Corporate Debt Structure and Unconventional Monetary Policy in the United States

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Abstract

This paper evaluates the effects of unconventional monetary policy on the corporate debt structure in the United States. It does so by using a vector autoregression in which policy shocks are identified through a high-frequency external instrument. Our results consistently show that an expansionary policy shock (1) produces a substitution from bank loans to corporate bonds in the short run; (2) improves the functioning of bond markets and stimulates banks' reach-for-yield behavior; and (3) has positive effects on aggregate activity.

Keywords: Unconventional monetary policy, Vector autoregression, External instruments, Corporate debt structure, Bank lending, Bond issuance.

JEL Classification: E43, E44, E52.

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I Introduction

It has been well documented that the composition of credit between loans and bonds has profoundly changed since the bankruptcy of Lehman Brothers in the fall of 2008. Among others, Adrian, Colla, and Shin (2013) highlight a decline in bank loans to non-financial corporations and a simultaneous increase in the corporate bonds issuance. At about the same time, the Federal Reserve's Federal Open Market Committee (FOMC) lowered its traditional monetary policy instrument — i.e., the federal funds rate — to its effective lower bound. Paralyzed by this constraint, the FOMC began to implement "unconventional" monetary policy measures, which mostly involved large-scale asset purchases and forward guidance, to improve firms' financing conditions and stimulate the real economy.

The coincidence of both events (i.e., the substitution from loans to bonds and the implementation of unconventional monetary policies) motivates us to ask the following questions. What is the role played by exogenous non-standard policy shocks in the substitution from bank financing to bond financing? Did they affect aggregate activity through an easier access to corporate bond markets? Providing an answer to these questions is crucial not only to policymakers, but also to economic theorists engaged in building models from stylized facts.

In this paper, we answer these questions by employing a vector autoregression (VAR) in which unconventional monetary policy shocks are identified with high frequency external instruments, along the lines of Stock and Watson (2012) and Mertens and Ravn (2013). We focus exclusively on the period that follows the first Federal Reserve's announcement of large scale asset purchases and the end of 2016. We estimate our benchmark VAR model for the U.S. economy with output, consumer prices, the amount of bonds issued by firms, the bank loans to firms, and a measure of monetary policy stance (i.e., the five-year real interest rate). Our results consistently show that an unconventional monetary policy implies an increase in the corporate bond issuance, but a slight decline in bank loans to non-financial corporations in the short run. Such evidence contributes to the significant shift in the composition of corporate credit between loans and bonds observed since the Great Recession. In the long run, by contrast, both bank loans and bond issuance rise following a monetary expansion. On the macroeconomic side, unconventional monetary policy actions are followed by large movements in output and prices that similarly last for three years.

Then, we extend our VAR model to investigate the effectiveness of expansionary unconventional monetary policy on a wider set of bank-balance-sheet and bond-market variables to better understand the mechanism of monetary transmission. We find that a more accommodative monetary policy stance induces financial intermediaries to increase their holdings of risky securities strongly and persistently, in detriment of government bond holdings. At the same time, borrowing costs for non-financial corporations in bond market, reflected by credit spreads and the Gilchrist and Zakrajšek (2012) excess bond premium — a measure of risk appetite in the corporate bond market — fall sharply. This finding suggests that the Federal Reserve interventions have prompted financial intermediaries to search for higher returns, thus affecting asset prices.[1] In addition, these beneficial effects of the Federal Reserve actions on the corporate market are supportive of the "gap-filling" theory by Greenwood, Hanson, and Stein (2010); the Federal Reserve's purchases of long-term Treasury bonds induce a shortage of long-term bonds in the market. Firms fill part of this gap by increasing the private issuance of long-term assets which are absorbed by banks.

Finally, we conduct several robustness checks of the results to address three potential shortcomings. The first one consists in appropriately capturing the formation of expectations about the future monetary policy actions. Indeed, many observers have argued that these interventions were already expected by markets before the official FOMC announcements. As a robustness check, we follow the methodology of De Santis (2016) by using the number of Bloomberg news concerning the U.S. quantitative easing as a proxy for the market expectations about the program being implemented.[2] The second robustness check narrows down the event window from one day to 30 minutes around the announcement to account for a possibility that some other news occurred on the same day. Our third robustness check employs an alternative measure of monetary policy stance, namely the spread between 30-year mortgage-backed securities (MBS) yields and 30-year Treasury bond yields. Our baseline results are robust to these alternative specifications and confirm that the Federal Reserve's unconventional monetary policies altered the corporate debt structure in the United States.

This paper belongs to the strand of literature that studies the effects of the Federal Reserve's unconventional monetary policies on corporate bonds markets, such as Krishnamurthy and Vissing-Jorgensen (2011), Wright (2012), Gilchrist and Zakrajšek (2013), and Altavilla and Giannone (2016). These studies document that non-standard measures have

[1] Becker and Ivashina (2015) study the insurance companies' behavior between 2004-2010 and show that they reached for yield in the corporate bond market when choosing their investments. While the authors provide evidence that this behavior was most pronounced during economic expansion of 2004-2007, several quarters in post-crisis period exhibit the same pattern which leaves open the discussion on the role of unconventional monetary policy in the reach-for-yield behavior.

[2] De Santis (2016) identifies the impact of the Asset Purchase Programme by the European Central Bank on euro area sovereign yields using Bloomberg news in a panel error correction model framework. The intuition behind this approach is that more intense discussion about the quantitative easing indicates the greater expectations that such policy would be implemented.

significantly declined yields and risk premia on long-term corporate bonds during the financial crisis. Lo Duca, Nicoletti, and Vidal Martínez (2016) also provide evidence of an increased corporate bond issuance worldwide. What distinguishes our paper from the rest of the literature is its focus on the corporate debt structure.[3] Indeed, we provide evidence on the role of U.S. monetary policy in the firms' substituting away from bank lending towards bond issuance since the fall of 2008 by looking also on the bank lending side. Becker and Ivashina (2014), can be seen as complementary to our analysis, as they study conventional monetary policy shocks and find that a more restrictive stance pushes non-financial corporations towards bond markets.[4] We show here that unconventional monetary policy has an opposite effect on the substitution between loans and bonds through their impact on longer-term corporate bond markets conditions.[5]

Our paper is also related to an increasing literature on the financial and macroeconomic effects of unconventional measures in an identified VAR framework. Notable examples include Baumeister and Benati (2013), Gambacorta, Hofmann, and Peersman (2014) and Weale and Wieladek (2016). Our approach differs in the identification method. While the literature cited until now employs a "sign-restrictions" approach, we use an external instrument to identify exogenous policy shocks. Our approach is clearly motivated by the fact that movements in long-term interest rates, an indicator of unconventional monetary policy stance[6], are also driven by factors other than the behavior of the Federal Reserve. The introduction of an external instrument, correlated with policy shocks but orthogonal to other structural shocks, allows us to isolate what is identified as non-standard policies from what is not. The choice of the best policy indicator along with its instrument is based on a number of regressions in which the reduced-form residual of a particular policy indicator from the monthly VAR model is regressed on an instrument, namely daily changes of the indicator around FOMC announcements and several speeches of Federal Reserve Officials.

[3]Grjebine, Szczerbowicz, and Tripier (2014) show that the substitution of loans for bonds in recoveries is a regular property of business cycle. Moreover the economies with high bond share and important bond-loan substitution recover from the recessions faster.

[4]For the euro area, Altavilla, Darracq Paries, and Nicoletti (2015) show that negative bank loan supply shocks explain the substitution between bank loans and bonds issued by firms.

[5]Governor Jeremy C. Stein argues in his speech (Stein (2012)) that unlike conventional monetary policy, the unconventional measures work by moving term premia and therefore alter the transmission to the real economy in important ways, in particular by encouraging firms to issue long-term bonds and to increase investment.

[6]Swanson and Williams (2014) find that even 2-year Treasury yield was constrained by the zero lower bound since 2011.

The reminder of the paper is organized as follows. Section II explains our VAR methodology with external instruments. Section III justifies the choice of our measure of policy stance along with its high-frequency instrument. Section IV presents the results. Section V explores alternative monetary policy identifications. Section VI concludes.

