.86	-0.43	-1.33	-0.57
t-stat	(3.22)	(0.86)	(-0.59)	(-0.60)	(-0.91)	(-0.91)
interaction	-0.09	-0.15	1.57	-0.22	1.66	-0.07
t-stat	(-0.45)	(-0.39)	(0.63)	(-0.13)	(0.64)	(-0.05)
dummy	0.02	-0.01	-0.00	0.11	-0.02	0.12
t-stat	(2.70)	(-0.63)	(-0.00)	(1.70)	(-0.16)	(1.81)
R^2	21.95	-5.30	-5.77	-0.88	-5.46	0.55

Table 4. Break-even inflation rates

This table reports estimated coefficients from the regression

$$\Delta(y_{i,t}^T - y_{i,t}^{r,T}) = \alpha_i + \beta_i Z_{\theta,t} + \gamma_i \underbrace{\text{Dummy}_t \times Z_{\theta,t}}_{\text{interaction}} + \delta_i \text{Dummy}_t + \epsilon_{i,t},$$

where $y_{i,t}^T$ and $y_{i,t}^{r,T}$ are five- or ten-year nominal and real yields, respectively. In turn, $\Delta(y_{i,t}^T - y_{i,t}^{r,T})$ are break-even inflation rates, i.e., the sum of expected inflation and an inflation risk premium. t -statistics are calculated using [Newey and West \(1987\)](#). R^2 reports the adjusted R-squared. Data run from August 2010 to December 2014.

	Illiquidity			CDS			CDS quantos		
	Core	Peripheral	Spread	Core	Peripheral	Spread	Core	Peripheral	Spread
Z_θ	-0.33	0.37	0.71	-0.09	0.44	0.53	0.07	0.09	0.03
t-stat	(-4.03)	(1.50)	(3.55)	(-1.47)	(0.91)	(1.22)	(1.76)	(2.64)	(0.40)
interaction	-0.70	-0.13	0.57	-1.43	-6.76	-5.33	-0.43	-1.03	-0.60
t-stat	(-2.40)	(-0.17)	(0.70)	(-2.11)	(-3.89)	(-4.03)	(-2.02)	(-5.77)	(-3.64)
dummy	-0.00	0.03	0.03	0.01	0.03	0.02	0.00	0.01	0.01
t-stat	(-0.10)	(0.94)	(0.83)	(1.28)	(1.02)	(0.87)	(0.95)	(1.56)	(0.76)
R^2	22.79	3.51	7.29	20.66	17.60	15.19	4.58	21.38	5.41

Table 5. Risk premium channels

This table reports estimated coefficients from the regression

$$X_{i,t} = \alpha_i + \beta_i Z_{\theta,t} + \gamma_i \underbrace{\text{Dummy}_t \times Z_{\theta,t}}_{\text{interaction}} + \delta_i \text{Dummy}_t + \epsilon_{i,t},$$

where $i = c, p$, and $X_{i,t}$ are bid-ask spreads, CDS spreads, and CDS quanto spreads described and discussed in the main body of the paper. t -statistics are calculated using [Newey and West \(1987\)](#). Data run from March 2009 to December 2014 for the bid-ask spreads. Data run from August 2010 to December 2014 for CDS and CDS quantos.

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Central Bank Communication and the Yield Curve

– Not for Publication –

This Online Appendix consists of several sections. Section **OA-1** presents ECB meeting days which we exclude from our analysis and argues that it is enough to focus on one factor per window when explaining the term structure of interest rate changes on ECB announcement days. Section **OA-2** studies the effect of US macroeconomic announcements on our results. Section **OA-3** explores the robustness of our main result with respect to different monetary policy shocks. Section **OA-4** examines the robustness of our main result when excluding outliers. Section **OA-5** provides some information on how we construct real term structures. Section **OA-7** studies the effect of unconventional monetary policy announcements on our results. Section **OA-6** contains tables omitted in the main paper. Section **OA-8** provides a microfoundation for the signalling channel discussed in the main paper and Section **OA-9** considers a model that allows for bank heterogeneity.

OA-1 Identification of Monetary Policy Shocks

date	Type of announcement
February 15, 2001	No press conference
March 15, 2001	No press conference
March 29, 2001	No press conference
April 26, 2001	No press conference
May 23, 2001	No press conference
August 2, 2001	No press conference
September 17, 2001	Unscheduled, no press conference
September 27, 2001	No press conference
October 25, 2001	No press conference
August 1, 2002	No press conference
July 31, 2003	No press conference
August 5, 2004	No press conference
August 4, 2005	No press conference
August 2, 2007	No press conference
October 8, 2008	Coordinated rate cut of 50bps with other central banks
November 6, 2008	BoE shocked market by 150bps cut

Table OA-1. Excluded ECB announcement days

This table lists ECB announcement dates which are excluded from our analysis. Excluded dates either include announcements which were not followed by a press conference, unscheduled meetings or days when unconventional monetary policy decisions were taken.

	PC1	PC2	PC3
Monetary Policy	87.68	6.56	2.48
Target	86.36	5.66	1.71
Communication	89.14	4.15	2.90

Table OA-2. Principal components in different windows

An eigenvalue decomposition of a positive definite covariance matrix is $Cov[\Delta Y] = QDQ^\top$. The columns of Q contain eigenvectors and the diagonal elements of D contain eigenvalues. Principal components (PC) are formed by $PC_t = Q\Delta Y$. The fraction of explained variance of the k 'th PC is given by $\pi(k, k) / \sum_i \pi(i, i)$. Target (Communication) captures change in yields between 13:40 and 14:25 CET (14:25 and 16:10 CET), while the monetary policy window measures yield changes between 13:40 and 16:10 CET.

To assess the economic significance of the principal components from high-frequency changes in money market rates, we regress zero-coupon rate changes, bootstrapped from the swap rate changes of the whole monetary policy window, on the first and second PC of each windows; regression coefficients, corresponding t -statistics, and adjusted R^2 s for six maturities are presented in Table OA-3. The upper panel contains our results for PCs constructed during the target rate window. For PC1, we find that the t -statistics are highly significant from the shortest maturity swap rate (three months) out to five years, as adjusted R^2 s decrease from 39% to 4%. The bottom part of the upper panel reports regression results for PC2; notice the significant drop in the explanatory power as well as the lower t -statistics compared to PC1. For intermediate maturities, between six and 24 months, the second PC is insignificant, then becomes negative and significant going out to ten years. The final row of the upper panel reports the change in the R^2 , denoted by ΔR^2 , when including PC2 in the regression compared to the one that uses only PC1. Since the PCs are orthogonal, this number represents the marginal explanatory power of PC2, and shows that the second factor has little impact on yield changes during the target window.

A similar picture emerges for the communication window in the lower panel. While the first PC is highly significant throughout all maturities, the second PC is marginally significant at the short end, and estimated coefficients are negative and highly significant at the long end. Different from the upper panel, however, coefficients for the first PC display a hump-shaped pattern around the one- and two-year maturity, with a corresponding R^2 of 80%, which then declines slowly to 57% at the ten-year maturity. Similar to the target window results, we find the marginal increase in R^2 from the second PC to be small, especially at the short-end. Taken together, we note that one principal component seems to explain a significant fraction of the variation of interest rate changes during ECB announcement days, whereas the second PC is economically mostly insignificant.

	3	6	12	24	60	120
Target Window						
PC1	0.77	1.05	1.09	1.05	0.59	0.24
<i>t</i> -stat	(4.26)	(18.75)	(16.30)	(15.91)	(3.90)	(1.55)
PC2	0.18	0.09	-0.06	-0.05	-0.17	-0.11
<i>t</i> -stat	(3.09)	(1.46)	(-0.78)	(-0.66)	(-2.23)	(-1.70)
R^2	38.92	36.79	22.87	20.84	9.65	3.91
ΔR^2	4.96	0.49	-0.27	-0.33	1.45	1.16
Communication Window						
PC1	0.53	0.82	1.23	1.25	0.98	0.57
<i>t</i> -stat	(10.48)	(19.55)	(44.86)	(41.15)	(24.82)	(9.09)
PC2	0.15	0.02	-0.23	-0.29	-0.59	-0.42
<i>t</i> -stat	(1.95)	(0.23)	(-2.03)	(-2.86)	(-7.06)	(-7.20)
R^2	44.37	58.24	78.36	81.20	75.84	56.67
ΔR^2	2.33	-0.22	2.04	3.17	17.05	16.89

Table OA-3. Swap rate loadings on PCs

This table reports estimated coefficients from univariate regressions from changes in swap rates during the monetary policy window (i.e., between 13:40 and 16:10 CET) onto the first (PC1) and second (PC2) principal components constructed from swap changes in the target or communication window around ECB monetary policy announcements:

$$\Delta y_t^\tau = \beta_1 \times \text{PC1}_t + \beta_2 \times \text{PC2}_t + \epsilon_t^\tau, \quad \tau = 3, \dots, 120 \text{ months,}$$

where PC1_t and PC2_t are either the first and second PC from the target (upper panel) or communication (lower panel) window, respectively, and τ is the maturity. ΔR^2 indicates the change in the adjusted R^2 when adding the second PC. *t*-statistics are calculated using [Newey and West \(1987\)](#) allowing for serial correlation. Data run between 2001 and 2014.

