The trade-off between monetary policy and bank stability

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Abstract

This paper investigates how monetary policy interventions by the European Central Bank and the Federal Reserve affect the stock market perception of bank systemic risk. In a first step, we identify monetary policy shocks using a structural VAR approach by exploiting the changes of the volatility of these shocks on days on which there are monetary policy announcements. The second step consists of a panel regression analysis, in which we relate monetary policy shocks to market-based measures of bank systemic risk. Our sample includes information on both Euro Area and U.S. listed banks, covering a sample period from October 2008 to December 2015. We condition the impact of the monetary policy shocks on a set of bank-specific variables, thereby allowing for a heterogeneous transmission of monetary policy. We furthermore use the differences between Euro Area core and periphery countries and the additional granularity of U.S. accounting data to assess which channels determine the transmission of monetary policy. Our results indicate that by supporting weaker banks and allowing banks to delay recognizing bad loans, accommodative monetary policy may contribute to the buildup of vulnerabilities in the banking sector and may make an eventual policy tightening more difficult. On the other hand, a continuation of expansionary monetary policy may increase risk-taking incentives by further compressing banks' net interest margins.

Keywords: banking, monetary policy, systemic risk,
identification-through-heteroskedasticity
EFM classification: 520, 560

1. Introduction

Since the major central banks have embarked on programs of unconventional monetary policy, the potential trade-off between monetary stability and financial stability has received

increasing attention from policymakers and academics (Smets, 2014; Adrian and Liang, 2016). The objective of this paper is to contribute to this topic by focusing on the link between monetary policy and the systemic risk of the banking sector in the Euro Area and the United States, and hence on a trade-off between the mandated objectives of the central banks and financial stability. While there is evidence on the impact of monetary policy actions on bank lending risk, we argue that it is useful to assess the total impact of various channels of monetary policy transmission on the overall systemic risk of banks. From a regulatory and supervisory point of view, it is equally important to identify which banks, or which bank business models, are most exposed to monetary policy measures. We therefore investigate how actions undertaken by the European Central Bank and the Federal Reserve between October 2008 and December 2015 affect systemic risk of European and U.S. banks as perceived by stock markets. To assess the relative importance of different transmission channels, we allow the impact of monetary policy actions to vary across banks.

Our analysis consists of three components. First, using a structural vector autoregression (VAR), we estimate the monetary policy shock by assuming that it will be more volatile on days on which there are monetary policy announcements. This 'identification-through-heteroskedasticity' approach, which was first proposed by Rigobon and Sack (2003, 2004), is ultimately based on the observation that monetary policy announcements will dominate other news on these days. Wright (2012) further develops this approach so that it does not require the definition of a specific policy instrument, hence allowing its use in an environment characterized by the zero lower bound and unconventional monetary policy programs. This method displays some advantages over alternative approaches, because it does not require to either propose an alternative policy instrument, e.g. the size of the central bank balance sheet, or to define the appropriate length of the event window, as is necessary in event studies. We find that the data support our identification strategy as the standard deviation of the structural monetary shock is found to more than double on announcement days in both the Euro Area and the United States. Second, we define bank systemic risk as a bank's contribution to the risk of the financial system as a whole as in, for instance, Acharya et al., 2010. This definition comprises a bank's vulnerability to systemwide stress as well as the risk of extreme losses spilling over to the rest of the financial system. In line with most of

the literature we estimate bank systemic risk using financial market information (see e.g. Billio et al., 2012, Huang et al., 2012, Adrian and Brunnermeier, 2016, Acharya et al., 2012, and Van Oordt and Zhou, 2014, for different approaches). Finally, we assess the impact of monetary shocks on bank systemic risk using a panel regression framework. By interacting the shock with a set of bank characteristics capturing the business model, we can furthermore evaluate the relative importance of different transmission channels.

Our results indicate that during the period under study expansionary monetary policy actions have supported banks' profitability and lowered their risk-taking incentives by increasing banks' net interest margins. However, maintaining accommodative monetary policy further in the future may compress net interest margins and lead to the buildup of financial vulnerabilities within the banking sector. Second, we find that more risky banks benefit more from expansionary monetary policy actions. Specifically, in response to monetary easing systemic risk declines more (or increases less) for banks that are characterized by a riskier asset composition, a more vulnerable funding structure or a lower level of capital adequacy. A comparison of these effects between core and peripheral Euro Area countries furthermore reveals that they are more important for banks in periphery countries. Consistent with Lambert and Ueda (2014), we also find evidence suggesting that accommodative monetary policy may delay balance sheet repair in the banking sector, by allowing banks more room to postpone recognizing bad loans. The expansionary monetary policy regime following the financial crisis may therefore have contributed to a build up of vulnerabilities within the banking sector. Consequently, a tightening of monetary policy may imperil financial stability in the medium term.

This paper is related to a growing literature investigating the effect of monetary policy on financial stability, and specifically bank risk-taking. These papers often use detailed loan-level data to check whether banks increase the risk of new loans in response to a decrease of interest rates (Dell'Ariccia et al., 2016; Ioannidou et al., 2015; Jiménez et al., 2014; Paligorova and Santos, 2013)[1]. We contribute to this literature by analyzing the transmission of monetary policy shocks to overall bank systemic risk, using stock market based measures of bank risk

[1]Maddaloni and Peydró (2013) and Buch et al. (2014) instead use survey data from the ECB's Bank Lending Survey and the Federal Reserve's Survey of Terms of Business Lending, respectively.

as in Altunbas et al. (2014). We furthermore argue that the impact of monetary policy interventions on banks may differ according to the business model following, among others, Ricci (2015), Delis and Kouretas (2011) and Brissimis and Delis (2010). Therefore we assess the importance of a set of bank characteristics that have been shown to determine the long-term profitability and risk profile of the banks (Mergaerts and Vander Vennet, 2016) in the transmission of monetary policy to systemic risk. These variables capture the asset, funding, capital and income structure of the banks.

The remainder of the paper is structured in the following way. In section 2, we discuss the transmission of monetary policy to bank systemic risk and the role of different bank characteristics. This results in several testable hypotheses. In section 3, we provide details on the methodology used in this paper to estimate the monetary policy shock and to measure bank systemic risk. We also present the panel regression framework that will be used to assess the strength of different transmission channels. Section 4 presents the data. In section 5 we discuss the results of our estimations and provide an analysis of the impact of monetary policy on financial stability. Section 6 concludes the paper with some policy implications.

2. Monetary policy and bank systemic risk

Expansionary monetary policy interventions ease financial conditions, but may also affect the risk-taking incentives of banks and hence influence financial stability. In this paper we investigate whether accommodative monetary policy promotes or deteriorates financial stability. If the impact is negative, this would imply a trade-off between stimulating the economy and avoiding the buildup of vulnerabilities within the financial system. In the following discussion we describe the different transmission channels of monetary policy to bank systemic risk, which are summarized in figure 1.