II VAR with external instruments

VAR models have been widely employed to estimate the effects of conventional monetary policy shocks on aggregate activity. Notable examples include Leeper, Sims, and Zha (1996) and Christiano, Eichenbaum, and Evans (1999). Identified VAR modeling allows to analyze and interpret the data while avoiding potentially "incredible restrictions" on the structure of the economy. In this paper, we also use the VAR framework to better understanding the transmission mechanism of unconventional monetary policy. We employ a VAR model of the following form:

$$y_t = \sum_{i=1}^{\rho} B_i y_{t-i} + C_y + \upsilon_t, \qquad t = 1, \ldots, T, \tag{1}$$

where y_t is an $n \times 1$ vector of endogenous variables; C_y contains the constant terms; ρ is the number of lags; and T is the sample size. Wa assume that $\upsilon_t = A\varepsilon_t$ where ε_t has the following distribution:

$$p(\varepsilon_t) = \text{normal}(\varepsilon_t | 0, I), \tag{2}$$

with I is an $n \times n$ identity matrix, and normal$(x|\mu, \Sigma)$ denotes the multivariate normal distribution of x with mean μ and variance Σ. This implies that υ_t has the following distribution $p(\upsilon_t) = \text{normal}(\upsilon_t|0, AA')$. The variable ε_t represents all structural shocks hitting the economy. We partition it as follows $\varepsilon_t = [\varepsilon_t^1, \varepsilon_t^2]$ where ε_t^1 represents exogenous variations in the policy indicator, and ε_t^2 denotes the remaining structural shocks.

Until the end of 2008, the federal funds rate, which was generally used as policy indicator, was mainly controlled by the Federal Reserve. It implies that the use of a Cholesky decomposition was relevant to identify policy shocks. However, since this period, the zero lower bound on the short-term nominal interest rates and non-standard policy measures by the Federal Reserve bring the profession to use long-term interest rates, such as Treasury bonds yields, as a measure of policy stance. These rates are, however, not fully controlled by the U.S. central bank, as they can respond quickly to both changes in the behavior of the Federal Reserve and private sector. Thus isolating the role of the monetary policy is an empirical challenge for the recent period.

To overcome this difficulty, our approach to identification of unconventional monetary policy is based on the use of one external instrument z_t, along the lines of Stock and Watson (2012) and Mertens and Ravn (2013). The instrument must satisfy several critical assumptions in order to identify movements in the policy indicator that are due to purely exogenous unconventional monetary policy disturbances. The instrument must be correlated with the unconventional monetary policy ε_t^1 but uncorrelated with all other structural shocks ε_t^2. This assumption can be summarized as follows:

$$\mathrm{E}\left[z_t\varepsilon_t^1\right] = \psi \tag{3}$$

$$\mathrm{E}\left[z_t\varepsilon_t^2\right] = 0 \tag{4}$$

We use unexpected changes in various interest rates and asset returns on FOMC dates as potential instruments z_t. The choice of the best instrument z_t is motivated by the event-study finding in Section III.

The harshest critics of high-frequency identification of monetary policy would mention that FOMC announcements were not completely surprising to the public and numerous announcements were already anticipated by financial markets. Under these circumstances, it might be possible that $z_t = 0$ for a given month[7]. As a robustness check, we also employ market news, recorded by Bloomberg, as a monetary policy indicator along the lines of De Santis (2016). Such an indicator should, in principle, take into account market expectations. In Section V, we will show that our main conclusions remain unchanged.

We re-write the system in (1) in a more compact form. The model becomes as follows:

$$y_t = By_{t-1} + C_y + \upsilon_t, \tag{5}$$

where $B = [B_1 \dots B_\rho]$, and $y_{t-1} = [y_1 \dots y_\rho]'$. We introduce an observation equation, which relates our instrument to the structural shocks as follows:

$$z_t = [\psi \quad \mathbf{0}]\varepsilon_t + C_z + \Omega^{-\frac{1}{2}}u_t, \tag{6}$$

where $\mathbf{0}$ is an $1 \times (n-1)$ row of zeros, and C_z contains the constant term. This equation is directly based on the assumptions in (3) and (4). The observation equation can also directly relate the instrument to the reduced-form shocks as follows:

$$z_t = [\psi \quad \mathbf{0}]A^{-1}A\varepsilon_t + C_z + \Omega^{-\frac{1}{2}}u_t, \tag{7}$$

$$= [\psi \quad \mathbf{0}]A^{-1}\upsilon_t + C_z + \Omega^{-\frac{1}{2}}u_t, \tag{8}$$

$$= F\upsilon_t + C_z + \Omega^{-\frac{1}{2}}u_t, \tag{9}$$

[7] As mentioned in Rogers, Scotti, and Wright (2016), the fact that $z_t = 0$ for some months is not a problem as long as we observe some surprises around FOMC announcements.

with $F = [\psi \quad \mathbf{0}]A^{-1}$.

Using (5) and (9), we compact the overall system as:

$$\mathrm{E}\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \text{normal}\left(\begin{bmatrix} y_t \\ z_t \end{bmatrix} \middle| \middle| \begin{bmatrix} C_y + By_{t-1} \\ C_z \end{bmatrix}, \begin{bmatrix} (AA')^{-1} & \Gamma' \\ \Gamma & \tilde{\Omega} \end{bmatrix}\right), \tag{10}$$

where Γ is the variance-covariance matrix between the instruments and the forecast errors are as follows:

$$\Gamma = \mathrm{Cov}[z_t, \upsilon_t], \tag{11}$$
$$= FAA', \tag{12}$$
$$= [\psi \quad \mathbf{0}]A^{-1}AA', \tag{13}$$
$$= [\psi \quad \mathbf{0}]A'. \tag{14}$$

Following Mertens and Ravn (2013), we can now identify the parameters of the contemporeanous matrix A. We assume that $A = [\alpha^{[1]}, \alpha^{[2]}] = \begin{bmatrix} \alpha_{1,1} & \alpha_{1,2} \\ \alpha_{2,1} & \alpha_{2,2} \end{bmatrix}$ with $\alpha^{[1]} = [\alpha_{1,1}, \alpha_{2,1}]'$ and $\alpha^{[2]} = [\alpha_{1,2}, \alpha_{2,2}]'$. Using the definitions of Γ and the forecast errors, it follows that:

$$\begin{aligned} \Gamma &= \mathrm{Cov}[z_t, \upsilon_t], \\ &= [\psi \quad \mathbf{0}]A', \\ &= \psi\alpha^{[1]}, \\ &= [\psi\alpha_{1,1}, \psi\alpha_{2,1}]. \end{aligned}$$

Partitioning $\Gamma = [\Gamma_1, \Gamma_2]$, we can identify the contemporaneous matrix, A, as follows:

$$\begin{aligned} \alpha_{1,1} &= \frac{1}{\psi}\Gamma_1 \\ \alpha_{2,1} &= \frac{1}{\psi}\Gamma_2 = \alpha_{1,1}\left(\Gamma_1^{-1}\Gamma_2\right). \end{aligned}$$

After identifying the structural parameters, we can directly compute the impulse responses of y_t to the unconventional monetary policy shock ε_t^1 from the system (1).

To characterize the uncertainty of our results, we follow Drautzburg (2016) by employing modern Bayesian methods to estimate our VAR model. More specifically, we use a Gibbs-sampling procedure to alternately sample from conditional distributions, namely a normal posterior distribution and a wishart posterior distribution. Equation (10) corresponds to a SUR model, allowing us to employ a standard technique of inference reviewed in any Bayesian textbook. We vectorize the model (10) as:

$$Y_{\text{SUR}} = X_{\text{SUR}}\beta_{\text{SUR}} + \nu_{\text{SUR}}, \qquad \text{normal}(\nu_{\text{SUR}}|0, V \otimes I_T), \tag{15}$$

where

$$V = \begin{bmatrix} AA' & \Gamma' \\ \Gamma & \tilde{\Omega} \end{bmatrix}. \tag{16}$$

with $\tilde{\Omega} = \Omega + FAA'F'$ as the covariance-variance matrix of the external instrument. Under the flat prior $p(\beta) = \text{normal}(\beta|\bar{\beta}_0, N_0)$ and $p(V^{-1}) = \text{wishart}(V^{-1}|((\nu_0 S_0)^{-1}, \nu_0)$, where $\text{wishart}(x|S, n)$ is the wishart distribution with S as the scale matrix and n as the degree of freedom, we can employ the Gibbs sampler technique for simulations by alternately sampling from two conditional posterior distributions. For $i = 1, 2, \ldots, N_1 + N_2$,

1. Draw $\beta^{(i)}$ conditional on $V^{(i-1)}$:

$$\text{normal}\left(\beta^{(i)}|\bar{\beta}_T(V), (N_{XX}(V) + N_0)^{-1}\right), \tag{17}$$

   with $\bar{\beta}(V) = (N_{XX}(V) + N_0)^{-1}(N_{XY}(V) + N_0\bar{\beta}_0)$.[8]

2. Draw $V^{(i)}$ conditional on $\beta^{(i)}$:

$$\text{wishart}\left(V^{(i)}\middle|\frac{S_T(\beta)^{-1}}{\nu_0 + T}, \nu_0 + T\right), \tag{19}$$

   with $S_T(\beta) = \frac{1}{\nu_0+T}\begin{bmatrix}(Y - XB)' \\ (Z - 1_{T\mu_z'})'\end{bmatrix}\begin{bmatrix}(Y - XB) & (Z - 1_{T\mu_z'})\end{bmatrix} + \frac{\nu_0}{\nu_0+T}S_0$.
   Note that $S_T(\beta)^{-1}$, $N_{XX}(V)$ and $N_{XY}(V)$ are the posterior parameters.