OA-2 US Initial Jobless Claims

In this section, we study the effect of macroeconomic releases on our results. While no other euro area macroeconomic variables are released on days when the ECB announces its monetary policy, data on US jobless claims are announced every Thursday at 8:30am Eastern Standard Time which often coincides with the start of the ECB press conference. To study any potential impact on our results, we re-estimate our shocks controlling for surprises in jobless claims data. Bloomberg collects surveys of forecasts for most of macroeconomic variables and we use the median of initial jobless claims forecasts as a proxy for market expectations. We then compute the surprise component as the difference between the actual release and market expectations. Finally, we compute communication shocks orthogonal to the surprise in the jobless claims announcement by regressing the original shocks on the surprise and taking the residual of the regression. Figure OA-1 shows that controlling for jobless claims announcements does not affect our communication shocks: the original communication shocks and orthogonalized one are virtually identical. The correlation between the original shocks and orthogonalized shocks is 0.97. We therefore conclude that US macroeconomic announcements do not significantly affect our main results.

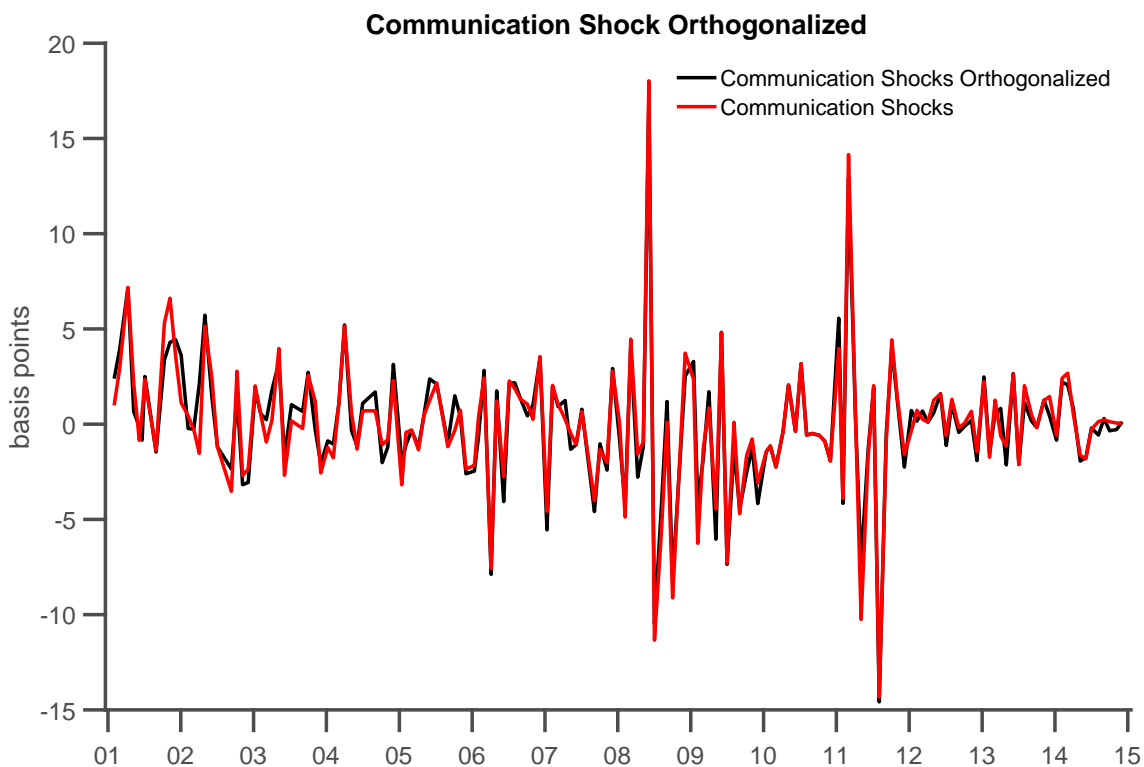


Figure OA-1. Time-series of orthogonalized shocks

This figure plots the time-series of our communication shocks and shocks orthogonal to US macroeconomic announcements between January 2001 and December 2014.

OA-3 Comparison with other shocks

OA-3.1 GSS shocks

In this section, we compare our monetary policy shocks (target and communication) to the level and path factor in [Gürkaynak, Sack, and Swanson \(2005\)](#). To this end, we follow the method in [Gürkaynak, Sack, and Swanson \(2005\)](#) and estimate principal components from the changes in interest rate over the full window, i.e. from 13:40 CET to 16:10 CET. We then rotate the principal components such that the first principal component corresponds to surprise changes in the target rate and the second factor corresponds to moves in interest rate expectations over the coming two years that are not driven by changes in the current target rate.

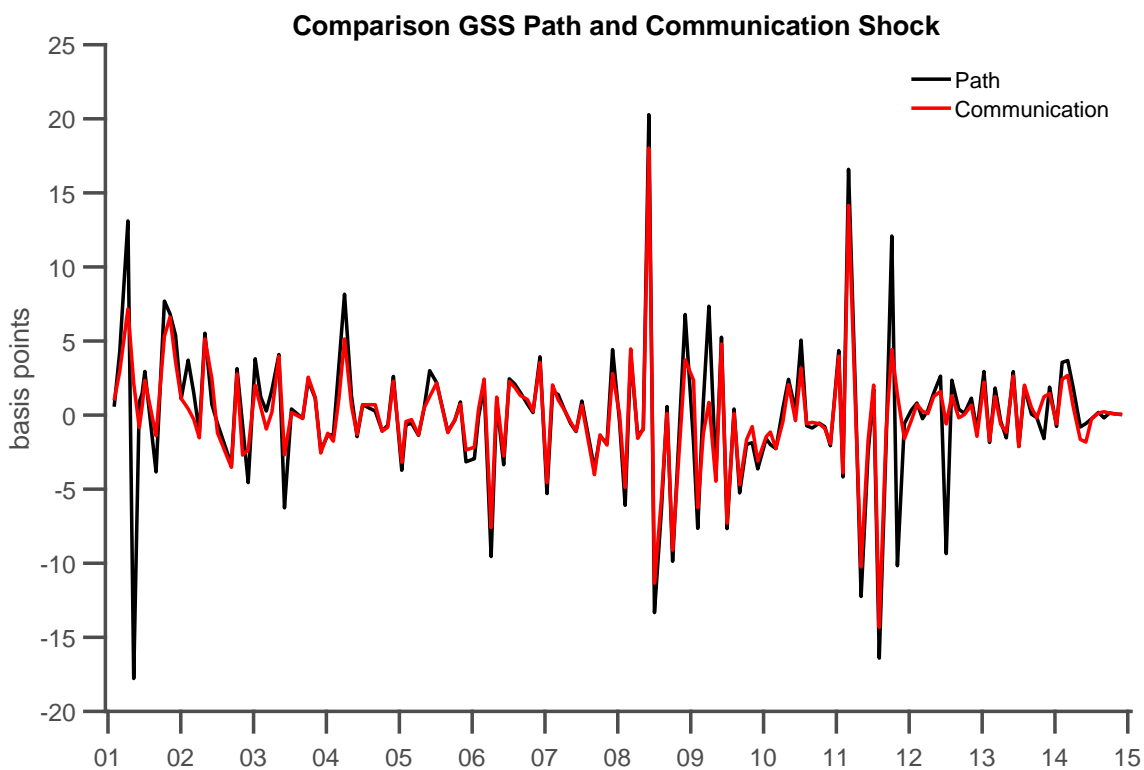


Figure OA-2. Time-series of the [Gürkaynak, Sack, and Swanson \(2005\)](#) path shock

This figure plots the time-series of [Gürkaynak, Sack, and Swanson \(2005\)](#) path shocks and our communication shocks between January 2001 and December 2014.

Figure [OA-2](#) plots the path factor together with our communication shock. We notice the almost perfect comovement between the two shocks. We now check whether the path factor leads to the same results as using our communication shock. To this end, we run the main regression from the main paper whereby we regress changes in core and peripheral bond yield changes onto the level and path factor. Figure [OA-3](#) depicts the results (left panels) and contrasts them to the results using the communication shock (right panels). We notice that the main message is the same: Pre-2009, there are no significant differences how path or

communication shocks affected core and peripheral bond yields. Post-2009, peripheral bond yields display an insignificant reaction to both path and communication shocks.