2.1. Monetary policy and bank systemic risk

When a central bank lowers its policy rate or expands its balance sheet, these actions feed through in market interest rates (columns 1 and 2 in figure 1). A direct positive impact of decreasing short-term interest rates for banks is that this is normally associated with an increasing net interest margin (NIM) and hence bank profitability. The rising NIM

is furthermore expected to affect banks' risk-taking incentives by increasing the pay-off of monitoring (see e.g. Dell'Ariccia et al., 2014). Both effects are expected to translate into a higher stock market valuation and lower riskiness. However, this channel may be reversed when deposit rates approach the zero lower bound and long-term interest rates are decreasing as well, compressing net interest margins (Borio et al., 2015; Busch and Memmel, 2015). In the period between 2008 and 2015 central banks have kept short-term interest rates very low and have implemented unconventional monetary policy programs, some of which were specifically designed to decrease long-term interest rates (e.g. forward guidance and operation twist). To the extent that the continuous decline of long-term interest rates decreases banks' net interest margin, it may increase their risk-taking incentives, e.g. as a consequence of search-for-yield (Rajan, 2005; Chodorow-Reich, 2014). If these risks are correlated across banks, as was the case in the run-up to the real estate crisis in, among other countries, the U.S. and Ireland, a period of low interest rates may increase systemic risk more for banks that already focus more on lending.

Second, expansionary monetary policy interventions tend to boost asset prices and can therefore be considered as what Brunnermeier and Sannikov (2014) have labeled stealth recapitalization, i.e. the increase of the value of legacy assets leads to a higher net worth of the bank. If stock market investors consider the revaluation of bank assets as sustainable, it may lead to lower bank systemic risk. A rising value of collateral pledged to secure bank loans may furthermore reduce the loss given default of bank portfolios, increasing their value as well. Finally, by stimulating the economy, expansionary monetary policy actions can further support loan quality by lowering default probabilities. This channel may therefore lead to a positive relationship between expansionary monetary policy and bank profitability and net worth. These effects are then expected to reduce bank systemic risk.

Finally, in both the Euro Area and the United States the start of the financial crisis in September 2008 was characterized by problems in wholesale funding markets, which laid bare the interconnectedness of the financial system and its potential for contagion. In response, monetary authorities have undertaken actions to improve the liquidity position of the banking sector. The alleviation of funding risk may have contributed to lower funding costs, and hence higher bank profitability, and a decline of banks' vulnerability to further financial shocks.

Given sufficient demand for credit, central bank liquidity provision may furthermore improve banks' lending capacity (Boeckx et al., 2014) and thereby increase profitability (column 4 in figure 1). These effects should translate in a decrease of systemic risk. However, stealth recapitalization and the ample availability of central bank liquidity may also allow banks to postpone cleaning up their balance sheets by writing off non-performing loans (Acharya et al., 2016; Lambert and Ueda, 2014; Peek and Rosengren, 2005). Such forbearance may increase uncertainty about potential future write-offs, and hence depress market values and increase bank systemic risk (column 5 in figure 1).

2.2. Monetary policy transmission and bank heterogeneity

While monetary policy interventions are likely to affect bank systemic risk, each bank may internalize these interventions differently conditional on its business model. In order to model the heterogeneity of the impact of monetary policy actions, we allow it to vary according to a set of business model characteristics. In practice, we capture the business model by accounting measures of asset, funding, capital and income structure.

A bank's asset structure may affect the transmission of monetary policy shocks to bank systemic risk in several ways. First, because banks characterized by a loan-oriented asset composition are more sensitive to changes in the net interest margin, we expect these banks to react more strongly to monetary policy shocks. However, it is impossible to predict the sign of this relationship because the impact of expansionary monetary policy on the NIM is ambiguous (columns 1 and 2 in figure 1). As accommodative monetary policy programs have influenced both short-term and long-term interest rates, the net effect of the loan ratio on the transmission of monetary policy to bank systemic risk may even become zero. Second, the increase of collateral values and the improvement of economic and financial conditions as a consequence of accommodative monetary policy might also lower risk and increase profitability more for banks that rely more on loans. Increasing asset prices and decreasing risk premiums may furthermore be especially beneficial for banks with high asset risk. Finally, banks with high loan ratios and lower loan quality may have stronger incentives to use the access to central bank liquidity to delay recognizing bad loans. According to this forbearance channel, markets may therefore consider banks with higher loan ratios to become

more systemically risky and less profitable following an expansionary monetary policy shock, especially if there are doubts about the loan quality [2].

The impact of the bank's income structure on the transmission of monetary policy on systemic risk also depends on the pass-through of expansionary interventions on the bank's net interest margin. A bank that relies more on activities that generate net interest income may benefit more from monetary policies that lower short-term interest rates, while it may face declining profitability if long-term rates decrease as well.

With respect to a bank's funding structure the literature offers different hypotheses for its influence on the transmission of monetary policy shocks to bank systemic risk. First, by lowering banks' dependence on wholesale markets, access to central bank funding may have made banks less vulnerable to systemic shocks. The funding risk hypothesis therefore implies that expansionary monetary policy is more beneficial (or less harmful) for banks that rely more on market-based funding sources. Second, a high reliance on deposit funding may weaken private monitoring because customer deposits are typically protected by deposit insurance and this feature may intensify agency problems (see e.g. Demirgüç-Kunt and Detragiache, 2002, and Demirgüç-Kunt and Huizinga, 2004). As such, the share of insured deposits may influence stock market expectations about banks' reactions to changes in the net interest margin. Again, the impact of expansionary monetary policy actions on the NIM, and therefore the role of the deposit ratio, is not a priori clear. The literature, however, mainly finds that expansionary monetary policy actions benefit banks with low deposit ratios. Mamatzakis and Bermpei (2016) show that the negative impact of the Federal Reserve's expansionary policies is stronger for banks characterized by a high deposit ratio (see also Yin and Yang, 2013). For the Euro Area, Ricci (2015) provides event study-based evidence that, in response to an expansionary monetary policy shock, stock prices of banks with a higher deposit ratio rise less than those of banks that rely more on wholesale funding.