3. Repeat (1) and (2) until the entire sequence ($N_1 + N_2$ draws) is simulated;

4. Keep the last N_2 draws in the sequence.

The results shown in Section IV are based on $10,000$ draws. We discarded the first ten percent draws as burn-in ($N_1 = 1,000$) so that to keep $N_2 = 9,000$ draws

By combining high-frequency identification with VAR models, our approach allows to trace out the dynamic effects (i.e., persistence and magnitude) of non stochastic shifts in unconventional monetary policy.

The next section aims at choosing our policy indicator along with its instrument to identify policy shocks.

[8] The posterior parameters $N_{XX}(V)$ and $N_{XY}(V)$ are defined as follows:

$$N_{XX}(V) = \tilde{X}'\tilde{X}, \qquad N_{XX}(V) = \tilde{X}'\tilde{Y}, \tag{18}$$

where $\tilde{X} = \left((U^{-1})' \otimes I_T\right)\begin{bmatrix} I_n \otimes X_y & \underset{T(n\rho+1)\times T}{\mathbf{0}} \\ \underset{T\times Tn}{\mathbf{0}} & X_z \end{bmatrix}$, $\quad \tilde{Y} = \left((U^{-1})' \otimes I_T\right)\begin{bmatrix} I_n \otimes Y & \underset{T(n\rho+1)\times T}{\mathbf{0}} \\ \underset{T\times Tn}{\mathbf{0}} & Z \end{bmatrix}$,
$X_y = [Y_{-1} \quad \ldots \quad Y_{-\rho} \quad \mathbf{1}_T]$, and $X_z = [\mathbf{1}_T]$.

III Policy indicator and instrument choice

In this section, we choose the best policy indicator along with its instrument to identify unconventional monetary policy shocks. First, we measure the financial markets reactions to the Federal Reserve's announcements using event-study regressions. Second, we examine the response of reduced-form residuals of policy indicators from the monthly VAR to potential instruments.

III.1 High-frequency identification

Unconventional monetary policies have different transmission channels than conventional monetary policy. They impact the long-term interest rates and credit spreads to much larger extent. The existing studies on the effects of the Federal Reserve's unconventional monetary policies approximate monetary policy shocks by the daily (or intradaily) changes in the long-term nominal Treasury yields and futures around FOMC meetings (e.g., Wright, 2012; Gilchrist, López-Salido, and Zakrajšek, 2015; Rogers, Scotti, and Wright, 2016). Indeed, the primary objective of the non-standard measures was to reduce the level of the yields of long-term safe assets. However, reducing the long term yields is not the only channel through which these policies affected the asset prices. For instance, Gagnon, Raskin, Remache, and Sack (2011) and Krishnamurthy and Vissing-Jorgensen (2011) show that MBS rates respond more than Treasury yields to the quantitative easing (QE) announcements. Rogers, Scotti, and Wright (2014) use the Italian-German sovereign spread changes around the European Central Bank (ECB)'s announcements as unconventional monetary policy surprises. We argue that the credit spread reaction on the days of FOMC meetings can be an independent measure of unconventional monetary policy surprises in the United States.[9]

The objective of this section is to determine the most relevant assets and their maturities to approximate the unconventional monetary policy stance and the corresponding shock. To do so, we conduct event-based regressions that evaluate the impact of announcements by the Federal Reserve on various markets. In modern financial markets the effect of an event should be reflected in asset prices over a short period of time so we consider here the daily changes in the interest rates.[10] We include 11 monetary policy announcements in our event-based

[9]We consider here all types of unconventional monetary policies, i.e. asset purchases and forward guidance, given that they were often announced on the same day.

[10]In Section V, we narrow down the event window to 30 minutes. There are pros and cons of narrowing the event window in case of unconventional monetary policy announcements. While this approach allows for a better isolation of monetary shock, it does not ensure that the news was fully incorporated into market

regressions analysis.[11] This exercise requires that the announcements be unanticipated by the market participants (MacKinlay (1997)). We define unexpected announcements based on the qualitative content of the news flow in the financial press that followed each measure. Table 3 presents the description of each event.

We estimate the following regressions:

$$\Delta y_t = \alpha + \beta\, UMP_t + \sum_{n=1}^{N} \psi_n \Delta S^M_{t-n} + \sum_{l=1}^{7} \psi_l D_{l,t} + \epsilon_t, \tag{20}$$

where UMP_t is a dummy equal to one on the days of unconventional monetary policy announcements; ΔS^M_{t-n} are lagged values of dependent variable included to correct for the auto-correlations of the residuals; $D_{l,t}$ are dummies for the day of the week (Monday, Tuesday...); α is the constant term; and ϵ_t is a stochastic error term. The dependent variable Δy_t is a 1-day change in corresponding interest rates. We use daily data sets from July 2, 2007 to December 31, 2016.[12]

We consider several policy indicators as dependent variables Δy_t, namely long-term Treasury yields, the real Treasury interest rates via the Treasury Inflation Protected Securities (TIPS) market, the corresponding breakeven inflation rates, the interest rate expectations, the term premium, and the MBS spread. For each series, we look at different maturities. Our procedure allows to disentangle the movements in Treasury yields that are due to (i) real rate expectations and inflation expectations; and (ii) short-term rate expectations and term premia. By looking at MBS spreads, we can also capture policy shocks that are not incorporated in the long-term Treasury yield movements.

Table 1 reports the estimation results. While the Federal Reserve's unconventional monetary policies reduced yields at all maturities, the strongest impact is noted on longer maturities (above 5 years). As the results indicate, the reduction of nominal rate is mostly due to real rate decrease. The 5-year and 10-year TIPS declined by 16 basis points (bp) while the decline of breakeven inflation compensation is mostly insignificant (only 2-year maturity goes down slightly, 4 bp, at the 10% significance level). These results are in line with Nakamura and Steinsson (2013) who show that asset purchases by the Federal Reserve worked mainly through real rate reduction.

Decomposing further the nominal rates of each maturity into future interest rates expectation and the term premia allows us to measure the reaction of each component to the

rates given the complexity of these new policies.

[11] We include the following announcement days: 2008-11-25, 2008-12-01, 2008-12-16, 2009-03-18, 2010-08-10, 2010-09-21, 2011-08-09, 2011-09-21, 2012-01-25, 2012-09-13, 2012-12-12 - see Table 3 for the description.

[12] Please refer to Appendix A.1 for the data description and sources.

Federal Reserve's announcements. The expectations component is reduced for almost all maturities, although the size of this reduction is relatively small (3-4 bp). The reduction of term premium component is much stronger, especially at medium- and long-term maturities (10 bp and 12 bp for respectively 5- and 10-year maturities). The stronger reaction of the term premium component is consistent with the duration channel and safety channel of asset purchases. Finally, Table 1 shows that the spread between the MBS yields and the Treasury yields at maturity of 30 year diminished by 21 bp following the Federal Reserve's announcements.

Overall, our results suggest that the Federal Reserve's announcements significantly lowered the longer maturity yields in various markets. The next section provides further evidence that allows us to choose the best policy indicator along with its instrument.

III.2 The choice of policy indicator and instrument in the VAR

Identifying the markets and maturities that respond the most to the Federal Reserve's announcements allows us to propose the potential indicators of monetary policy stance that we could include in our VAR analysis. We now look closer at the relevance of each potential policy indicator and the instrument in the monthly VAR.

To this purpose, we adapt here the Gertler and Karadi (2015)'s methodology to make it suitable for unconventional monetary policy environment. The authors study macroeconomic effects of conventional monetary policy shocks by approximating the monetary policy stance with the one-year nominal interest rate. They find that the best instrument for the one-year nominal interest rate are the movements in the three month ahead fed funds future rate around the FOMC announcements. Since we study the unconventional monetary policy period, we consider longer-term rates and spreads to be more representative of the stance of monetary policy.