We interpret these findings as an independent validation of the approach in [Gürkaynak, Sack, and Swanson \(2005\)](#).

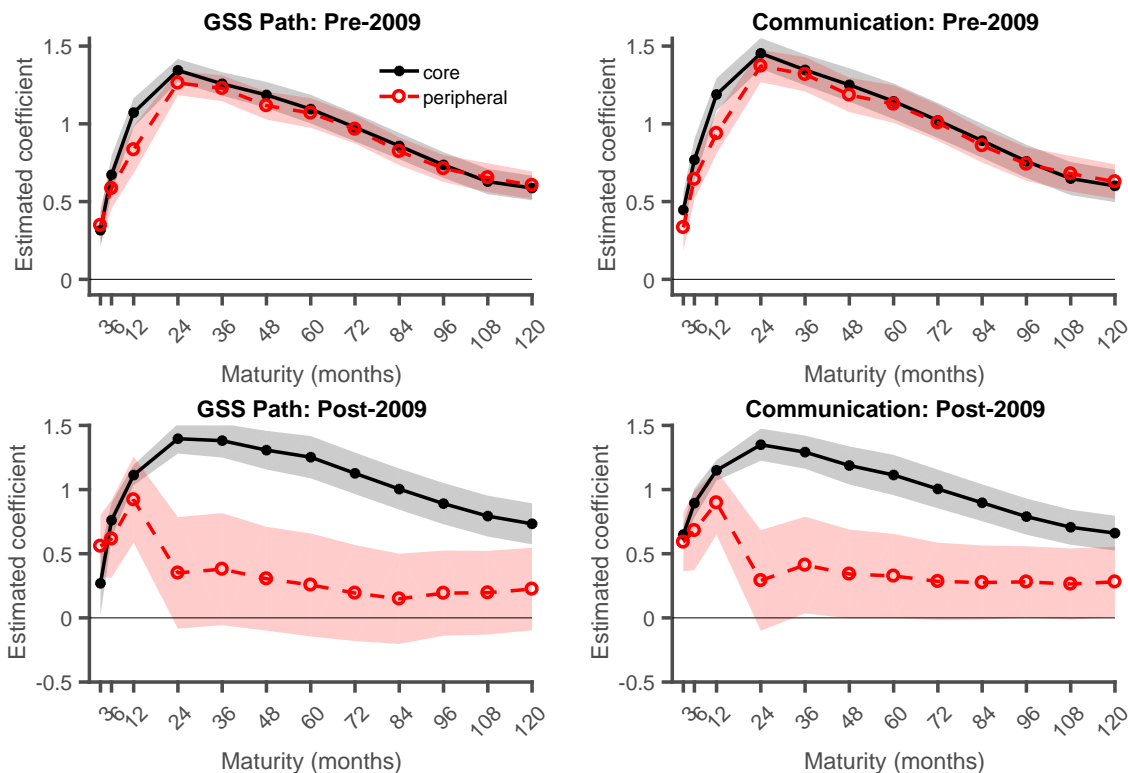


Figure OA-3. Core and peripheral yield response before and after the onset of the crisis
 This figure plots the response of core (solid line) and peripheral (dashed line) countries' bond yields at different maturities for a [Gürkaynak, Sack, and Swanson \(2005\)](#) path shock (left panels) and communication shock (right panels) on ECB announcement days:

$$\Delta y_{i,t}^{\tau} = \beta_{i,c}^{\tau} \{ \text{path}_t \text{ or } Z_{\theta,t} \} + \epsilon_{i,c,t}^{\tau},$$

where $\tau = 3m, \dots, 10y$. 90% confidence intervals are based on [Newey and West \(1987\)](#) standard errors. The sample period is from January 2001 to February 2009 for the upper two panels and from March 2009 to December 2014 for the lower two panels.

OA-3.2 Level/Slope shocks

In this section, we instead compare our monetary policy shocks to shocks identified using measures of level and slope from the OIS curve. We define level shocks as changes in the OIS-1m rates over the full window, i.e. from 13:40 CET to 16:10 CET. We instead define slope shocks as changes in the difference between OIS-12m and OIS-1m rates over the same window. We consider level and slope shocks as different measure of our target and

communication shocks, respectively. Figure OA-4 plots the slope shocks together with our communication shock. We find that also slope shocks exhibit high correlation with our communication shocks measure.

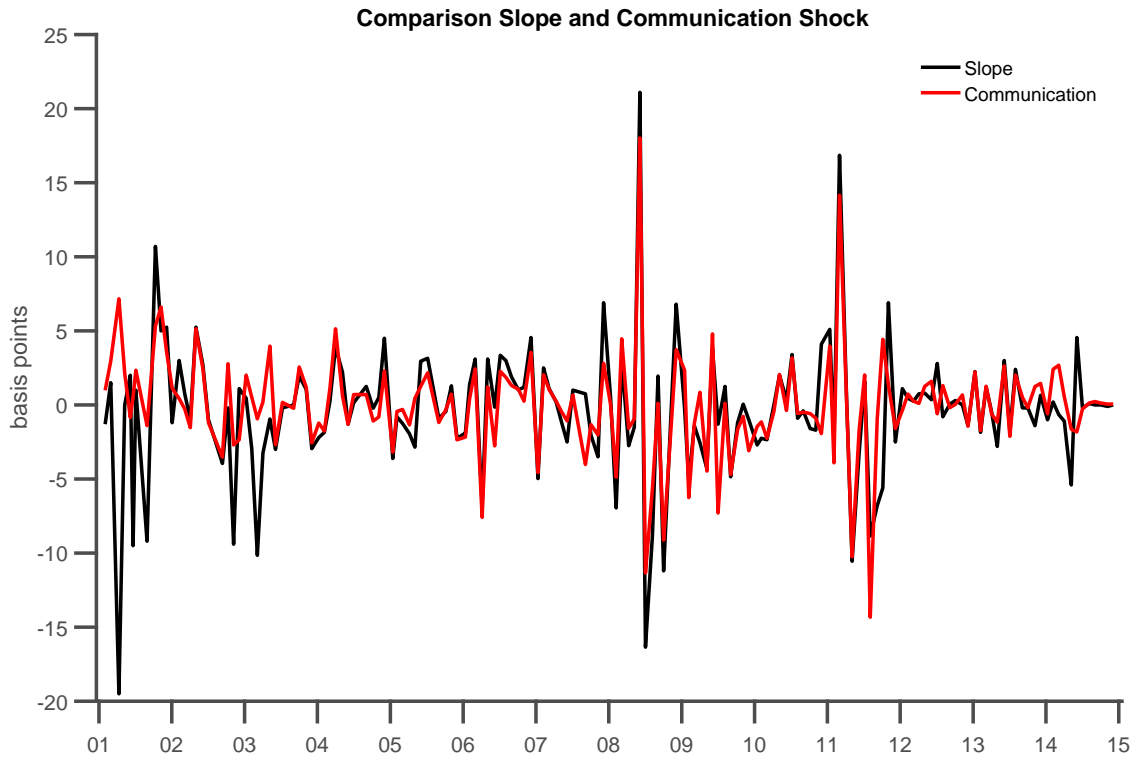


Figure OA-4. Time-series of slope shocks

This figure plots the time-series of slope shocks and our communication shocks between January 2001 and December 2014.

Moreover, replicating the main regression from the main paper, we notice that our conclusions are basically unchanged when using slope shocks (left panel) or communication shocks (right panel).