Concerning the impact of a bank's capital ratio on the effects of monetary policy shocks, the banking literature advances divergent theories. Most straightforward, less capitalized

[2]Such doubts may be stronger for banks in Euro Area periphery countries. For instance in Italy non-performing loans have tripled during our sample period, eventually rising to a proportion of 18% of total outstanding loans by December 2015. Garrido et al. (2016) suggest that write-offs may have taken too long because of economic and legal obstacles.

banks may benefit more from accommodative changes in the monetary policy stance, because markets consider them to be less safe. Furthermore, because they rely more on debt funding, their profitability is more responsive to monetary policy shocks that affect short- and long-term interest rates (Ricci, 2015; Yin and Yang, 2013; Madura and Schnusenberg, 2000). Theories focusing on the moral hazard induced by monetary policy shocks consider the capital ratio to capture the severity of agency problems within banks, i.e. less capitalized banks have more incentives to transfer risks to debtholders. The search-for-yield channel implies that banks increase risk-taking when interest rates decline and that the strength of this effect increases with the prevalence of agency problems. This implies that less capitalized banks are expected to increase risk more in the case of an expansionary monetary policy shock. On the other hand, the risk-shifting channel (Dell'Ariccia et al., 2014) suggests that, as far as expansionary monetary policy increases banks' net interest margins, it increases their incentives to monitor and hence should lower risk. This effect is expected to be stronger for banks with low capital ratios that have more scope to reduce risk, because more highly capitalized banks' monitoring incentives are less dependent on the stance of monetary policy. De Nicolò et al. (2010) and Dell'Ariccia et al. (2016) provide evidence supporting the existence of a risk-shifting effect in the United States. However, the risk-shifting channel could be reversed if monetary policy actions focus on lowering long-term interest rates, thereby reducing banks' net interest margins and increasing less capitalized banks' risk-taking incentives. These hypotheses are also summarized in figure 1. In this paper we investigate the relative strength of these hypotheses in order to assess the trade-off between traditional objectives of monetary policy and financial stability.

3. Methodology

In this section we discuss the three components of our methodology. In section 3.1 we describe the estimation of the monetary policy shocks and analyze the results of applying our identification strategy. In section 3.2 we define bank systemic risk and the set of variables we use to measure it. Finally, in section 3.3, we present the panel setup we use to assess the impact of monetary policy actions on bank systemic risk. This model allows the impact of the monetary policy shock to vary across banks and over time by taking into account the

heterogeneity of banks' business models.

3.1. Monetary policy shock

3.1.1. Model

We estimate a time series of the exogenous monetary policy shock by modeling a set of relevant financial variables in a structural VAR model at daily frequency. Our identification strategy, which was first proposed by Rigobon and Sack (2003, 2004) and adapted by Wright (2012), is based on the assumption that the structural monetary policy shock is more volatile on days on which there is a monetary policy announcement (the specific set of days must be determined a priori). On the other hand, the volatility of any other structural shocks and the transmission of the shock within the model are assumed to be time-invariant[3]. Other studies employing this 'identification-through-heteroskedasticity' methodology to identify the effects of structural monetary policy shocks include, for example, Rogers et al. (2014), Arai (2015) and Gilchrist and Zakrajsek (2013).

Estimating the monetary policy shock this way has some advantages over alternative approaches. First, while event studies are often used to identify the impact of monetary policy announcements on bond yields and financial markets (e.g. Neely, 2015, Gagnon et al., 2011, Joyce et al., 2011, Krishnamurthy and Vissing-Jorgensen, 2011, Swanson, 2011, and Taylor and Williams, 2009), they may be susceptible to simultaneity bias as a consequence of concurrent financial shocks that influence monetary policy as well as asset prices. To circumvent this problem, some event studies use an intraday event window and effectively assume that the variance of the other shocks within this window is zero (Joyce and Tong, 2012). Gilchrist and Zakrajsek (2013) document that event study approaches therefore underestimate the impact of monetary policy announcements. On the other hand, event studies also require full adjustment of asset prices within the event window. However, because unconventional monetary policy actions were mostly untested in the Euro Area and the U.S., adjustment periods may be longer and would hence require longer event windows (Neely, 2015; Meaning and Zhu, 2011). Finally, some announcements may have been largely anticipated, leading to

[3]Note that this time-invariance is a necessary condition for identification, but that it excludes the possibility to examine and compare the impacts of different policies, e.g. conventional interest rate changes and unconventional asset purchasing programs.

limited adjustments of asset prices and bond yields within the event window. In our model we do not assume the absence of other shocks on announcement days, but only that they become relatively less important compared to the monetary policy shock. We can furthermore estimate the monetary policy shock on non-announcement days to pick up anticipation of monetary policy actions. Second, most other approaches require the definition of a policy instrument. However, using the short-term interest rate may be problematic due to the zero lower bound. Alternative measures have therefore been proposed, including the size of the central bank balance sheet (Garcia Pascual and Wieladek, 2016; Boeckx et al., 2014; Gambacorta et al., 2014), the interbank interest rate (Gambacorta and Shin, 2016), long-term interest rates (Chen et al., 2012, 2015; Gilchrist et al., 2014) or the term spread (Baumeister and Benati, 2013)[4]. The identification-through-heteroskedasticity approach allows us to avoid having to choose a specific policy instrument.

The identification of the monetary policy shocks is based on the following structural VAR model:

$$Y_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + R\nu_t \tag{1}$$

where Y_t is an N-dimensional vector of endogenous variables ($t = 1, \ldots, T$), ν_t an N-dimensional vector of orthogonal structural innovations with mean zero and $A_1, \ldots, A_p$ and R are $N \times N$ time-invariant parameter matrices. The reduced-form residuals corresponding to this structural model are given by the relationship $\varepsilon_t = R\nu_t$. In this model we assume that the first[5] structural shock changes on announcement days, while the other structural innovations are homoskedastic, so that:

$$Var\left(\nu_t\right) = \Omega_t = \begin{cases} \Omega^{(0)} = \text{diag}\left(\omega_1, \omega_2, \ldots, \omega_N\right) & \text{if } \textit{no announcement} \\ \Omega^{(1)} = \text{diag}\left(\omega_1^*, \omega_2, \ldots, \omega_N\right) & \text{if } \textit{announcement} \end{cases} \tag{2}$$

It can be shown that, as long as the covariance matrix of the reduced form errors V_t changes on announcement days, these assumptions suffice to uniquely identify the first column of R

[4]Another approach consists of estimating a latent policy stance, such as a shadow policy rate (Lombardi and Zhu, 2014) or a latent propensity for QE (Meinusch and Tillmann, 2016).

[5]Note that ordering the monetary policy shock first is purely for convenience and does not affect the model.

and the structural monetary policy shock apart from their scale and sign. In our setup we normalize the monetary policy shock by fixing the response on impact of one of the included variables to a unit monetary policy shock.