We employ a unified VAR framework with four lags and consisting of the following six endogenous variables: interpolated monthly real GDP (gdp_t), the core personal consumption expenditure price index (p_t), the Gilchrist and Zakrajšek (2012)'s excess bond premium (ebp_t), the six-month moving average of the amount of bonds issued by non-financial corporations (b_t), bank loans to non-financial corporations (l_t), and a policy indicator. To find the best policy indicator along with its instrument for identifying policy shocks, we proceed as follows. First, we estimate the above-mentioned VAR model with different policy indicators. Second, for each VAR estimation, we compute the reduced-form residuals of the policy indicator. Third, we regress the reduced-form residuals of a given policy indicator on the preselected instrument. Fourth, we compare their R^2 and F-statistics across regressions. Note also that the VAR models are estimated over the sample period from June 2008 through August 2016. Given that we impose a four-period lag, all calculations described in this section are for the period October 2008 through August 2016. Appendix A provides a detailed description of the data. We measure all variables in log units, except for the excess bond premium, the policy indicator and the instrument.

Based on our event-based regression results, we consider nominal and real Treasury yields at the maturities of 5 and 10 years, as well as the 30-year MBS spread, as potential policy indicators. We use the daily variations in the same interest rates on the Federal Reserve's announcement days as potential instruments.[13] The movements in the interest rates on FOMC dates reflect revisions in beliefs about the future path of short-term rates and the expected risk premia. Measuring this surprise allows us to isolate the portion of the innovation in the monetary policy indicator coming from VAR that is due to the exogenous policy surprise. In the VAR exercise we do not need to discriminate between "surprising" and "unsurprising" announcements as we do not rely on dummy variables to define the unanticipated component. We use instead the interest rates changes on announcement days to capture the surprises. This is why we consider all FOMC meetings and several speeches.[14] If the announcement was not surprising, the interest rate change would automatically be zero.

Table 2 shows the regression results. Each column represents a regression of the policy indicator residual on the corresponding instrument. Stock, Wright, and Yogo (2002) recommend a threshold of ten for the F-statistic from the first-stage regression to be confident that weak instrument problem is not present. All of our Treasury instruments have statistically high F-statistic but the 5-year real interest rate stands out with the value of 33.11. Note also that the F-statistic associated with the 30-year MBS spread is above ten, meaning that it is also a potential candidate for representing monetary policy stance.

[13]Our VAR has a monthly frequency, thus we need to turn the daily financial markets surprises on FOMC days into monthly average surprises. The day of announcement is important feature as an announcement made on November 25 would affect only last few days of the month, while the announcement on December 1 would affect the whole month. To be sure to capture all the information in a given month we follow Gertler and Karadi (2015) procedure and attribute weights to each surprises according to the day of the month it occurred on. For instance, in case of the 25-November surprise 5/30 would be attributed to the month of November and the remaining 25/30 to December.

[14] We follow Rogers, Scotti, and Wright (2014) and consider all FOMC announcements during the estimation period, as well as the following communications: announcement of LSAP-I on 2008-11-25 and B. Bernanke's speeches and testimony containing information about future policy actions: 2008-12-01, 2010-08-27, 2010-10-15, 2011-08-26, 2012-08-31, 2013-05-22.

Overall, our results support the 5-year real interest rate as an indicator of monetary policy stance along with its daily changes as an external instrument in the VAR analysis. In a robustness check, we will, however, show that our results are maintained when choosing another policy indicator, namely the 30-year MBS spread.

IV Empirical results

In our benchmark specification the model has four lags and includes the above-cited six endogenous variables. Based on the previous findings, we use the five-year real interest rate approximated by TIPS as a monetary policy indicator and we define our instrument z_t as the changes in the five-year TIPS rates in a daily window around the Federal Reserve's announcements.

In the figures, we report the deviation in percent for the series entered in log-levels, and the deviation in percent points for the remaining variables. For each panel, we report the median in solid black line and the 68% error bands in dotted black lines.

Figure 1 reports the impulse responses of endogenous variables to an unconventional monetary policy shock. After a negative innovation in the policy indicator, interpreted as an expansionary monetary policy shock, the output increases immediately, reaches its maximum after $12 - 18$ months, then begins to decline in a steady manner. Note that the 68 percent error bands lie with the positive region, making the estimate robust. Prices follow a similar pattern to output, with a steady increase until the 10th month. Surprisingly, their magnitudes are also similar.[15] Indeed, a one standard deviation monetary policy shock that moves down the 5-year Treasury rate by about 25 basis points increase both output and prices by 0.40 percent. This similitude is slightly different from what we observe on the real effects of standard monetary policy widely discussed in the literature, which shows that the response of output is usually larger than that of prices. See, for example, Leeper, Sims, and Zha (1996) for further discussion.

Looking at the financial variables, the expansionary shock induces a 15 basis point decline in the excess bond premium, which then returns to its original level over the course of two years. A decline in the excess bond premium represents an increase in investors' risk appetite in the corporate bond market. The firms' borrowing costs diminish, and consequently the

[15] Weale and Wieladek (2016) employ a VAR with zero-sign restrictions and also obtain comparable responses of output and prices. They find that an asset purchase announcement of 1% of gross domestic product (GDP) leads to a statistically significant rise of 0.58% and 0.62% rise in real GDP and CPI in the United States.

level of production rises, as described previously. Finally, the structural shock seems to push bonds and loans in opposite directions. More specifically, the amount of corporate bonds issuance increases dramatically to reach its maximum quickly (i.e., about 5 percent increase). By contrast, the amount of bank loans declines slightly in the short run (i.e., until the first six months), and then increases persistently in the long run.

Overall, these results imply that expansionary unconventional monetary policy affects the real economy through a substitution from loans to bonds. The objective of the next section is to provide a better understanding of these monetary transmission channels. We argue that this effect is specific to non-standard measures given their influence on corporate bond markets conditions and banks' reach-for-yield behavior.

IV.1 Further inspection in the corporate bond markets and banks' balance sheets

In this section, we attempt to understand what happens in the corporate bond markets and bank balance sheets after a monetary policy shock in more detail. We first look at the responses of a number of bond rates and bond spreads that are not observed in the benchmark model. In a next step, we examine the effect of the shock on other bank balance sheet positions, such as risky and non-risky securities holdings. To do so, we augment our benchmark VAR model as follows:

$$\begin{bmatrix} y_t \\ y_t^* \end{bmatrix} = \begin{bmatrix} B & 0 \\ C & D \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{t-1}^* \end{bmatrix} + \begin{bmatrix} A & 0 \\ E & F \end{bmatrix} \begin{bmatrix} \varepsilon_t \\ \varepsilon_t^* \end{bmatrix}, \tag{21}$$

with y_t^* is a vector of additional variables; y_{t-1}^* consists of the lagged additional variables as follows $y_{t-1}^* = [y_1^* \ldots y_\rho^*]'$; ε_t^* is a multivariate normal distribution. The system (21) means that the inclusion of additional variables does not affect the block of endogenous variables of the benchmark model. As a result, the estimated matrices, A and B are not altered by the inclusion of "periphery" variables. This "near-VAR" framework follows closely Zha (1999) and Peersman and Smets (2003). It is essential to prevent over-parameterization, which could makes the estimation of parameters unreasonable with our short sample. Note also that we do not impose any "incredible restrictions" to let the data speak (See Sims, 1980). For each estimation, we include until two variables in y_t^*. As previously, we estimate our near-VAR models by using a Gibbs-sampling procedure to generate draws from the posterior distribution. We discard the first $1,000$ draws as "burn-in" and then keep the $9,000$ remaining draws.

We first look at the dynamic effects of an unconventional monetary policy shock on the corporate bond yields and spreads, as shown in Figure 2. For each estimated model, we introduce two series, along the columns of the figure, into y_t^*. That is, the two variables of a single column represent an estimation of the near VAR model. The first column includes the standard corporate risk premia — the difference between Moody's BAA corporate bond yield and Moody's AAA corporate bond yield — and the Gilchrist and Zakrajšek (2012) spread[16]. The two panels of the first column of the figure show a large decline in credit costs, with a stronger effects on the Gilchrist and Zakrajšek (2012)'s spread. The decline in this spread indicates that corporate bond yields diminish more than the corresponding sovereign yields. It can be due to increased risk appetite in the corporate bond market as shown by the excess bond premium response in our benchmark specification and/or by the expected corporate default risk. It also in line with the "default risk channel" of non-standard policies that predicts that the purchases of long-term Treasuries and agency MBSs should boost the economy, implying a fall in the default risk of corporations and thus a decline in corporate bond spreads (Krishnamurthy and Vissing-Jorgensen, 2011). The second column of Figure 2 reports the responses of medium-term and long-term corporate-sovereign spreads and confirms the previous result. As in case of Gilchrist and Zakrajšek (2012) spread, these risk premia are particularly sensitive to our policy shock, with the corresponding declines of 10 and 5 basis points.