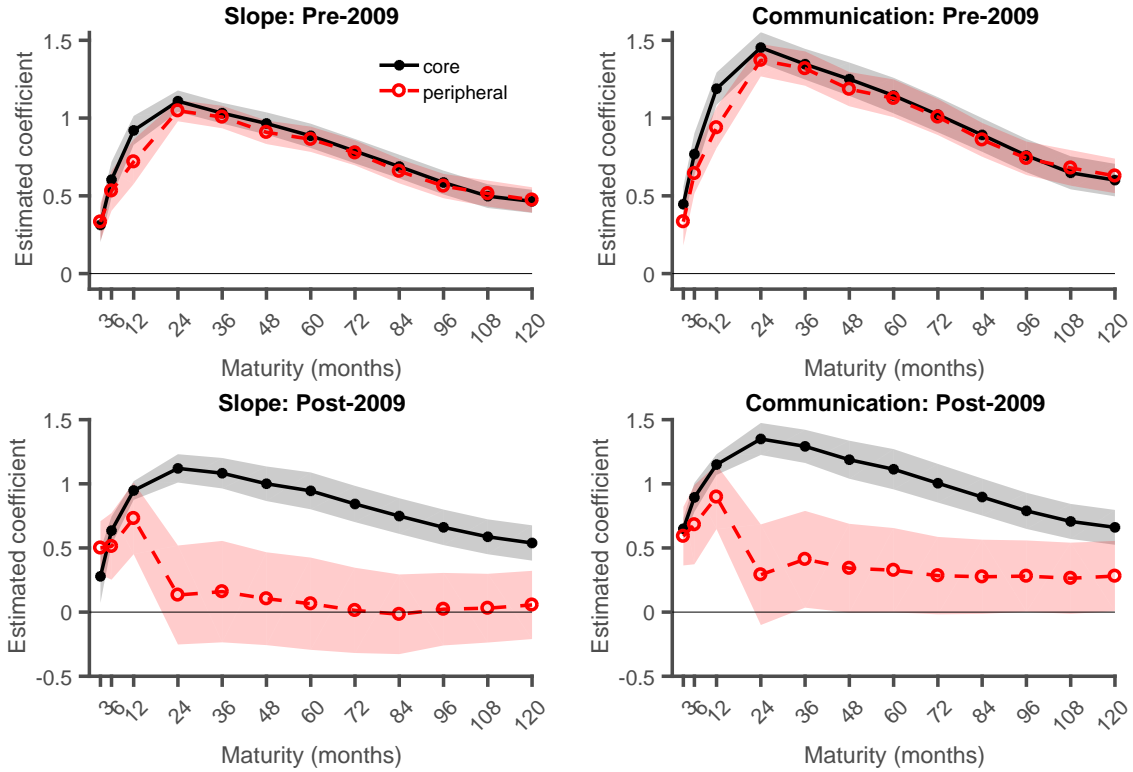


Figure OA-5. Core and peripheral yield response before and after the onset of the crisis
This figure plots the response of core (solid line) and peripheral (dashed line) countries' bond yields at different maturities for a slope shock (left panels) and communication shock (right panels) on ECB announcement days:

$$\Delta y_{i,t}^{\tau} = \beta_{i,c}^{\tau} \{\text{slope}_t \text{ or } Z_{\theta,t}\} + \epsilon_{i,c,t}^{\tau},$$

where $\tau = 3m, \dots, 10y$. 90% confidence intervals are based on [Newey and West \(1987\)](#) standard errors. The sample period is from January 2001 to February 2009 for the upper two panels and from March 2009 to December 2014 for the lower two panels.

OA-4 Outliers

A further concern of our results may be the impact of potential outliers. Figure OA-6 provides the main result (right panels) together with estimated coefficients when we exclude 5% of all outliers (left panel). We notice that the results look virtually the same. We therefore conclude that outliers are unlikely driving our results.

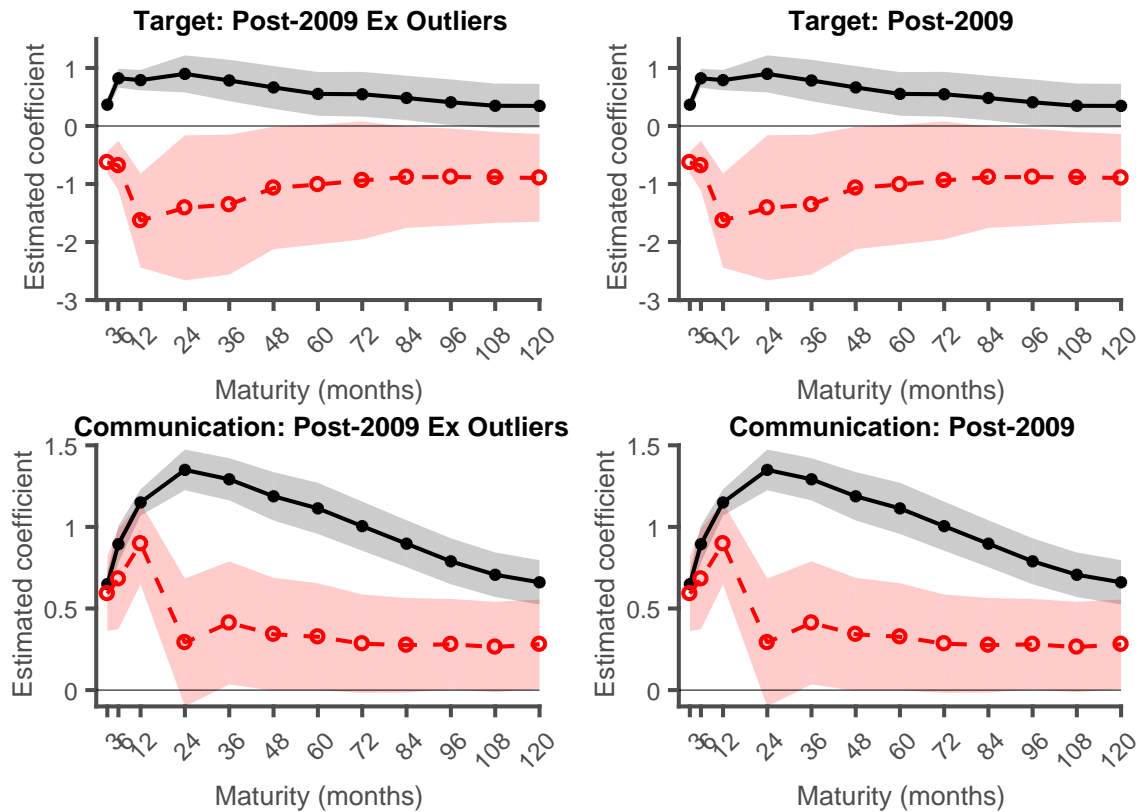


Figure OA-6. Core and peripheral yield response excluding outliers

This figure plots the response of core (solid line) and peripheral (dashed line) countries' bond yields at different maturities for a target (upper panels) and communication shock (lower panels) on ECB announcement days:

$$\Delta y_{i,t}^{\tau} = \beta_{i,c}^{\tau} \{\text{slope}_t \text{ or } Z_{\theta,t}\} + \epsilon_{i,c,t}^{\tau},$$

where $\tau = 3m, \dots, 10y$. 90% confidence intervals are based on [Newey and West \(1987\)](#) standard errors. The left panels exclude 5% of the top and bottom extremes. The sample period is from March 2009 to December 2014.

OA-5 European Real Yields

We estimate real zero coupon bond yields for Germany, France, Italy, and Spain. For example, the first inflation protected security issued by Germany or France was a 10-year bond issued in 2005. Italy and Spain only started issuing inflation protected bonds after 2008. Par-yields are obtained from Bloomberg. To obtain curves of zero coupon real discount rates we estimate a Nelson-Siegel model on all outstanding inflation protected bonds. The Nelson-Siegel model assumes that the instantaneous forward rate is given by a 3-factor parametric function. To estimate the set of parameters we minimize the weighted sum of the squared deviations between actual and model-implied prices. Specifically, we search for the parameters which solve $b_t^j = \arg \min_b \sum_{h=1}^{H_t^j} \left[(P^h(b) - P_t^h) \times \frac{1}{D_t^h} \right]^2$, where H_t^j denotes the number of bonds available in country j in month t , $P^h(b)$ is the model-implied price for bond $h = 1, \dots, H_t^j$, P_t^h is its traded bond price, and D_t^h is the corresponding Macaulay duration. The time-series of estimated real bond yields is displayed in Figure OA-7