3.1.2. Estimation and testing

To estimate the model defined by equations 1 and 2, we follow the iterative estimation procedure of Lanne and Lütkepohl (2008). It consists of the following steps:

1. The reduced form VAR model in (1) is estimated using OLS, i.e. under the assumption of homoskedasticity. The estimated residuals are used to construct estimates of the covariance matrices V_t. Defining D_t as a dummy variable that takes value 1 on announcement days and 0 on other days, we can write:

$$\tilde{V}_t = \begin{cases} \frac{\sum_{t=1}^{T}(1-D_t)\hat{\varepsilon}_t\hat{\varepsilon}_t'}{T-\sum_{t=1}^{T}D_t} & \text{if } D_t = 0 \\ \frac{\sum_{t=1}^{T}D_t\hat{\varepsilon}_t\hat{\varepsilon}_t'}{\sum_{t=1}^{T}D_t} & \text{if } D_t = 1 \end{cases} \tag{3}$$

2. Using our estimates for V_t, we minimize the following loss function to obtain the estimates for R and Ω_t:

$$\left(\hat{R}, \hat{\Omega}_t\right) = \arg\min_{\hat{R},\hat{\Omega}_t} \left\{ -\left(\sum_{t=1}^{T} \log |R\Omega_t R'| + \operatorname{tr}\left[\tilde{V}_t \left(R\Omega_t R'\right)^{-1}\right] \right) \right\} \tag{4}$$

3. The estimates $\hat{R}$ and $\hat{\Omega}_t$ can then be used to re-estimate the VAR model in (1) by FGLS. This step again results in estimates for the reduced form residuals, which are used to construct new estimates of V_t.

Steps 2 and 3 are iterated until convergence, resulting in Gaussian maximum likelihood estimators if we do not impose that the residuals are normally distributed (and quasi-maximum likelihood estimators otherwise). Using $\hat{R}$ and the FGLS estimates of the reduced form errors, we can then trace out the structural monetary policy shock.

Since the identification strategy relies on the presence of a heteroskedastic monetary policy shock, it is important to test whether our model indeed supports a rejection of homoskedastic

errors. The following hypothesis is therefore of interest:

$$\begin{cases} H_0 : \omega_1 = \omega_1^* \\ H_1 : \omega_1 \neq \omega_1^* \end{cases} \tag{5}$$

In other words, we compare the homoskedastic model under the null hypothesis to a model in which we relax the restriction on one parameter, i.e. we do not impose $\omega_1^* = \omega_1$. Our use of (Q)ML estimators enables us to perform a likelihood ratio test[6] to examine this hypothesis.

3.1.3. Results

To estimate the VAR we use a set of variables that should capture the pass-through of monetary policy to the financial sector. Hence, following Rogers et al. (2014), we select those variables that are expected to respond most to a monetary policy shock. For both the Euro Area and the U.S. we include a medium- and long-term interest rate, a measure for inflation expectations and the return and implied volatility of a broad stock market index. Because the sovereign debt crisis has forced the ECB to implement unconventional policy actions aimed at restoring the transmission of monetary policy, we furthermore include a sovereign stress indicator in the Euro Area VAR. Details of the specific variables can be found in table 1. A VAR of order 2 is estimated over a sample period from 1 October 2008 to 31 December 2015[7].

The identification of the monetary policy shock requires a set of announcement dates for both central banks. For the ECB we include all announcements pertaining to interest rates, asset purchase programs, long-term refinancing operations, central bank funding conditions, forward guidance and new swap arrangements with other central banks[8]. Federal Reserve

[6] In the framework of this model these tests will retain their standard asymptotical properties. We refer to Lanne and Lütkepohl (2008) for a more complete discussion of their statistical properties.

[7] In unreported regressions we find that the results are robust to different choices of the VAR order.

[8] Interest rate announcements also include the ECB governing council decisions to leave the interest rate unchanged so that all governing council meetings are present in the set of announcement dates. Asset purchase programs announcements relate to the three covered bond purchase programs, the ABS purchase program, the (sterilized) securities markets program, the outright monetary transactions and the public sector purchase program. The corporate sector purchase program was announced in April 2016 and is therefore not part of the sample. With central bank funding conditions we refer to changes in tendering procedures such as fixed-rate full allotment and collateral requirements.

announcement dates include interest rate decisions as well as announcements regarding asset purchase programs, lending facility conditions, forward guidance and swap agreements[9]. This selection procedure leads to a set of 106 announcements in the Euro Area and 81 in the United States. Details on the specific dates and announcements can be found in the appendix in tables A.1 and A.2 for the Euro Area and United States, respectively. While the specific choice of announcement dates is of course open for debate, we believe our choices to be reasonable[10]. Finally, our identification strategy only identifies the shock up to its scale and sign. We therefore define a unit expansionary monetary policy shock as a shock that decreases the Spanish 5 year CDS spread by 25 basis points upon impact for the Euro Area and as a shock that decreases the 10 year treasury bill yield by 25 basis points for the U.S., in line with Wright (2012) and Rogers et al. (2014).

The estimation of the model yields variance multipliers of 4.45 and 5.96 for the Euro Area and the United States, respectively, implying that the standard deviation of the monetary shock is more than twice as high on announcement days in both regions. A likelihood ratio test for the hypothesis test (equation 5) results in test statistics of 166.79 for the Euro Area and 213.76 for the U.S., so that the null hypothesis of equal variance on both announcement and non-announcement days is strongly rejected by the data. Hence these tests provide support to our identification strategy. In figure 2 we present the impulse response functions of the variables to a unit monetary policy shock. In the Euro Area (figure 2a) we find that an expansionary monetary policy shock increases long-term inflation expectations and the value of the broad stock market index, while decreasing market-wide

[9]As for the ECB we include all announcements following FOMC meetings, even if they only decide to keep the interest rate unchanged. Asset purchase programs include the three quantitative easing programs and the (sterilized) operation twist. Lending facility conditions refer to both the institution and closing of specific lending facilities such as the term auction facility and the term ABS loan facility, among others.

[10]In an unreported analysis, we experiment with different choices for the set of announcement dates. For the Euro area, we find that a more strict choice of 50 policy dates, leaving out the ECB governing council meetings that produced no interest rate changes or UMP actions, leads to an increase of the variance change of the monetary policy shock on announcement days, yielding a variance multiplier of 8.32. However, it does not affect any of our further results as the correlation with the baseline shock remains 0.99. If we restrict our sample even more to 32 days by also excluding policy days on which there was a press release related to central bank funding conditions or swap agreements with other central banks, the correlation with the baseline shock is still 0.61. For the US, a more strict choice of 62 policy dates, leaving out the FOMC meetings that produced no interest rate changes or UMP actions, leads to an increase of the variance change of the monetary policy shock on announcement days, yielding a variance multiplier of 7.06. However, it does not affect any of our further results as the correlation with the baseline shock remains 0.97.

implied volatility ($VSTOXX$). Although the negative contemporaneous impact on sovereign stress is a consequence of our identification strategy, the effect remains significantly negative across the whole horizon. We do not observe a significant impact on the yields of the medium- and long-term safe assets, possibly due to a flight-to-safety effect in which monetary easing lowers the demand for safe assets, such as German bunds, by decreasing the risk of stressed sovereign bonds (see also Rogers et al., 2014, and Altavilla et al., 2014). For the United States the effects are very similar, in that we observe a positive effect on long-term inflation expectations and the value of the S&P500 stock market index and a negative effect on market-wide implied volatility (VIX). However, for the U.S. the effect of an expansionary monetary policy shock on medium- and long-term safe asset yields is significantly negative over the entire horizon. The decline of the ten-year treasury yield furthermore exceeds that of the two-year yield, flattening the yield curve.