The decline in the Moody's BAA-AAA corporate spread indicates that the lower-rated bonds yields diminished more than the higher-rated bonds yields. The last column of the Figure 2 shows indeed that both types of yields decrease but the decline is stronger for the BAA-rated bonds. It is consistent with the argument that the expectation of low nominal interest rates creates incentives for yield-oriented investors to take additional risk, increasing the demand and reducing the risk premia for higher-yielding debt (See Hanson and Stein, 2015; Foley-Fisher, Ramcharan, and Yu, 2016).

The improved conditions on the corporate bonds markets explain the spike in corporate bond issuance that we found in the previous section. However, we are also interested in investigating the bank lending side of the bond-loan substitution. To that aim we analyze the response of other bank balance sheet positions after an expansionary unconventional monetary policy shock. We consider in particular the response of the securities held by

[16]Gilchrist and Zakrajšek (2012) construct their spread from the market price of bonds issued by U.S. non-financial corporations. The authors take the difference between corporate bonds and government securities of comparable maturity to obtain each corporate bond spread. Then, they weigh all credit spread by their corresponding volumes.

banks, as shown in Figure 3. As a first step, we include only the total amount of securities held by banks into y_t^*. Looking at the response (i.e., left panel), one can see that securities holdings quickly rise and stay persistently above its pre-shock level. We now assess whether the shock influences differently risky and non-risky securities. To do so, we remove the total amount of securities from y_t^* and we introduce the amount of government (safe) and non-government (risky) securities held by banks. The two right panels reveal that the holdings of government securities remain almost unaffected while financial intermediaries seem to accumulate riskier assets following the expansionary monetary policy shock. Such a pattern confirms the so-called "portfolio-balance" effect, which is one of the desired objectives of the Federal Reserve. By providing large amount of liquidity, the asset purchase programmes give incentives to investors who sold Treasuries to the central bank to rebalance their portfolio with riskier assets, which in turn would drive up the prices of these assets. Our results suggest that the non-standard measures stimulated banks' "reach for yield" behavior. In the short-run they substituted away from government bonds towards more risky securities, and in the long-run they increased lending to non-financial corporations.

Our results are also consistent with the "gap-filling" theory by Greenwood, Hanson, and Stein (2010). When the central bank purchases long-term government bonds, there is a lack of long-term bonds in the market. Acting as macro liquidity providers, the firms fill the gap by issuing more long-term bonds to meet the demand for long-term assets.

IV.2 Wider set of macroeconomic variables

In the previous section, we have documented that the Federal Reserve has a significant effect on the corporate debt structure. We have also reported that the central bank stimulates economic activity and inflation. It might be useful to take advantage of the new high-frequency identification suited for unconventional monetary policy to investigate its impact on a wider set of macroeconomic variables.[17] As mentioned previously, the degrees-of-freedom problem prevents us from the inclusion of additional variables in our benchmark model. Therefore, we follow the previous approach by adding the macroeconomic aggregates as periphery variables in the near VAR model.

Figure 4 characterizes the dynamic effects of policy shocks on a wider range of economic variables. As before, each column refers to a specific estimation of the model. Looking at the

[17] The existing studies either evaluate the macroeconomic impact of standard monetary policy using the high-frequency instrument up to two years (Gertler and Karadi (2015) or used longer-maturity instrument to study the effects on the financial markets (Wright (2012), Rogers, Scotti, and Wright (2016)).

first column, durable consumption and non-durable consumption increase to reach the peak after 10 months and then return to the pre-shock level in a steady manner. Interestingly, the effects seem to be more persistent on durable consumption than on non-durable consumption. The estimates further show that the effects of non-standard policy shocks are important for residential and non-residential investment (i.e., the second column), with a higher impact on the former. Finally, there is also evidence that Federal Reserve interventions have positive effects on labor markets (i.e., the third column). Indeed, the unemployment rate falls by 0.13 percent while the number of employees increases persistently in response to a policy shock.

Overall, our findings indicate that U.S. unconventional monetary policy had powerful effects on economic activity. The behavior of the economy shown in Figures 1 and 4 is consistent with a number of studies analyzing the macroeconomic effects of U.S. unconventional monetary policy. Notable examples include Chen, Cúrdia, and Ferrero (2012), Baumeister and Benati (2013), Gambacorta, Hofmann, and Peersman (2014), and Del Negro, Eggertsson, Ferrero, and Kiyotaki (2017).

V Robustness Analysis

We test the robustness of our results by introducing three main changes to our baseline specification. First, we identify policy shocks using intraday changes in the instrument. Second, we examine whether the main results change when using another indicator of unconventional monetary policy. Third, we use market news as an external instrument. For each robustness exercise, we reestimate the VAR model with the new specification. The results of this section are reported in Figure 5. We only report key financial variables, namely the excess bond premium, bonds issued by non-financial corporations and bank loans.

V.1 Monetary policy shocks identified with intraday data

Our identification is based on the use of daily changes in interest rates around the Fed's announcements as an instrument. Gürkaynak, Sack, and Swanson (2005) mention that the use of a daily frequency might be potentially problematic since daily changes in interest rates around FOMC meetings might also reflect the Federal Reserve's accommodation of the Bureau of Labor Statistics employment report, which sometimes releases on the same day as FOMC meetings.

To address this potential issue, Gürkaynak, Sack, and Swanson (2005) propose to use intraday data in order to identify movements of assets prices that are uniquely due to monetary policy announcement. We follow this approach to construct our monetary policy instrument based on the changes in five-year real Treasury rate around the Federal Reserve's announcements. More specifically, monetary surprises are defined by a narrow 30-minute window around the announcements; i.e., we take changes in yields from 10 minutes before FOMC meeting to 20 minutes after the announcement release.[18] By focusing on a higher-frequency identification, we hope to purge our instrument from non-policy noise.

As shown in the first column of Figure 5, our results are not sensitive to a narrower window.[19] In the first periods, bond issuance increases rapidly while the bank loans do not react which leads to a shift in the corporate debt structure. Such a pattern confirms our earlier findings obtained with the daily surprises.

V.2 MBS spread as policy indicator and instrument

In section III, we have tested the relevance of several interest rates as a measure of policy stance. Although it has been argued that the best policy indicator was the five-year real interest rates (TIPS) along with its daily changes as instrument, the MBS spread and its daily changes on announcement days have also good explanatory power. The choice of such a variable is also justified by the massive purchases of MBS on several occasions during the Great Recession. The interventions in MBS markets have played a crucial role in driving down MBS yields relative to Treasury yields of the same maturity. Say it differently, MBS spread may also be a good measure of policy stance.

We evaluate the relevance of MBS spread as policy variable by reestimating our benchmark model with 30-year MBS spread as a monetary policy indicator and daily changes of this spread around the Federal Reserve's announcements as instrument. The second column of Figure 5 reports the results from this exercise. The impulse responses of the excess bond premium and bond issuances remain very similar to those reported in section IV. That is, excess bond premium declines quickly, while the quantity of bonds issued by firms rises rapidly to reach its peak in the third month after the initial shock. Interestingly, the bond issuance remains positive also in a longer run, even though at the lower level than at the impact. The decline in the bank loans in the short run is more pronounced, and there is no significant increase in the long run. The effects on lending are different from what we observe

[18] We thank Refet Gürkaynak for sharing the data on intraday monetary policy surprises.

[19] Gürkaynak, Sack, and Swanson (2005) compare daily and intradaily monetary policy surprises and also find that the surprise component of monetary policy announcements can be measured very well using daily data.

in our benchmark model, in which bank loans decline slightly in the short run but increase in the longer run. This might be due to fact that monetary policy surprises approximated by MBS spread reduction increase to larger extent the banks' reach-for-yield behavior and stimulate banks' risky securities holdings at the expense of making loans. However, these results confirm our main finding that an expansionary unconventional monetary policy shock involves a shift in the composition of the debt structure between loans and bonds.