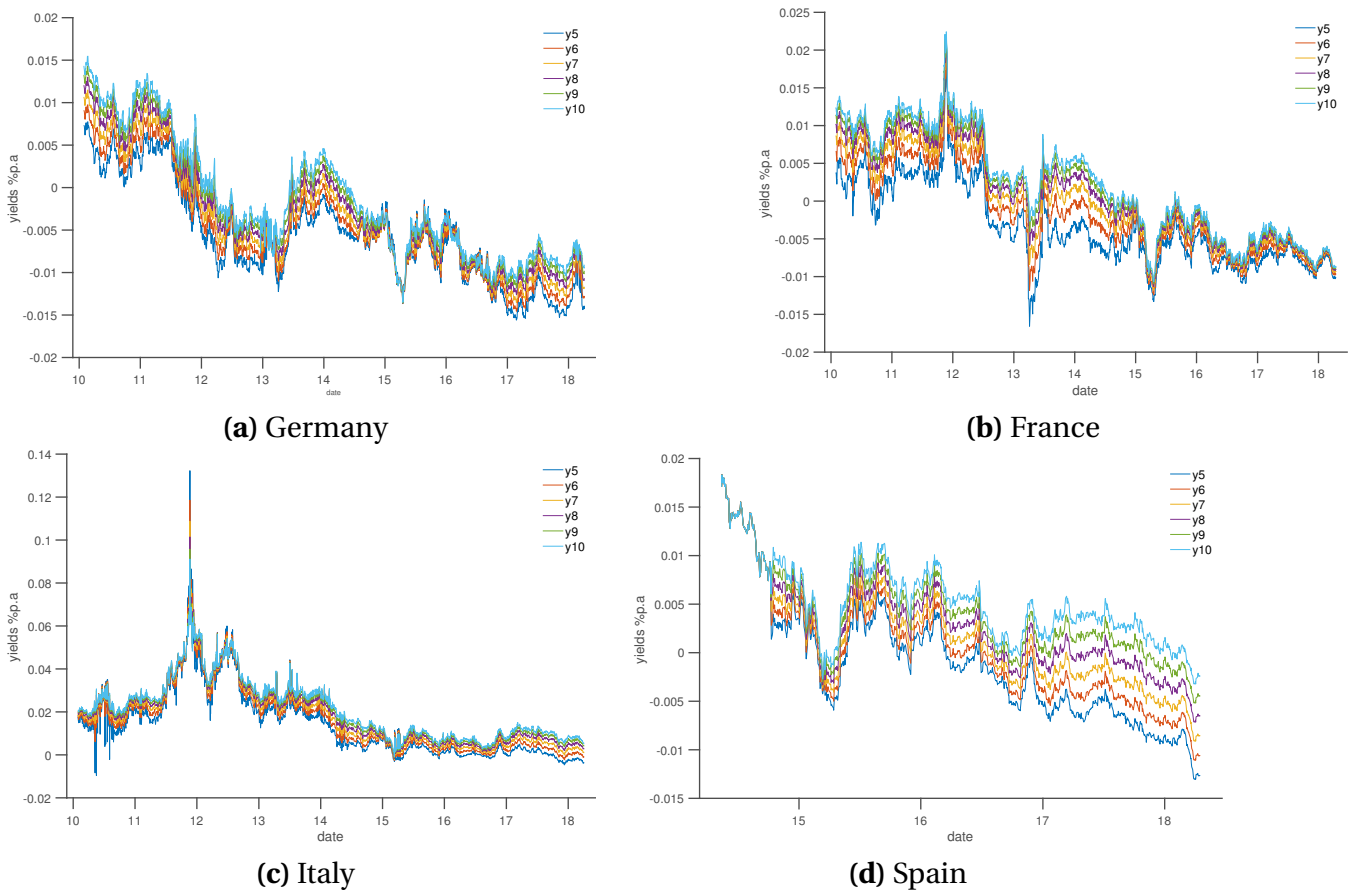


Figure OA-7. Real Yields

This figure displays time-series of zero-coupon real bonds yields estimated using a Nelson-Siegel model for maturities between five- and ten-years.

OA-6 Additional Tables and Figures

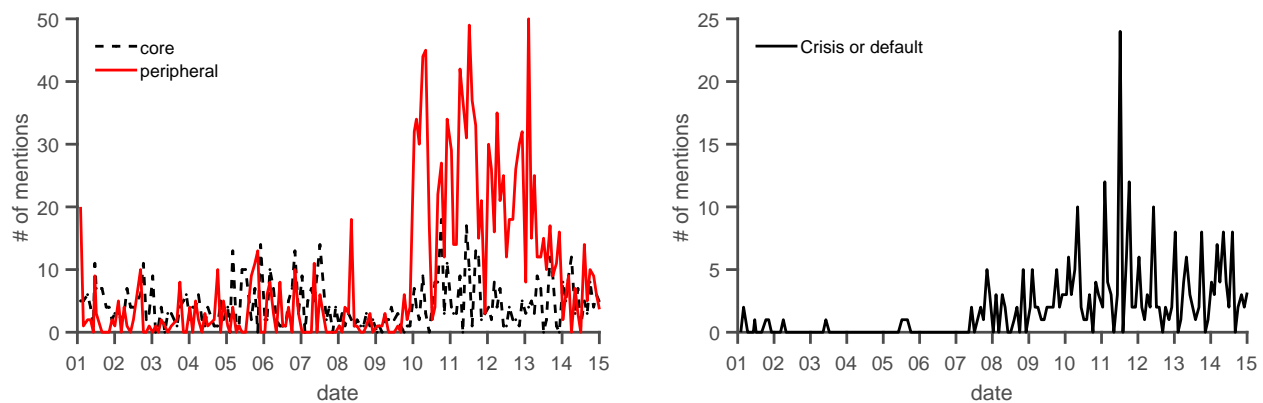


Figure OA-8. Textual analysis of press conference transcripts

The left panel plots the number of mentions of core versus peripheral countries during ECB press statements. The right panel plots the number of mentions of “crisis” or “default”. ‘Peripheral’ words include: *Italy, Spain, Greece, Portugal, Ireland* and *periphery*. ‘Core’ words include: *Belgium, France, Germany, Netherlands* and *core*. ‘Crisis’ words include: *crisis* and *default*.

	CDS (\$)	CDS (€)	3	6	12	24	60	120
France								
mean	0.57	0.41	1.92	1.93	2.01	2.22	2.89	3.67
stdev	0.55	0.36	1.52	1.50	1.48	1.42	1.23	0.96
min	2.47	1.98	4.74	4.68	4.66	4.83	4.91	5.43
max	0.02	0.02	-0.06	-0.07	-0.05	-0.05	0.18	0.85
Germany								
mean	0.30	0.21	1.86	1.89	1.98	2.12	2.68	3.37
stdev	0.27	0.18	1.54	1.53	1.53	1.48	1.39	1.17
min	1.15	0.91	4.91	4.83	4.73	4.70	4.99	5.35
max	0.01	0.01	-0.13	-0.62	-0.09	-0.10	0.02	0.57
Italy								
mean	1.52	1.30	2.19	2.32	2.53	2.89	3.70	4.54
stdev	1.41	1.16	1.35	1.34	1.25	1.14	0.95	0.76
min	5.90	5.01	6.53	7.90	8.16	7.84	7.76	7.34
max	0.05	0.05	0.13	0.14	0.21	0.34	1.03	2.04
Spain								
mean	1.53	1.26	2.10	2.24	2.45	2.86	3.67	4.47
stdev	1.48	1.14	1.34	1.28	1.22	1.09	0.97	0.89
min	6.33	5.04	5.77	6.02	6.07	6.85	7.69	7.69
max	0.02	0.02	0.01	0.04	0.11	0.19	0.77	1.67

Table OA-4. Summary statistics of CDS and bond yields

This table presents summary statistics for five-year CDS denominated in US Dollars (first column), Euros (second column) and bond yields for maturities ranging between three to 120 months (columns 2 to 7). Data is in percent. CDS are sampled between October 2005 and 2014. Bond yields are sampled between 2001 and 2014.

OA-7 Unconventional Monetary Policy

Our paper focuses on conventional monetary policy announcements. In the following, we explore the effect of so-called unconventional monetary policy on our results. Unconventional measures include the securities markets program (SMP), Outright Monetary Transactions (OMT), Asset Purchase Programmes (APP), and Long-Term Refinancing Operations (LTROs). Table OA-5 summarizes a list of these announcement dates from Dewachter, Iania, and Wijnandts (2016). Bold dates coincide with ‘normal’ ECB announcement days.

Date	Program	What
May 5, 2010	SMP	Government debt purchase of distressed countries (Greece, Ireland, and Portugal)
August 8, 2011	SMP	Extension of first round of SMP to include Italy and Spain
December 1, 2011	LTRO	Draghi’s speech at European parliament
December 8, 2011	LTRO	Announcement of 3-year loan scheme for European banks.
July 26, 2012	OMT	Draghi’s “whatever it takes” and “believe me, it will be enough” speech at investors’ conference
August 2, 2012	OMT	OMT mentioned at press conference
September 6, 2012	OMT	Official announcement
June 5, 2014	LTRO	Operations that provide financing to credit institutions for periods of up to four years.
August 22, 2014	APP	Draghi’s speech at Jackson Hole
September 4, 2014	APP	Asset-backed securities purchase programme (ABSPP) and third covered bond purchase programme (CBPP3)
October 2, 2014	APP	ABSPP and third covered bond purchase programme (CBPP3)
November 6, 2014	APP	Draghi expresses commitment to using additional unconventional instruments within its mandate.
November 21, 2014	APP	President Draghi’s speech at the Frankfurt European Banking Congress “ECB will do what it must”

Table OA-5. Unconventional Monetary Policy Announcements

This table lists ECB announcement dates which contained unconventional monetary policy news. Bold dates are dates which coincide with ‘normal’ ECB announcement dates.

We notice that six dates coincide with ‘normal’ announcement days. One obvious question now is whether either target and especially communication shocks displayed any special feature during these days. We report in Table OA-6 the size of target and communication shocks and find them to be virtually zero.