Finally, in figure 3 we plot the time series for the cumulative monetary policy shock for both the Euro Area and the United States[11]. A rise in the cumulative series corresponds to an expansionary monetary policy shock relative to the prevailing financial market conditions, so that the series itself reflects the stance of monetary policy. The graphs show that the shocks are able to capture important monetary policy measures, as well as the anticipation of some measures. For the Euro Area, the one-year LTRO/CBPP1 announcement in May 2009 and the SMP announcement in May 2010 are among the largest expansionary daily shocks and can therefore be considered surprises to financial markets. On the other hand, the OMT announcement of September 2012 and the QE announcement of January 2015 appear to have been largely anticipated following preceding speeches by ECB president Mario Draghi, in which he alluded on the implementation of additional unconventional monetary policy measures. For the United States, the announcement of the first quantitative easing program (QE1) is identified as the largest shock, and hence the largest surprise to financial markets, while the small shocks on the QE2 and QE3 announcement days suggest that these programs were largely anticipated. Further in line with anticipation, the cumulative monetary policy shock reflect the buildup of the accommodative monetary policy stance around the

[11]Note that the cumulative shock does not necessarily sum to zero, due to the use of feasible GLS for its estimation.

announcements of the QE1, Operation Twist and QE3 programs, at which the central bank had hinted in prior speeches. The cumulative shock gradually decreases following the taper announcement in May 2013 and the signals of a federal funds rate increase at the end of 2014. As such, the inspection of the cumulative monetary policy shock series further supports the appropriateness of our identification strategy.

3.2. Bank systemic risk

In line with Acharya et al. (2010, 2012) and Adrian and Brunnermeier (2016) we define a bank's systemic risk as its contribution to the risk of the financial system as a whole. This definition encompasses two complementary dimensions. First, it means that a bank's systemic risk increases as it becomes more vulnerable to adverse shocks within the financial system as a whole. If a bank is prone to suffer extreme losses during an industry-wide stress event, its activities are less likely to be taken up by other actors within the financial sector, because their ability to do so is also severely impaired. In addition, a potential recapitalization to allow the bank to continue its activities is both difficult and costly during a systemic event due to the entire banking system being undercapitalized. However, if the bank is able to bear severe losses, it can continue its activities without requiring recapitalization. Hence, bank capital is a crucial second dimension of systemic risk. In figure 4 we illustrate the trade-off between the capital ratio (horizontal axis) and the vulnerability to systemic shocks, measured as the proportion of equity capital a bank would lose (vertical axis). The lines in this figure are isoquants of equal levels of *post-shock* capital ratios, so that a lower value reflects higher systemic risk. It is clear that, to maintain an equivalent level of systemic risk, a bank should raise its capital ratio when it becomes more vulnerable to system-wide shocks.

We estimate the first dimension, a bank's vulnerability to large financial shocks, using the marginal expected shortfall (Acharya et al., 2010):

$$MES_{i,t} = -E_t(r_{i,t+1}|r_{m,t+1} < C)$$

MES estimates the expected drop in the share price of bank i in case of an adverse event affecting the economy, which is defined as a broad market return below some threshold C. A financial crisis, however, is defined as a longer period with potentially severe cumulative

drops in the valuation of banks' equity. In our analysis we therefore focus on the long-run MES, which estimates the valuation loss a bank would incur following a stock market decline of 40% over a period of six months[12]:

$$LRMES_{i,t} = -E_t(r_{i,t+6M}|r_{m,t+6M} < -40\%)$$

The second component, the perception of the stock market of a bank's capacity to absorb unexpected losses is, given the amount of assets, reflected by the total market value of its equity (MV). Finally, to analyze systemic risk, we need to consider the potential trade-off between systemic vulnerability and capitalization. We therefore combine the two components, which yields our measure of bank systemic risk, the stressed market value (SMV).

$$SMV_{i,t} = (1 - LRMES_{i,t}) \times MV_{i,t}$$

SMV is the capital the bank is expected to end up with in the event of a large adverse shock to the financial system. This variable can be considered as the market-based equivalent of the accounting-based simulated stress test exercises that are currently being undertaken on a regular basis by bank supervisors in Europe, the U.S. and other jurisdictions[13]. Because monetary policy affects the market's perception of the value of a bank's assets and its vulnerability to stress events, SMV is likely to react immediately to announcements regarding monetary policy. Finally, SMV can capture a potential risk-return trade-off if $LRMES$ and MV react in different ways. A monetary policy action that lowers the interest rate may, for instance, increase a bank's market capitalization through a higher net interest margin, but at the same time increase risk-taking. By analyzing both components we can quantify this potential trade-off.

[12]Our estimation of the MES follows Brownlees and Engle (2012) setting C to -2% and using an ADCC model to construct series of time-varying return volatilities and correlations. The ADCC model is estimated over the period ranging from 1 January 2008 to 31 December 2015. We construct the $LRMES$ as $1 - \exp(-18 * MES_{it})$ as in Acharya et al. (2012).

[13]The relationship between marginal expected shortfall and stress testing scenarios is documented in more detail by Acharya et al. (2014).

3.3. Transmission of monetary policy and bank heterogeneity

In order to investigate the impact of monetary policy on the market's perception of banks' systemic risk we conduct a panel analysis in which we account for bank heterogeneity. Concretely, we estimate the following panel model using variables of monthly frequency:

$$Y_{i,t} = \alpha_i + (\beta_0 + \sum_{k=1}^{K} \beta_k BM_{k,i,t}) \times Shock_t + \sum_{k=1}^{K} \gamma_k BM_{k,i,t} + \varepsilon_{i,t} \tag{6}$$

in which $Y_{i,t}$ represents one of the dependent variables, $BM_{i,t}$ is a vector of business model characteristics and $Shock_t$ is the value of the monetary policy shock in month t. In using this approach, we allow the impact of the monetary policy shock to vary both over banks and over time, conditioning the effect on the bank's business model.

Our main dependent variable is the monthly percentage change of the stressed market value ΔSMV as a measure of a bank's systemic risk. We also use as dependent variables the components of the change of SMV, i.e. changes in the $LRMES$ and in market valuation. Note that we consider the changes of these variables because the monetary policy shock is itself interpreted as a change in the stance of monetary policy. We focus on the immediate changes in bank systemic risk due to monetary policy that are solely driven by the changing market appraisal of the bank. However,MV is also influenced by dividend payouts or changes in the outstanding number of shares, e.g. because of new issuance or share buybacks. We therefore measure MV by a total return index so that ΔMV equals the monthly holding period return.