V.3 Bloomberg news as an external instrument

Many commentators have argued that the Federal Reserve's announcements during the Great Recession were to some extent expected by markets. Indeed, some of the interventions were communicated to financial markets before the official Federal Reserve's announcement. This suggests that high-frequency surprises around the announcements could be approximately equal to zero for some dates and that the impact of the Federal Reserve interventions might be underestimated. As an example, in a December 1, 2008 speech, the former chairman of the Federal Reserve, Ben Bernanke, indicated that the Federal Reserve "could purchase longer-term Treasury securities... in substantial quantities" in order to restore financial stability. The speculation about the possibility of a QE following this statement was growing and thus, large movements were observed in U.S. stock and bond markets. To cope with this issue, we already included in our benchmark specification the major speeches and testimonies of the Fed's officials that are known to announce informally certain unconventional monetary policy actions in addition to FOMC official announcements.[20]

In this section, we use the number of Bloomberg news concerning the US quantitative easing as a proxy for the market expectations about the program being implemented. We follow the approach of De Santis (2016) who identifies the impact of the ECB Asset Purchase Programme on euro area sovereign yields using Bloomberg news in a panel error correction model framework. More specifically, we construct a new series using the number of references to QE from Bloomberg news. For each month, we take the sum of all Bloomberg news mentioning the following words: "Bernanke, QE or quantitative easing, and United States". The idea behind this approach is that more intense discussion about the quantitative easing indicates the greater expectations that such policy would be implemented. In our VAR model, we use this indicator as an external instrument, while keeping the five-year real interest rate as policy indicator. In order not to confuse the QE expansion and retraction, we use the Bloomberg news only until the Bernanke's "tapering" speech of May 2013.

[20]See footnote 14.

The results, reported in the third column of Figure 5, are not affected. We still observe a decline in borrowing costs, reflected by the fall in the excess bond premium. In the short run, non-financial corporations have substituted from bank loans to bonds. Under this specification that takes into account market expectations, the issuance of bonds is even higher than under our benchmark specification, with an 10 percent increase in the short run. Twelve months after the initial shock, bank loans rise smoothly and steadily to reach a one-percent increase, then remain at that level before returning to their trend.

VI Conclusion

Many studies have documented that there has been a shift in the corporate debt composition between bank loans and bonds since the fall of 2008 in the United States. Several observers have suggested that the Federal Reserve, through the implementation of unconventional monetary policy, has played a role in this shift. To assess this concern, we have examined the effects of monetary policy shocks on the substitution between bank financing and bond financing using a VAR model identified with an external instrument. We have shown empirically that a more accommodative monetary policy stance contributes to the shift in the corporate debt composition from bank loans to bonds. We have further documented what happens in the corporate bond market. Unconventional monetary policies reduce yields and spreads on corporate bonds and boost investors' appetite for risky securities.

Overall, our findings suggest that further empirical research on unconventional monetary policy and its effects on the structure of corporate debt is crucial in order to better understand the mechanism of monetary transmission to the real economy when short-term interest rates are at zero. From a theoretical perspective, modeling such patterns is also an interesting future research topic.

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A Data

A.1 Event Study Data

In the event-based regressions, we use daily data from July 2, 2007 to December 31, 2016. Treasury rates and MBS rates come from Datastream, TIPS and inflation compensation from Gürkaynak, Sack, and Wright (2010)[21] and term premium and risk neutral yields from Adrian, Crump, and Moench (2013)[22].

A.2 VAR Data

All data are organized monthly from June 2008 to October 2016. Most data comes from Federal Reserve Economic Database (FRED).

- gdp_t: output is the real interpolated GDP (GDPC1). Source: FRED. The Chow and Lin (1971) procedure is used to interpolate the real quarterly GDP.
- p_t: prices are the monthly consumer price index (CPI). Source: FRED.
- r_t: the real five-year Treasury yield (TIPS). Source: Gürkaynak, Sack, and Wright (2010);
- b_t: the six-month moving average of the amount of bonds issued by non-financial corporations. Source: Board of Governors of the Federal Reserve System;
- l_t: bank loans to non-financial corporations. Source: Datastream;
- ebp_t: the excess bond premium. Source: Gilchrist and Zakrajšek (2012);
- mbs_t: mortgage-back securities; Source: Datastream.

For inference, we use the natural log of output. Our interest rate variables remain unchanged.

[21] Dataset available here `https://www.federalreserve.gov/pubs/feds/2008/200805/200805abs.html`.

[22] Dataset available here `https://www.newyorkfed.org/research/data_indicators/term_premia.html`.

B Tables

Table 1: Financial Markets Responses to UMP announcements

Dependent variables	Coefficient	Standard error	R-squared
2y Treasuries	-0.06***	0.02	0.02
5y Treasuries	-0.14***	0.04	0.03
10y Treasuries	-0.15***	0.04	0.03
30y Treasuries	-0.10***	0.03	0.02
2y TIPS	-0.11***	0.04	0.05
5y TIPS	-0.16***	0.04	0.05
10y TIPS	-0.16***	0.04	0.04
2y Break-evens	0.04*	0.02	0.07
5y Break-evens	0.02	0.02	0.04
10y Break-evens	0.00	0.01	0.02
2y Interest rates expectations	-0.03*	0.02	0.01
5y Interest rates expectations	-0.04**	0.02	0.01
10y Interest rates expectations	-0.04**	0.02	0.01
2y Term premium	-0.04***	0.01	0.01
5y Term premium	-0.10***	0.03	0.03
10y Term premium	-0.12***	0.04	0.02
15y MBS Spread	-0.06*	0.03	0.01
20y MBS Spread	-0.11***	0.04	0.03
30y MBS Spread	-0.21***	0.07	0.05

Note: This table presents the impact of unconventional monetary policy announcements on interest rates and their components (nominal rates, TIPS, break-even inflation, interest rate expectations, term premium and MBS spreads). Each estimate comes from a separate regression of the general form: $\Delta y_t = \alpha + \beta UMP_t + \sum_{n=1}^{N} \psi_n \Delta S^M_{t-n} + \sum_{l=1}^{7} \psi_l D_{l,t} + \epsilon_t$ where UMP_t is a dummy equal to one on the days of unconventional monetary policy announcements (2008-11-25, 2008-12-01, 2008-12-16, 2009-03-18, 2010-08-10, 2010-09-21, 2011-08-09, 2011-09-21, 2012-01-25, 2012-09-13, 2012-12-12); The dependent variable Δy_t is a 1-day change in corresponding interest rate of maturity between 2 and 30 years. We use daily data from July 2, 2007 to December 31, 2016. OLS estimation with standard errors adjusted for heteroskedasticity and autocorrelation. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Effects of high-frequency instruments on the first stage residuals of the VAR

	Nom_5y	Nom_10y	Real_5y	Real_10y	MBS Spread_30y
S_Nom_5y	0.860***				
	(0.194)				
S_Nom_10y		0.769***			
		(0.205)			
S_Real_5y			1.256***		
			(0.218)		
S_Real_10y				0.839***	
				(0.188)	
S_MBS Spread_30y					0.557***
					(0.154)
Observations	95	95	95	95	95
R-squared	0.175	0.132	0.263	0.177	0.123
F test model	19.75	14.10	33.11	20.01	13.03

Note: This table presents the OLS regressions of first stage VAR residuals on monetary policy surprises. Dependent variables: monetary policy indicator residuals from six-variable VAR including output, CPI, Excess Bond Premium, bank lending to firms, corporate bond issuance and monetary policy indicator (one at a time): 5-year and 10-year Treasury rates (respectively Nom_5y and Nom_10y), 5-year and 10-year TIPS rates (respectively Real_5y and Real_10y) and 30y MBS spread. Independent variables: mensualized daily surprises around monetary policy announcements in 5-year Treasury rate (S_Nom_5y), 10-year Treasury rate (S_Nom_10y), 5-year TIPS (S_Real_5y), 10-year TIPS (S_Real_10y) and 30y MBS spread (S_MBS Spread_30y). We use monthly data data from October 2008 to August 2016. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