To check the effect of these six dates on our results, we re-estimate the shocks by excluding the six dates. We then re-run our regressions using these new shocks. The results are reported in Table OA-7. The upper two panels report our baseline results, i.e., these are the regressions

		Z_r	Z_θ
LTRO	December 8, 2011	0.01	-0.02
OMT	August 2, 2012	0.01	0.01
OMT	August 2, 2012	0.01	0.01
APP	September 4, 2014	0.00	0.00
APP	October 2, 2014	0.00	0.00
APP	November 6, 2014	0.00	0.00

Table OA-6. Target and Communication Shocks on UMP Dates

This table reports the size of target (Z_r) and communication (Z_θ) shocks on ECB announcement days where unconventional measures were announced during the statement.

using our shocks consisting of all announcements and the lower two panels report the same regressions but when we exclude the unconventional monetary policy dates. We notice that the two sets of results are literally the same.

	3	6	12	24	60	120
Core: 2009 - 2015						
Z^r	0.343	0.824	0.781	0.886	0.546	0.337
t -stat	(3.79)	(5.00)	(4.35)	(2.76)	(1.55)	(1.05)
Z^θ	0.649	0.893	1.149	1.349	1.113	0.660
t -stat	(9.29)	(8.26)	(14.70)	(10.12)	(8.15)	(7.15)
R^2	25.27%	39.70%	77.24%	61.70%	34.80%	16.19%
Peripheral 2009 - 2015						
Z^r	-0.643	-0.718	-1.654	-1.408	-1.021	-0.898
t -stat	(-4.20)	(-1.83)	(-2.05)	(-1.12)	(-1.01)	(-1.26)
Z^θ	0.592	0.682	0.898	0.292	0.327	0.281
t -stat	(2.98)	(2.69)	(4.06)	(0.69)	(0.98)	(0.99)
R^2	30.86%	24.10%	15.77%	2.09%	-0.09%	0.39%
Core: 2009 - 2015 without 6 UMP dates						
Z^r	0.343	0.824	0.781	0.886	0.546	0.337
t -stat	(3.79)	(5.00)	(4.35)	(2.76)	(1.55)	(1.05)
Z^θ	0.649	0.893	1.149	1.349	1.113	0.660
t -stat	(9.29)	(8.26)	(14.70)	(10.12)	(8.15)	(7.15)
R^2	25.27%	39.70%	77.24%	61.70%	34.80%	16.19%
Peripheral 2009 - 2015 without 6 UMP dates						
Z^r	-0.643	-0.718	-1.654	-1.408	-1.021	-0.898
t -stat	(-4.20)	(-1.83)	(-2.05)	(-1.12)	(-1.01)	(-1.26)
Z^θ	0.592	0.682	0.898	0.292	0.327	0.281
t -stat	(2.98)	(2.69)	(4.06)	(0.69)	(0.98)	(0.99)
R^2	30.86%	24.10%	15.77%	2.09%	-0.09%	0.39%

Table OA-7. Baseline Regression with and without UMP

The upper two panels report regression coefficients when regressing changes in bond yields of core and peripheral countries on the target and communication shock in the March 2009 to December 2014 sample. The lower two panels run the same regression but we exclude the six announcement dates when unconventional monetary policy was included in the statement.

OA-8 Monetary policy signalling

Suppose there are two fundamental factors that describe the evolution of the Eurozone economy, $f_{1,t}$ and $f_{2,t}$, and they determine all important aspects of the macroeconomy, including the probability of the (next-period) credit event that affects bond and equity payoffs – e.g., a peripheral default or the breakup of the Eurozone. In general, we write this probability as $L_t = L(f_{1,t}, f_{2,t})$, decreasing in both arguments: better fundamentals mean a lower probability of default or breakup.

We assume the central bank (CB) chooses values of its policy tools, the target rate and communication, to affect realized fundamentals: $f_{1,t} = f_1(r_t, \theta_t)$ and $f_{2,t} = f_2(r_t, \theta_t)$, while trying to get these values close to optimal values of the two factors, $f_{1,t}^*$ and $f_{2,t}^*$. While these values are unknown, we assume the CB has imperfect signals about them, $s_{1,t}$ and $s_{2,t}$. Thus, we write the CB's (myopic) objective as

$$\max_{r_t, \theta_t} \mathbb{E}_t [U(f_{1,t}, f_{2,t}; f_{1,t}^*, f_{2,t}^*) | s_{1,t}, s_{2,t}]$$

To be able to solve the model in closed form, we consider specific forms for f_1 , f_2 , L and U that simplify the calculations. In particular, we assume that f_1 , f_2 and L are all linear:

$$f_1(r_t, \theta_t) = \alpha_1 r_t + (1 - \alpha_1) \theta_t, \quad f_2(r_t, \theta_t) = \alpha_2 r_t + (1 - \alpha_2) \theta_t, \quad \text{and} \quad L_t = -\delta f_{1,t} - (1 - \delta) f_{2,t};$$

while U is quadratic:

$$U(f_{1,t}, f_{2,t}; f_{1,t}^*, f_{2,t}^*) = -(f_{1,t} - f_{1,t}^*)^2 - (f_{2,t} - f_{2,t}^*)^2.$$

The FOCs then become

$$\begin{aligned} 0 &= \mathbb{E}_t [\alpha_1 (f_{1,t}^* - \alpha_1 r_t - (1 - \alpha_1) \theta_t) + \alpha_2 (f_{2,t}^* - \alpha_2 r_t - (1 - \alpha_2) \theta_t) | s_{1,t}, s_{2,t}] \quad \text{and} \\ 0 &= \mathbb{E}_t [(1 - \alpha_1) (f_{1,t}^* - \alpha_1 r_t - (1 - \alpha_1) \theta_t) + (1 - \alpha_2) (f_{2,t}^* - \alpha_2 r_t - (1 - \alpha_2) \theta_t) | s_{1,t}, s_{2,t}], \end{aligned}$$

which imply

$$\begin{aligned} r_t &= \frac{1 - \alpha_2}{\alpha_1 - \alpha_2} \mathbb{E}_t [f_{1,t}^* | s_{1,t}, s_{2,t}] - \frac{1 - \alpha_1}{\alpha_1 - \alpha_2} \mathbb{E}_t [f_{2,t}^* | s_{1,t}, s_{2,t}] \quad \text{and} \\ \theta_t &= -\frac{\alpha_2}{\alpha_1 - \alpha_2} \mathbb{E}_t [f_{1,t}^* | s_{1,t}, s_{2,t}] + \frac{\alpha_1}{\alpha_1 - \alpha_2} \mathbb{E}_t [f_{2,t}^* | s_{1,t}, s_{2,t}]. \end{aligned}$$

Thus, market participants can invert policy actions into the information of the central bank:

$$\mathbb{E}_t [f_{1,t}^* | s_{1,t}, s_{2,t}] = \alpha_1 r_t + (1 - \alpha_1) \theta_t \quad \text{and} \quad \mathbb{E}_t [f_{2,t}^* | s_{1,t}, s_{2,t}] = \alpha_2 r_t + (1 - \alpha_2) \theta_t.$$

Further, agents' best estimate for the probability of breakup can be written as

$$\pi_t = \mathbb{E}_t [L_t | r_t, \theta_t] = -\delta \mathbb{E}_t [f_{1,t}^* | s_{1,t}, s_{2,t}] - (1 - \delta) \mathbb{E}_t [f_{2,t}^* | s_{1,t}, s_{2,t}] = \eta_r r_t + \eta_\theta \theta_t,$$

with $-1 < \eta_r = -[\delta \alpha_1 + (1 - \delta) \alpha_2] < 0$ and $-1 < \eta_\theta = -1 - \eta_r < 0$.

Therefore, bond holders update their beliefs about the probability of the credit event by reacting to target rate and communication surprises, exactly as assumed in our model.

OA-9 Theoretical framework with two investors

We consider a model similar to the one presented in the main part of the paper. The main difference is that we allow for heterogeneity across agents—we assume one core and one peripheral agent, whose losses conditional on default can be different, and we show that in this setting all our previous results go through, plus we get an additional prediction that investors' holdings also respond to monetary policy shocks. In particular, we show that upon negative shocks, agents increase their home and reduce their foreign bond holdings, in line with the more pronounced home bias observed in bank portfolios in the post-2009 period.

OA-9.1 Bond market

Time is indexed by $t = 0, 1$ and 2 . Agents, described below, make investment decisions at dates 0 and 1 , and by date 2 all assets pay out. Our main interest lies in the date- 0 relationship between monetary policy shocks and stock and bond prices.