The business model characteristics in BM are derived from the banks' balance sheets and the income statements and capture the asset, liability, capital and income structure of the banks. However, while our panel analysis is conducted on monthly frequency, accounting data are only available on an annual basis in the Euro Area and on a quarterly basis in the United States. To tackle this issue we replace the value of the business model variables by their last known value of the previous month, e.g. the value reported for the end of December 2014 is used for the entire year of 2015 in Europe and for the first quarter of 2015 in the United States. By using the last known value prior to month t we also avoid endogeneity issues as systemic risk and market valuation may also influence a bank's business model decisions.

Finally, the dependent variables $\Delta LRMES$, ΔMV and ΔSMV and the monetary policy shock are aggregated from daily to monthly frequency so that they reflect the changes of systemic risk and the monetary policy stance over the entire month. Hence, the changes in the systemic risk measures are computed using end-of-month values, while the change of the monetary policy stance is calculated as the sum of the shocks during the month.

4. Data

To conduct our analysis we require both financial market and accounting data for a set of listed Euro Area and U.S. banks. With respect to the Euro Area we obtain annual balance sheet and income statement data from Bankscope and daily stock return data from Datastream, which are linked based on the ISIN codes. We limit the sample to banks of which the Bankscope specialization is either bank holding company, commercial bank, cooperative bank, investment bank or real estate and mortgage bank. We furthermore exclude financial holding companies that lack banking activity of their own and the listed regional branches of the French bank Crédit Agricole. For the U.S. sample we collect quarterly balance sheet and income statement data from the FR Y-9C reports and daily stock return data from CRSP on all listed U.S. bank holding companies. The financial market data is linked to the accounting based data using the identifier match provided by the Federal Reserve Bank of New York[14]. Finally, because the MES is estimated on a daily frequency we require that the stocks in our analysis are liquidly traded. In the Euro Area we therefore impose that at least 75% of returns are non-zero during the sample period, while for U.S. banks we require that there should be trading activity on at least 85% of trading days[15]. After the application of this data selection procedure we end up with 63 Euro Area banks resulting in 4502 observations and 438 U.S. bank holding companies for a total of 24467 monthly observations.

On the basis of the accounting data we construct a set of business model variables to

[14]We control for business model changes through mergers by creating a new bank identifier when a bank's size increases by more than 50% (otherwise it is classified as an acquisition). Similarly, we also create a new identifier when the bank's size decreases by more than 50% in one quarter to control for large divestments that may fundamentaly affect a bank's business model. Finally, we make sure that we have continuous data on each bank by creating a new identifier whenever there is a gap in the bank-specific time series.

[15]The threshold is put lower for the Euro Area due to the lower available number of listed banks and hence the need to maintain the representativeness of the sample, especially with respect to subsample analysis.

capture the asset, liability, capital and income structure of the banks. We also include bank size, measured by total assets, as a control variable. The more granular nature of the (publicly available) FR Y-9C reports allows us to define a more detailed set of variables for U.S. banks. In table 2 we present descriptive statistics for both the dependent and the independent variables. Note that all variables have been winsorized per month to control for potential noise in the estimation induced by outliers[16].

5. Results

In table 3 we report the impact of an expansionary monetary policy shock on banks' systemic risk exposure based on the specification in equation 6. As outlined in section 3.3, we consider the effect on the change of the stressed market value (ΔSMV), as well as on its components. The change of the market value (ΔMV) and the change of the $LRMES$ ($\Delta LRMES$) reflect the shift in the stock market's assessment of the banks' value and vulnerability to systemwide downward shocks, respectively. Given that the interest of this paper lies in the heterogeneity of banks' responses to monetary policy, we only present the coefficients of the interaction effects (β_0 to β_K in equation 6). In addition, in table 4 we present results in which the Euro Area sample is split into core and periphery countries, the latter group consisting of Greece, Italy, Ireland, Portugal and Spain, to exploit regional differences. Finally, we make use of the more granular data of U.S. bank holding companies, which can be obtained from the FR Y-9C reports. These results are shown in table 5.

Before advancing to a detailed analysis of our results, we discuss the total effect of monetary policy shocks on bank systemic risk. Using the notation of equation 6, we can write the total impact of the monetary policy shock on bank systemic risk in the following way:

$$\frac{\partial Y_{i,t}}{\partial Shock_t} = \beta_0 + \sum_{k=1}^{K} \beta_k BM_{k,i,t}$$

In figure 5 we show for both the Euro Area and the U.S. histograms of the total impact of monetary policy shocks on each dependent variable, that are based on the estimation results

[16]The U.S. data are winsorized at the 1% level, while for the Euro Area banks we winsorize the highest and the lowest value of each variable in each month. This difference in winsorizing procedures is a consequence of the lower number of banks in the Euro Area.

presented in table 3. We find that the impact of an expansionary monetary policy shock on MV is mainly positive for both the Euro Area and the United States, implying that for most banks accommodative monetary policy actions increase the market value of their equity capital. The effect on $LRMES$, however, differs. For the Euro Area the majority of bank-year observations exhibit a negative effect on $LRMES$, which can be primarily attributed to banks in Euro Area periphery countries (figure 5c). In contrast, for the United States the impact of expansionary monetary policy shocks on $LRMES$ is positive for most bank-quarter observations. The complementary effects on $LRMES$ and MV in the Euro Area translate into an impact on SMV that is positive for the majority of observations, while in the U.S. the effects counteract each other, so that the median impact on SMV is close to zero. Finally, we note that although the total impact of monetary policy shocks on bank systemic risk and its components is heterogeneous, it can become quite large, suggesting that monetary policy interventions are economically relevant drivers of bank systemic risk.

5.1. Bank heterogeneity and transmission of monetary policy

As discussed in section 3.3, we model the heterogeneous impact of monetary policy shocks on bank systemic risk using a set of business model variables that capture a bank's asset, funding, capital and income structure. We measure a bank's asset structure by defining a set of variables that capture the composition of earning assets (the loan ratio), the risk of earning assets (the ratio of risk-weighted assets to total assets, or RWA density) and the quality of the loan portfolio (the proportion of non-performing loans in total loans). We use the ratio of customer deposits to total liabilities and an unweighted capital ratio, i.e. the ratio of total equity to total assets, to capture banks' funding and capital structures, respectively. As an indicator for banks' income structures, we use the share of non-interest income in total income as a proxy for the extent to which they engage in non-traditional income-generating activities[17].