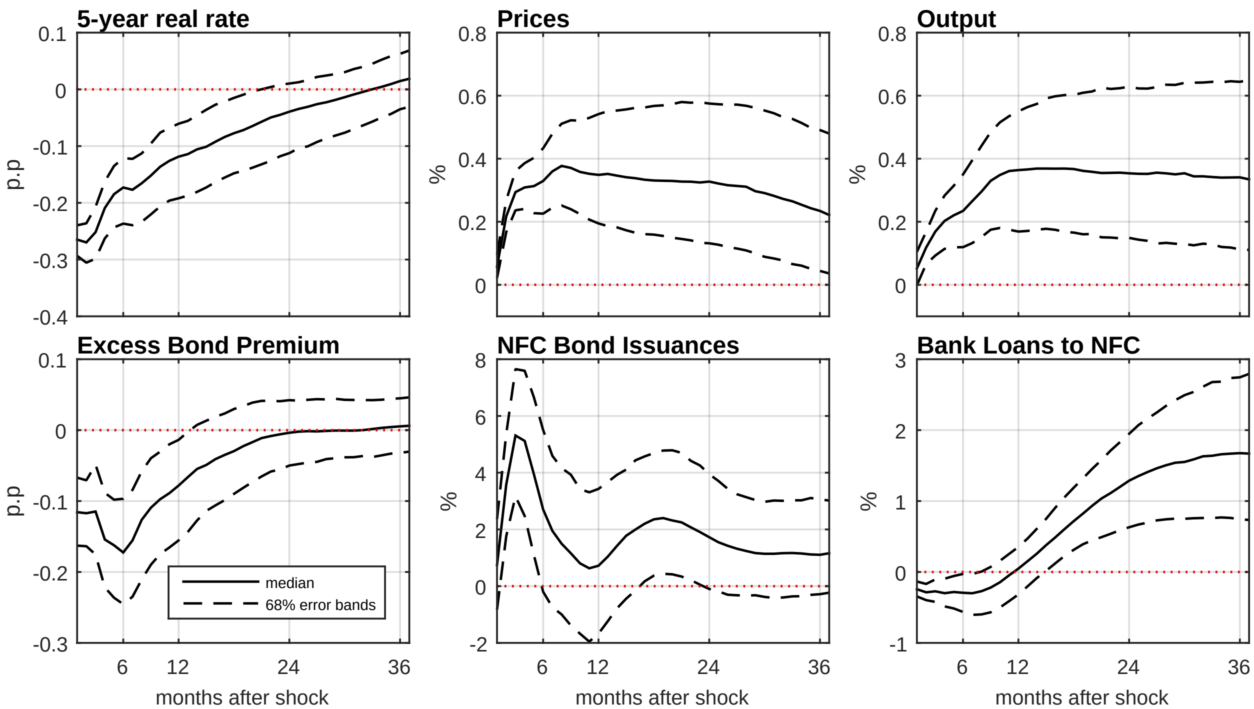
Table 3: Event-based regressions: monetary policy announcements

Date	Monetary Policy Announcement	Press comments
25-Nov-08	Announcement that starts LSAP-I.	Reuters, 25 November 2008 'Global Markets-World stocks rise after Fed programme": "World stocks rose more than one percent on Tuesday after the Federal Reserve unveiled a programme to buy mortgage and consumer-related securities".
1-Dec-08	B. Bernanke's speech indicating potential purchases of Treasury securities.	Financial Times, 1 December 2008 "Data signal deep global downturn": "Mr Bernanke surprised the bond market by saying the central bank may purchase "substantial quantities" of US Treasuries in the open market".
16-Dec-08	Target federal funds is lowered to its effective lower bound; Fed "evaluates" the benefits from purchasing longer-term Treasury securities; first reference to forward guidance.	Financial Times, 17 December 2008 "Fed Reserve decision catches markets by surprise".
18-Mar-09	Announcement to purchase Treasuries and increase the size of purchases of agency debt and agency MBS; also, first reference to extended period in the forward guidance.	Financial Times, 18 March 2009, "Federal Reserve plan stuns investors": "The Federal Reserve on Wednesday stunned investors by announcing plans to buy $300bn".
10-Aug-10	Announcement that starts LSAP-II.	Reuters, 11 August 2010, "Treasuries-Bonds jump on Fed's purchase plan, lower stocks": "The Fed's surprise announcement on Tuesday that it will buy Treasuries (...)".
21-Sep-10	Announcement reaffirming the existing reinvestment policy.	Reuters, 22 September 2010, "Treasuries-Bond rally on Fed easing hopes": "Yields on benchmark U.S. Treasuries fell to their lowest levels in three weeks on Wednesday as prices extended a rally spurred on Tuesday when the Federal Reserve raised the prospect of more quantitative easing if needed to support the economy".
9-Aug-11	First "calendar-based" forward guidance.	Reuters, 9 August 2011, "Fed to keep rates low for two years, stocks jump": "Financial markets, hungry for support from the Fed (...), were jolted by the news".
21-Sep-11	Announcement of the Maturity Extension Program (MEP) and of the reinvestment of principal payments from the Fed's holdings of agency debt and agency MBS in agency MBS.	FT Alphaville, 21 September 2011, "A few more analyst reactions to the FOMC statement": "given the unexpected decision to reinvest MBS and agency debt proceeds into MBS"; "A rough estimate from the US rates strategy team is that this operation by the Fed will take out upwards of $500Bn 10yr equivalents of duration risk from the market... So, this operation by the Fed was clearly a surprise".
25-Jan-12	Second "calendar-based" forward guidance.	Financial Times, 25 January 2012, "Treasuries rally on rates outlook": "the US Federal Reserve surprised markets halfway through the global session by saying benchmark interest rates would remain "exceptionally low until at least late 2014".
13-Sep-12	Third "calendar-based" forward guidance. In addition, first forward guidance regarding the pace of interest rates after lift-off and announcement of LSAP-III.	Financial Times, 13 September 2012, "Fed launches QE3 - Financial Times": "The Federal Reserve today made a dramatic step forward in its attempt to revive the US economy".
12-Dec-12	Announcement of an increase in LSAP-III; first "threshold-based" forward guidance.	Reuters, 12 December 2012, "Treasuries-Prices slip as Fed announces new buying program": "The bigger surprise for the bond market was the forward guidance, which changed from a calendar-based one to one based on economic thresholds".

Note: This table presents the 11 monetary policy announcements used in the event-based regressions in Section III.

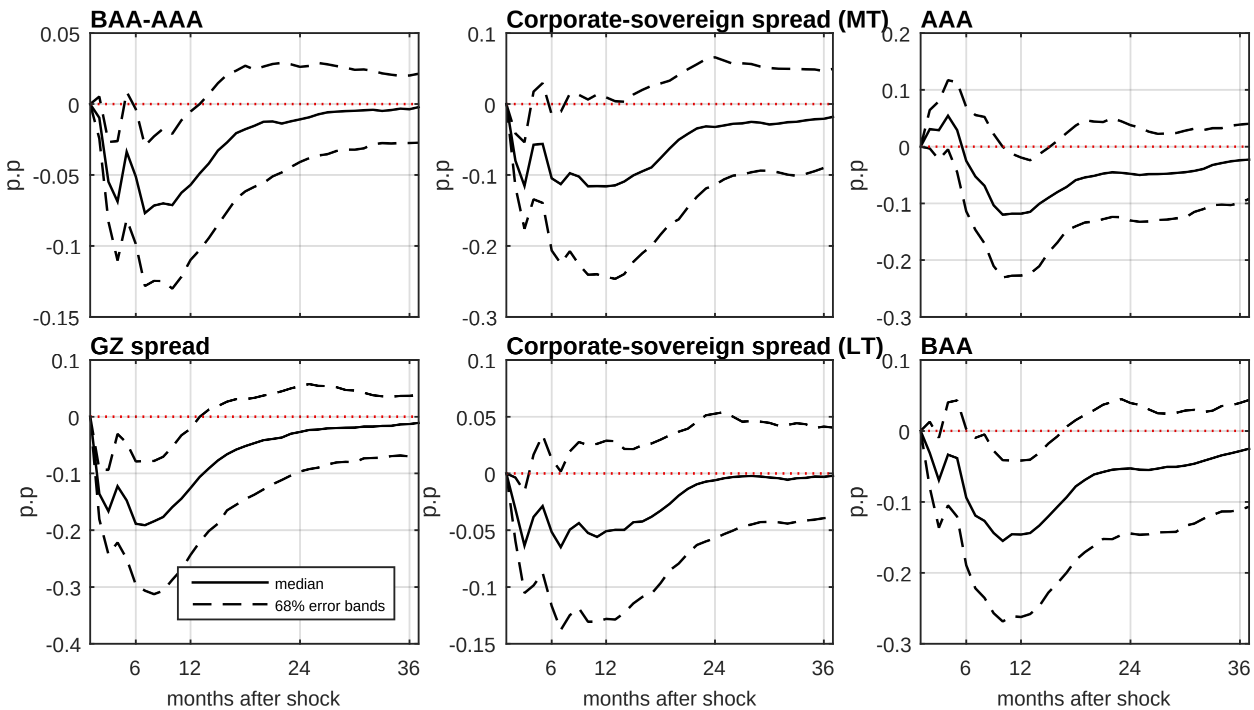
C Figures

Figure 1: Responses of endogenous variables to an expansionary monetary policy shock from the benchmark model.