We consider a world economy with two countries of a currency union, e.g. the Eurozone, referred to as core and peripheral and indexed by c and p . There are four assets in this economy that agents can invest in. First, at $t = 0$ and 1 , agents have access to a global riskless asset, akin to one-period risk-free bonds of the two countries, and this asset pays a net return of r_t at time $t + 1$. Further, there exist (long-term) zero-coupon bonds of both countries that mature at $t = 2$. The log price of the bond of country i , $i = c, p$, with date- 2 face value of one Euro, the currency unit, is denoted by $p_{i,t}$, $t = 0, 1$, the yield-to-maturity by $y_{i,t} = -p_{i,t}/(t - 2)$, and the (risky) one-period net return on this bond, between t and $t + 1$, by $r_{i,t+1} = p_{i,t+1} - p_{i,t}$. We assume the country- i bond is in net Euro supply $S_{i,t} = S_i \geq 0$ for $i = c, p$. Finally, at date 0 there exists an asset that represents an aggregate stock index of the Eurozone, with a risky terminal log dividend d_1 paid out at date 1 , in fixed Euro supply $S_{s,t} = S_s \geq 0$. We denote the date- 0 log price of the stock by $p_{s,0}$, and the one-period net return by $r_{s,1} = d_1 - p_{s,0}$.

The risk-free rate r_t is assumed to be exogenously given, and its dynamics under the physical probability measure follows

$$r_{t+1} = r_t + \kappa_r (\theta_t - r_t) + Z_{r,t+1}, \quad (\text{OA-1})$$

where

$$\theta_{t+1} = \theta_t + \kappa_\theta (\bar{\theta} - \theta_t) + Z_{\theta,t+1}, \quad (\text{OA-2})$$

$\kappa_r, \kappa_\theta \in (0, 1)$ constants, and $Z_{r,t+1}$ and $Z_{\theta,t+1}$ are i.i.d. random variables with mean zero and variances σ_r^2 and σ_θ^2 , respectively. We interpret r_t as the target short rate set by the central bank and θ_t as information provided by the central bank that shapes the future path of interest rates. Thus, $Z_{r,t}$ are changes to the target rate unexpected by investors, and $Z_{\theta,t}$ stand for communication shocks that provide information about the future path of interest rates.

We assume that at the beginning of date 1 , that is between the two trading rounds, a credit event can happen in the economy that we interpret as either the default of the peripheral country and/or the breakup of the Eurozone. Formally, this is triggered by the random variable $Z_{b,1}$ that takes the value of 1 with conditional probability π_0 and is zero otherwise, independent of all $Z_{r,t}$ s and $Z_{\theta,t}$ s. From its definition, $E_0 [Z_{b,1}] = E_0 [Z_{b,1}^2] = \pi_0$ and $\text{Var}_0 [Z_{b,1}] = \pi_0 - \pi_0^2$. To keep the calculations simple, we make the linear approximation $\text{Var}_0 [Z_{b,1}] \approx \pi_0$, which would be exact in a continuous-time framework, and is approximately

true when π_0 is close to zero. We allow π_0 to be random; in particular, we want to capture that monetary policy shocks signal news about the future of the Eurozone and hence affect the perceived probability of the credit event:¹

$$\pi_0 = \bar{\pi} - Z_{\pi,0} - \eta_r Z_{r,0} - \eta_\theta Z_{\theta,0}, \quad (\text{OA-3})$$

with $\bar{\pi}$ constant and a random variable $Z_{\pi,0}$ that has mean zero and variance σ_π^2 , and is independent of all $Z_{r,t}$, $Z_{\theta,t}$, and $Z_{b,1}$. The constant coefficients η_r and η_θ are crucial variables of the model as having non-zero η_r and η_θ implies that monetary policy decisions and communications can provide information about the state of the economy to market participants that we refer to as signalling. In particular, having $\eta_r, \eta_\theta > 0$ captures that in turbulent times market participants can interpret negative target rate shocks (i.e., target rates lower than what the market expects) and negative communication shocks (i.e., future rates staying low longer as the market expects) as bad news: the central bank that might have superior information believes that rates must be held low for a prolonged period, so market participants increase their estimate regarding the probability of the credit event. If instead $\eta_r = \eta_\theta = 0$, the probability of a credit event is independent of monetary policy.

Bonds are held by competitive agents who can be based in either the core or the peripheral country; we assume there is a representative agent of each country, indexed by $a = c, p$. They live for one period and choose optimal bond and equity holdings to trade off the mean and variance of wealth change over the next period. In case of the credit event, e.g. if the Eurozone breaks up, terminal payoffs on sovereign bonds and equity are affected; we consider this an event after which agents cannot capture the full intrinsic value of assets due to an actual default, or, e.g., search or transaction costs, lower liquidity, or a change in monetary policy by the now independent central banks. We model this outcome as a drop in the face value from one Euro to $e^{-\gamma_{a,i}}$, $a, i = c, p$, with coefficients $\gamma_{a,i}$ that can vary across bonds and agents.

In line with the general view that in case of a Eurozone breakup bonds issued by peripheral countries would be more exposed to credit, (potential) redenomination, and liquidity risks, and hence less valuable than bonds issued by core countries, we assume that the losses are expected to be larger on peripheral bonds for all agents. This means $\gamma_{c,p} > \gamma_{c,c} > 0$ and $\gamma_{p,p} > \gamma_{p,c} > 0$. On the other hand, to capture that peripheral agents holding bonds of their own sovereign might be subject to the above concerns to a smaller extent than core investors, e.g., due to their liabilities covarying more with the value of peripheral bonds in case of the breakup or being better experts of home-country bonds, we assume $\gamma_{c,p}/\gamma_{c,c} > \gamma_{p,p}/\gamma_{p,c}$. Therefore, peripheral agents have a relative advantage of holding peripheral bonds over core agents, and vice versa.

For the equity, we allow monetary policy shocks and the credit event to affect the terminal log dividend:

$$d_1 = g + \phi_r Z_{r,0} + \phi_\theta Z_{\theta,0} - \gamma_s Z_{b,1} \quad (\text{OA-4})$$

where the random variable g , with mean \bar{g} and variance σ_g^2 , stands for a standard risky equity payout independent of all other random variables, the coefficient $\gamma_s \geq 0$ captures that the credit event can affect equity dividends, too, and the constant coefficients ϕ_r and ϕ_θ capture

¹We have in mind a setting where the central bank has superior information about the fundamentals of the economy, and through its decisions, can affect some important macro variables, including the probability of breakup. If the central bank picks r_t and θ_t as solutions to an optimization problem subject to their information set, changes to r_t and θ_t will provide information to market participants. In Section OA-7 of the Online Appendix we provide a simple model as a microfoundation for this assumption.

the direct effect of monetary policy signalling in terms of dividend news.

By no arbitrage, returns between dates 1 and 2 on all bonds are r_1 , so the only non-trivial investment decision agents face is at date 0. If $x_{a,i,0}$, $i = c, p, s$, denotes the Euro amount that type- a agents of period 0 borrow to invest in core and peripheral bonds and in the stock, respectively, their budget constraint is written as

$$w_{a,1} = \sum_{i=c,p,s} x_{a,i,0} (r_{a,i,1} - r_0), \quad (\text{OA-5})$$

and the optimization problem is given by

$$\max_{\{x_{a,i,0}\}_{i=c,p,s}} \mathbb{E}_0 [w_{a,1}] - \frac{\alpha}{2} \text{Var}_0 [w_{a,1}], \quad (\text{OA-6})$$

where $\alpha \geq 0$ is the coefficient of risk aversion. Finally, the market-clearing conditions are $x_{c,i,0} + x_{p,i,0} = S_i$ for $i = c, p$, and $x_{c,s,0} + x_{p,s,0} = S_s$. To improve on the exposition, only for the purpose of this Online Appendix, we set $S_c = S_p = 0$. Our results would be qualitatively be the same without this simplification.