With respect to asset structure, the results in table 3 show that an expansionary monetary

[17]Because during the financial crisis non-interest income has in some cases become negative, we calculate the share of non-interest income by dividing the absolute value of non-interest income by the sum of the absolute values of non-interest income and net interest income (see e.g. Köhler, 2015, and Mergaerts and Vander Vennet (2016) for similar approaches) .

policy shock reduces systemic risk more for banks with higher asset risk. In both the Euro Area and the United States, the interaction term of the monetary policy shock and the RWA density is negative for the $LRMES$ and positive for the market value and stressed market value, although the effect on $LRMES$ is not statistically significant in the Euro Area. This result is consistent with an expansionary monetary policy shock improving the financial environment (column 3 in figure 1), in line with the negative impact of the monetary policy shock on market-wide implied volatility and the positive impact on the value of stock market index (see figure 2). Increasing security prices can cause a positive revaluation effect on the banks' securities portfolios. At the same time the market risk of investment portfolios goes down so that banks using VaR models may see their market risk exposure, which is part of RWA, decrease. Increasing collateral values may furthermore decrease the probability of default within the banks' loan portfolios. Our results indicate that stock markets acknowledge these effects, which translates into a beneficial effect of expansionary monetary policy shocks on systemic risk for banks with high asset risk.

Considering the composition of a bank's assets, we find limited evidence for a negative impact of the loan ratio on the transmission of an expansionary monetary policy shock to the market value of Euro Area banks: the interaction term of the monetary policy shock and the loan ratio is significantly negative. Based on the discussion in section 2.2, a negative coefficient is consistent with two hypotheses. On the one hand, a high loan ratio could make banks more vulnerable to a long period of near-zero short-term interest rates and decreasing long-term interest rates, provoking a negative revenue effect (column 2 in figure 1). However, easing liquidity and financing conditions could also allow banks to defer acknowledging bad loans, i.e. forbearance (column 4 in figure 1). The assessment of the relative strength of these hypotheses requires a deeper inspection of the results. First, in table 3 we find that the interaction term of the non-interest income share and the monetary policy shock negatively affects market value in both the Euro Area and the United States. Hence, banks that rely more on net interest revenues appear to benefit from expansionary monetary policy actions. This result is not consistent with monetary policy decreasing bank profitability through the net interest margin, because this hypothesis would suggest that especially banks characterized by a high reliance on net interest income are vulnerable to expansionary shocks.

Second, we use the regional heterogeneity in the Euro Area to further discriminate between the two hypotheses. Doubt about the quality of banks' loan books are likely to be stronger in Euro Area periphery countries, because these countries experienced deeper recessions and weaker recoveries. Lower asset quality, combined with higher exposure to distressed sovereign debt, which depresses bank profitability and capital buffers, may increase forbearance incentives for banks in these countries. Such forbearance would, however, weigh on current profitability and lead to future loan impairments (see Peek and Rosengren, 2005). Acharya et al. (2016) find that the OMT program in the Euro Area allowed banks to evergreen distressed loans and that this effect was especially strong in the peripheral countries. However, if the negative effect of the loan ratio interaction works through a decrease of the net interest margin, one would expect that the impact is negative in both the periphery and the core. The results in table 4 support the forbearance hypothesis: the effect of the loan ratio interaction on MV and SMV is significantly negative for the periphery, but not the core countries.

Finally, we exploit the higher granularity of the U.S. accounting data by examining the impact of different types of loans. A decreasing net interest margin as a consequence of expansionary monetary policy should affect all types of loans equally. On the other hand, forbearance incentives may be larger for banks that rely more on business loans, rather than real estate loans or consumer loans, because the Federal Reserve explicitly supported the quality of the latter[18]. Different studies furthermore indicate that these programs have indeed had a positive impact on house prices (Rahal, 2016; Gabriel and Lutz, 2015). Again, the results in table 5 are in line with the forbearance hypothesis. We find that the market value and stressed market value of banks that rely more on business loans is more negatively affected by an expansionary monetary policy shock, while a higher reliance on consumer

[18]In its 25 November 2008 press release the FOMC motivates its decision to purchase mortgage backed securities by its intention to support property values: "The Federal Reserve [...] will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises [...] This action is being taken to reduce the cost and increase the availability of credit for the purchase of houses, which in turn should support housing markets". On the same day, the Term Asset-Backed Securities Loan Facility (TALF) was introduced in order to support the credit needs of consumer and small businesses. "The TALF is designed to increase credit availability and support economic activity by facilitating renewed issuance of consumer and small business ABS at more normal interest rate spreads."

loans or real estate loans increases the impact of monetary policy on the market value and the stressed market value.

Apart from asset and income structure, the transmission of monetary policy shocks to bank systemic risk may also be influenced by the way in which a bank funds its activities, i.e. through either customer deposits, wholesale debt or through equity capital. Consistent with Mamatzakis and Bermpei (2016), the results in table 3 indicate that a bank's funding structure, captured by the share of deposit funding in total liabilities, significantly affects the transmission of monetary policy to bank systemic risk for U.S. bank holding companies. We find that the interaction term of the deposit ratio and the monetary policy shock has a positive impact on $LRMES$ and a significant negative effect on market value. The combination of these effects furthermore translates into a significantly negative effect on the stressed market value. However, these results do not allow us to determine whether these effects are caused by expansionary monetary policy either relieving stock market's concerns about banks' funding risk (column 5 in figure 1) or by incentivizing banks with high deposit ratios to take more risk (column 2 in figure 1).

We therefore again turn to the more detailed data for the United States sample in table 5. Applying the weighting scheme of DeYoung and Jang (2016), we use the more granular data of the FR Y-9C reports to construct a variable that mimics the Basel III definition of the net stable funding ratio ($NSFR$) as closely as possible. We furthermore replace the ratio of deposits to liabilities by the ratio of core funding to total funding to better capture the share of insured deposits. While the coefficients for the share of core funding are in line with the results in table 3, we find no evidence to suggest that the $NSFR$, and thus banks' funding risk, affects the impact of monetary policy shocks on bank systemic risk. As such, these results provide support to the hypothesis that a higher deposit ratio increases agency problems, implying that the failure of depositors to adequately price risk strengthens the risk-taking incentives of banks in response to monetary easing. This conclusion is furthermore supported by the regression results exploiting the regional differences within the Euro Area presented in table 4. We find a significant negative effect of the deposit ratio interaction term on the market value, but only in core countries. Given that wholesale funding conditions deteriorated more for periphery banks, especially during periods of severe sovereign distress,

the funding risk hypothesis would imply that the impact of the deposit ratio should be more negative for the periphery sample. However, the strong link between banks and sovereigns may have weakened the credibility of deposit insurance in these countries[19], which may in turn have led to better private monitoring, alleviating the risk-taking incentives caused by expansionary monetary policy. These results are therefore also consistent with the risk-taking hypothesis.