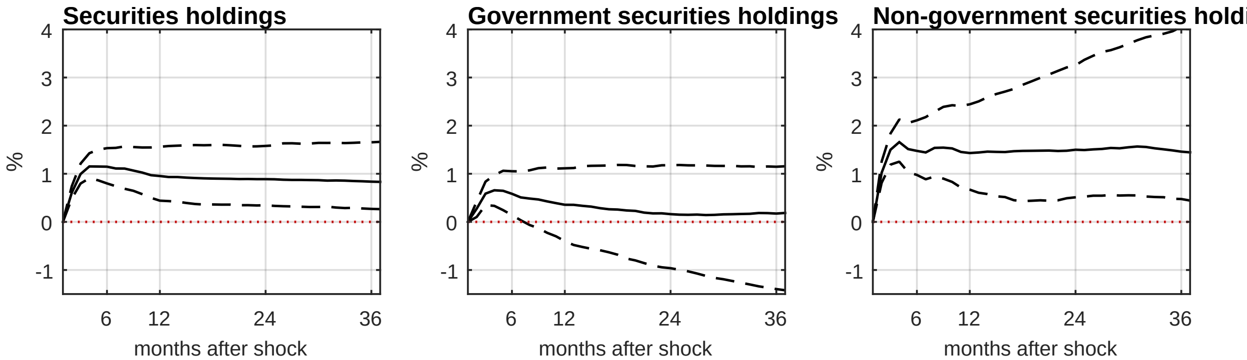
Note: The solid black line represents the median responses. The 16th and 84th percentile are displayed in dotted black.

Figure 2: Responses of variables in the bond market to an expansionary monetary policy shock.



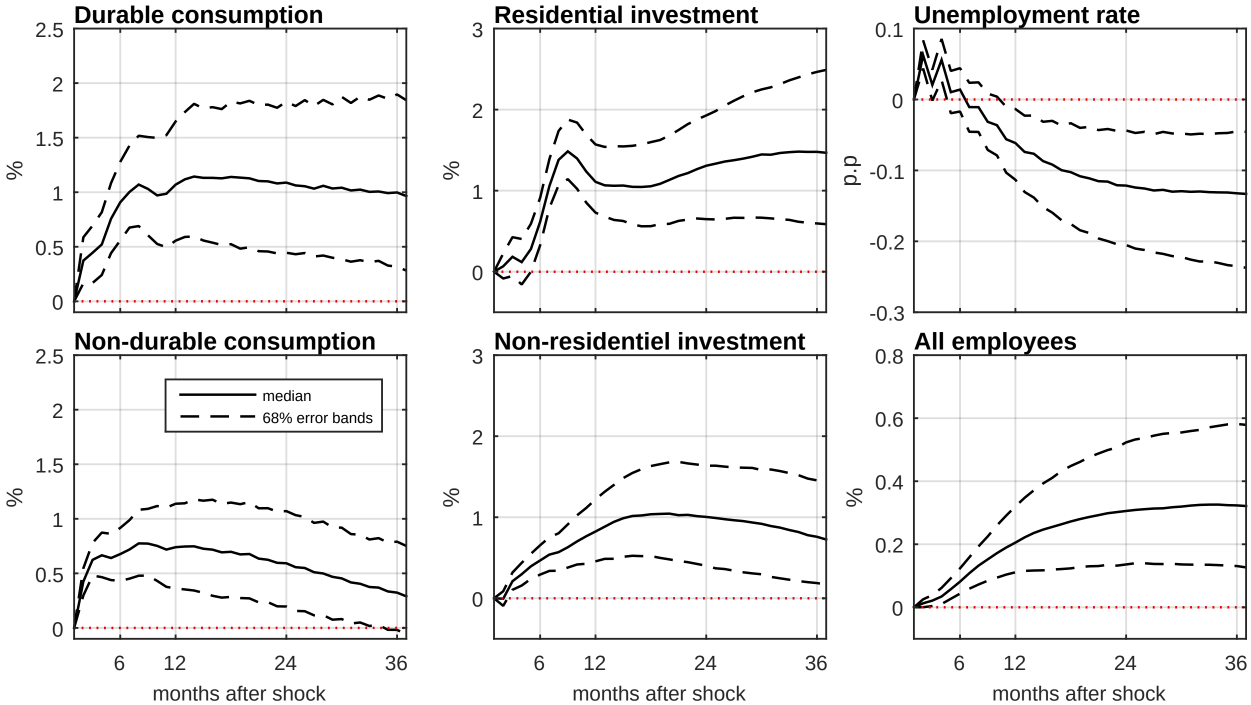
Note: The solid black line represents the median responses. The 16th and 84 percentile are displayed in dotted black.

Figure 3: Responses of securities held by banks to an expansionary monetary policy shock.



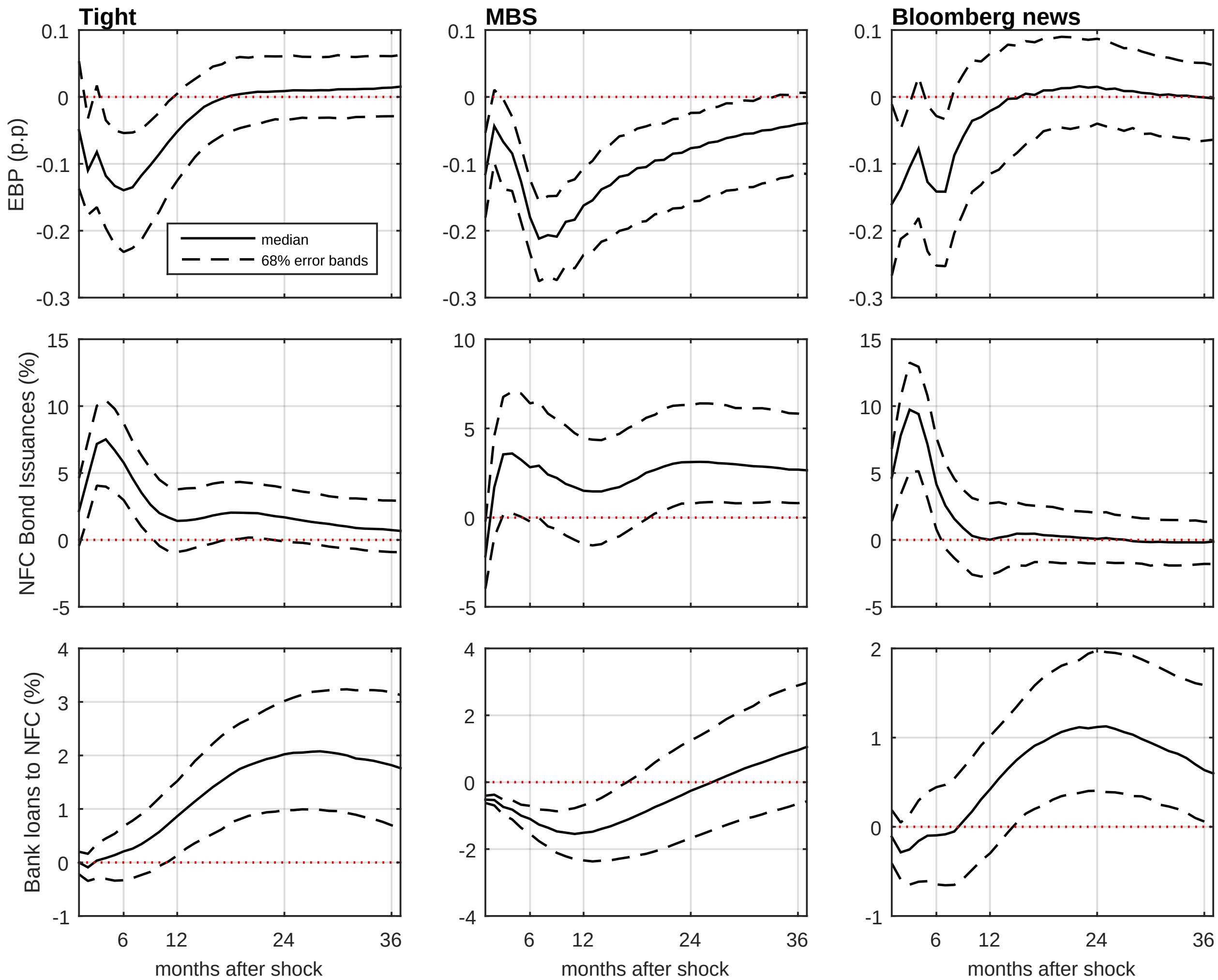
Note: The solid black line represents the median responses. The 16th and 84 percentile are displayed in dotted black.

Figure 4: Responses of wider set of macroeconomic variables to an expansionary monetary policy shock.



Note: The solid black line represents the median responses. The 16th and 84th percentile are displayed in dotted black.

Figure 5: Robustness analysis: responses of endogenous variables to an expansionary monetary policy shock under several specifications.



Note: The solid black line represents the median responses. The 16th and 84 percentile are displayed in dotted black.