OA-9.2 Equilibrium

Bond returns for agent a between dates 0 and 1 can be simply written as

$$r_{a,i,1} = 2y_{i,0} - r_1 - \gamma_{a,i} Z_{b,1}, \quad (\text{OA-7})$$

whereas the equity return is given by

$$r_{a,s,1} = g + \phi_r Z_{r,0} + \phi_\theta Z_{\theta,0} - \gamma_{a,s} Z_{b,1} - p_{s,0}. \quad (\text{OA-8})$$

Combining these with (OA-5), the optimization problem (OA-6) at date 0 is equivalent to

$$\begin{aligned} & \max_{\{x_{a,i,0}\}_{i=c,p,s}} \sum_{i=c,p,s} x_{a,i,0} (\mathbb{E}_0 [r_{a,i,1}] - r_0) - \frac{\alpha}{2} \text{Var}_0 \left[\sum_{i=c,p,s} x_{a,i,0} r_{a,i,1} \right] \\ & = \sum_{i=c,p,s} x_{a,i,0} (\mathbb{E}_0 [R_{a,i,1}] - r_0) - \frac{\alpha}{2} \left[(x_{a,c,0} + x_{a,p,0})^2 \sigma_r^2 + x_{a,s,0}^2 \sigma_g^2 + \left(\sum_{i=c,p,s} \gamma_i x_{a,i,0} \right)^2 \pi_0 \right]. \end{aligned}$$

The first-order conditions of the optimization problem highlight that expected excess returns must compensate agents for risk they hold, which is the interest rate and break-up risk for bonds, and the cash flow and break-up risk for stocks:

$$\mathbb{E}_0 [r_{a,i,1}] - r_0 = \mu_{i,0} - \gamma_{a,i} \pi_0 - r_0 = \alpha \sigma_r^2 (x_{a,c,0} + x_{a,p,0}) + \alpha \gamma_{a,i} (\gamma_{a,c} x_{a,c,0} + \gamma_{a,p} x_{a,p,0} + \gamma_{a,s} x_{a,s,0}) \pi_0$$

for $i = c, p$, and

$$\mathbb{E}_0 [r_{a,s,1}] - r_0 = \mu_{s,0} - \gamma_{a,s} \pi_0 - r_0 = \alpha \sigma_g^2 x_{a,s,0} + \alpha \gamma_{a,s} (\gamma_{a,c} x_{a,c,0} + \gamma_{a,p} x_{a,p,0} + \gamma_{a,s} x_{a,s,0}) \pi_0,$$

where $\mu_{i,0} = 2y_{i,0} - E_0[r_1]$ denotes the expected return on a hypothetical long-term bond that is only exposed to interest rate risk but not the risk of the credit event, and $\mu_{s,0} = \bar{g} + \phi_r Z_{r,0} + \phi_\theta Z_{\theta,0} - p_{s,0}$ denotes the expected return on a hypothetical stock that is only exposed to dividend risk but not the risk of the credit event. Solving for all $x_{a,i,0}$ s and imposing market clearing, we obtain the following result (the proof, the exact form for the function $h(\cdot)$, and the coefficients are available upon request):

Lemma 1. *There exists an equilibrium in which risk premia on bonds and equity are characterized by*

$$\mu_{i,0} - r_0 = \psi_i h(\pi_0) \text{ for } i = c, p \text{ and } \mu_{s,0} - r_0 = \alpha \sigma_g^2 \frac{S_s}{2} + \psi_s h(\pi_0),$$

with

$$\psi_i = \frac{\gamma_{c,i}}{\gamma_{c,p} - \gamma_{c,c}} + \frac{\gamma_{p,i}}{\gamma_{p,p} - \gamma_{p,c}}, \text{ for } i = c, p, \text{ and } \psi_s = \frac{\gamma_{c,s}}{\gamma_{c,p} - \gamma_{c,c}} + \frac{\gamma_{p,s}}{\gamma_{p,p} - \gamma_{p,c}},$$

and the function $h(\pi_0)$ increasing in π_0 . Moreover, agents' positions in the two bonds can be written in the form

$$x_{c,c,0} = -x_{p,c,0} = \frac{1}{\alpha} [\psi_1 + \psi_2 h(\pi_0)] \text{ and } x_{p,p,0} = -x_{c,p,0} = \frac{1}{\alpha} [\psi_3 + \psi_4 h(\pi_0)],$$

with constants $\psi_j, j = 1, \dots, 4$. Given our assumptions on the γ parameters, we have $\psi_p > \psi_c > 0$, $\psi_s > 0$, and $\psi_2, \psi_4 > 0$.

The inequality $\psi_p > \psi_c$ means that the risk premium difference, $(\mu_{p,0} - r_0) - (\mu_{c,0} - r_0)$, increases in π_0 . Negative communication shocks increase the probability of the credit event, π_0 , and agents who suffer losses in case of the credit event will demand a higher risk premium on risky long-term bonds. However, as these losses are larger on peripheral bonds, the risk premium on peripheral bonds that compensate agents for holding them must increase more than on core bonds.

This extension has one more implication: The second set of inequalities, $\psi_2, \psi_4 > 0$, implies that $x_{c,c,0}$ and $x_{p,p,0}$ increase in π_0 . On negative news, when the perceived probability of the credit event increases, investors need a higher compensation to hold risky assets. Both agents would suffer larger losses on peripheral bonds conditional on breakup, so they want to sell (or short more) peripheral bonds and hold instead more core bonds – flight to safety/quality. Investors, however, are heterogeneous in the losses: peripheral agents dislike peripheral bonds relatively less compared to core agents. Thus, in equilibrium peripheral agents buy peripheral bonds from core agents, who instead increase their holdings in core bonds; on bad news about the future of the Eurozone (negative communication shocks) investors' sovereign holdings exhibit a higher home bias.

Our results on investors' home bias in response to news shocks is consistent with the large empirical literature that documents a home bias in sovereign bond holdings of Eurozone countries starting in 2009. In particular, banks in peripheral countries acquired only domestic government bonds while selling those from other Euro area sovereigns. During this period, peripheral countries' banks increased their sovereign bond holdings between January 2009 to end of 2014 from 5% of total bank assets to 13% (see Figure OA-9). Theories aiming to explain the increase in home bias by peripheral countries include risk-shifting theories (see, e.g., [Gennaioli, Martin, and Rossi \(2014\)](#)) and financial repression theories (see, e.g., [Becker](#)

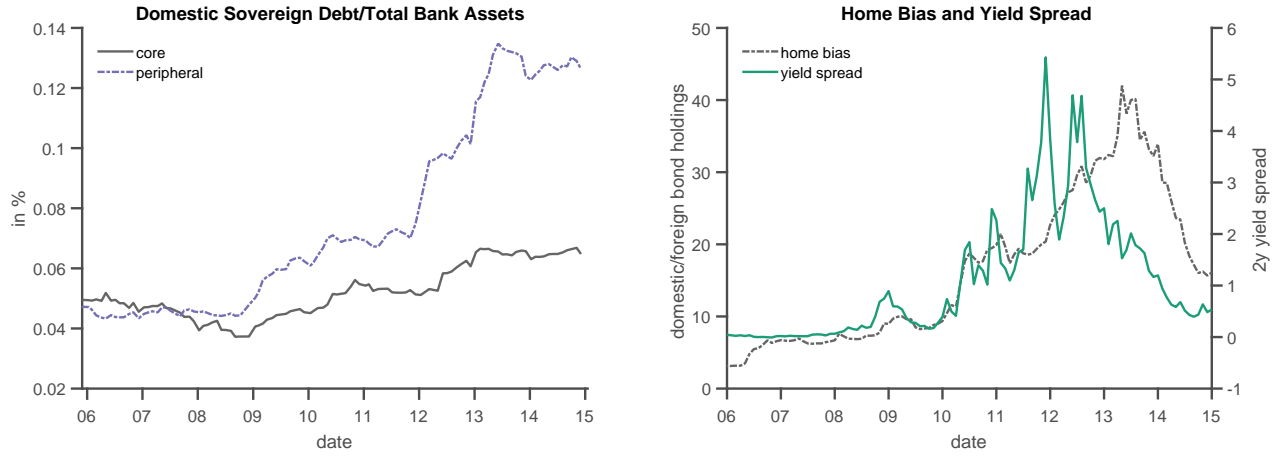


Figure OA-9. Home bias and the yield spread

The left panel plots the ratio of domestic sovereign bonds held by core and peripheral banks and total bank assets. The right panel plots the ratio of domestic and other Euro area bonds held by peripheral banks and the spread between two-year yields on peripheral and core countries.

and Ivashina (2018) and Chari, Dovis, and Kehoe (2016)), see, e.g., Farhi and Tirole (2018) for a literature review.

Combining Lemma 1 with the definition of bond and equity returns, (OA-7) and (OA-8), we obtain the following result:

Theorem 1. *In the model described above, date-0 equilibrium bond yields are given by*

$$y_{i,0} = \frac{r_0 + E_0[r_1] + \psi_i h(\pi_0)}{2} = \frac{1}{2} [(2 - \kappa_r) r_0 + \kappa_r \theta_0] + \frac{1}{2} \psi_i h(\pi_0), \quad (\text{OA-9})$$

and the date-0 equilibrium stock price is

$$p_{s,0} = \bar{g} + \phi_r Z_{r,0} + \phi_\theta Z_{\theta,0} - r_0 - \alpha \sigma_g^2 \frac{S_s}{2} - \psi_s h(\pi_0). \quad (\text{OA-10})$$

From here it is imminent that while the model-implied regression coefficients are different from those in Section 1 of the main paper, all our previous model predictions hold.

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