In addition, the results in table 3 suggest that the capital structure, measured by the ratio of total equity to total assets, is also relevant for the transmission of monetary policy to systemic risk for U.S. banks. We find a significantly positive impact on the $LRMES$ and a negative impact on the stressed market value (columns 4 and 6). The subsample analysis comparing the core and the periphery Euro Area countries presented in table 4, indicate that this effect is also present in the Euro Area, but only in the periphery: the effects on both the market value and stressed market value are significantly negative. These results imply that better capitalized banks are perceived by markets to become more systemically risky following an expansionary monetary policy shock, consistent with the existence of a risk shifting effect (Dell'Ariccia et al., 2016) and also in line with the results of Ricci (2015), Yin and Yang (2013) and Madura and Schnusenberg (2000). However, the absence of an effect in core countries indicates that the risk shifting effect may be less important, at least within the Euro Area. Because funding conditions worsened more for banks in periphery countries, while large exposures to distressed sovereign debt put pressure on their capital buffers, it is especially in the periphery countries that a lower capital ratio allows banks to benefit more from expansionary monetary policies.

Finally, our results indicate that bank size, which we include as a control variable, affects the transmission of monetary policy to bank systemic risk. For the Euro Area we find that larger banks benefit more from monetary policy shocks in terms of $LRMES$, market value and stressed market value. These findings are consistent with Dell'Ariccia et al. (2014) and

[19]The declining credibility of deposit insurance in the Euro Area periphery is illustrated by the 2013 EU and IMF proposal to impose a one-time tax on both insured and uninsured deposits in Cyprus in exchange for financial support. Greece has had to instate capital controls to prevent the banking sector from collapsing during the 2015 negotiations on the country's third bail-out package. While the European Commission acknowledges the need for a European deposit insurance scheme to complete the banking union, deposit insurance is still a national responsibility.

Buch et al. (2014) who document that, to the extent that size is correlated with market power, larger banks can better protect their net interest margins when an extended period of accommodative monetary policy puts pressure on long-term interest rates. In addition, smaller banks may rely more on collateral as a substitute for expensive monitoring, so that a rise in asset prices, and hence collateral values, may increase bank risk by lowering monitoring incentives.

5.2. Is there a trade-off between traditional monetary policy objectives and financial stability?

Thus far we have examined the impact of the separate bank characteristics on the transmission of monetary policy to stock market perceptions of bank systemic risk. In this section we evaluate the consequences of the identified transmission channels for financial stability. Based on our findings, we argue that accommodative monetary policy may contribute to the buildup of financial vulnerabilities within the banking sector and hence undermine medium term financial stability. First, our results suggest that for most of the period under study low short-term interest rates and expansionary unconventional programs have supported banks' net interest margins (column 1 in figure 1). However, maintaining a very accommodative monetary policy further in the future may eventually lead to declining net interest margins (Borio et al., 2015; Borio and Zabai, 2016) and hence more risk-taking, especially by less capitalized banks that are more susceptible to the search-for-yield channel (Rajan, 2005). Because a declining NIM also adversely affects the profitability of banks that rely more on net interest income, such banks may experience more incentives to increase their risk-taking or to expand to non-interest income sources. While diversifying into non-traditional activities may bolster profitability (Mergaerts and Vander Vennet, 2016), it may at the same time increase the correlation between banks' income streams and hence raise systemic risk (De Jonghe, 2010).

Second, consistent with Ricci (2015) the results show that, all else equal, banks with a riskier asset composition, a higher reliance on wholesale funding and low levels of capital adequacy benefit more (or, at least, suffer less) from expansionary monetary policy interventions with respect to both $LRMES$ and valuation. Exploiting the differences between core and periphery countries in the Euro Area furthermore shows that these effects are more pronounced for banks headquartered in the periphery. The easing of monetary policy in the

years following the financial crisis may therefore in effect have supported less healthy banks. This implies that an eventual policy tightening will more negatively (or less positively) affect these risky banks, which could in turn present challenges to the preservation of financial stability in the medium term. Finally, we find evidence suggesting that expansionary monetary policy actions have given banks more room to delay balance sheet cleaning, in line with Lambert and Ueda (2014) and Acharya et al. (2016). In case of a tightening of monetary policy, it can be expected that such forbearance may become more difficult and that banks with lower loan quality will have to recognize the bad loans in their loan books. Our results furthermore again indicate that this problem could be more severe in Euro Area periphery countries. In conclusion, we argue that the expansionary regime of monetary policy following the financial crisis in 2008 has contributed to the buildup of vulnerabilities in the banking sector. Ultimately, both a continuation of accommodative policies and a tightening of monetary policy may increase these vulnerabilities and imperil the stability of the banking sector, because they are both likely to harm banks' net interest margins.

6. Conclusion

Overall, our results support the conjecture that accommodative monetary policy may increase the risk-taking incentives of banks. Moreover, the finding that loose monetary policy has supported the weaker banks may increase financial stability risks in the future. In terms of policy implications, it is clear that longer periods of very low short and long term interest rates may jeopardize bank profitability and amplify risk-taking incentives. Hence, measures of exceptional monetary accommodation should be complemented with macroprudential measures specifically targeted at the most vulnerable banks. Moreover, after a period of bank distress it should be recommended that the clean-up of the balance sheets proceeds in a swift manner, so that legacy and forbearance issues can be avoided. Finally, the switch from monetary policy accommodation to a tightening stance should be gradual and carefully guided in order to avoid disruptions among the weaker banks.

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Tables

Table 1: The financial market variables used in the VAR model to obtain the monetary policy shock. Inflation expectations are based on inflation swap rates. Data are obtained from Datastream.

Euro Area	**United States**
10Y German bund yield	10Y Treasury bill yield
2Y German bund yield	2Y Treasury bill yield
5Y, 5Y fwd. inflation expectation rate	5Y, 5Y fwd. inflation expectation rate
MSCI Europe	S&P500
VSTOXX	VIX
Spanish 5Y CDS spread	

Table 2: Descriptive statistics. Data are obtained from Bankscope and Datastream for the Euro Area and the FR Y-9C reports and CRSP for the United States.

	Euro Area				**United States**			
	Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max
Loans to earning assets	0.63	0.19	0.12	0.88	0.72	0.15	0.07	0.98
Cons. loans to earning assets					0.04	0.06	0.00	0.44
RE loans to earning assets					0.54	0.18	0.00	0.93
Bus. loans to earning assets					0.15	0.10	0.00	0.69
Non-performing loans to loans	0.09	0.08	0.00	0.41	0.03	0.03	0.00	0.21
RWA to earning assets	0.59	0.19	0.20	1.11	0.81	0.13	0.42	1.18
Size	18.04	1.83	14.14	21.47	10.60	1.59	8.45	16.58
Deposits to liabilities	0.48	0.17	0.06	0.91	0.85	0.13	0.09	0.99
Share of core funding					0.70	0.17	0.06	0.97
NSFR					1.09	0.15	0.57	1.80
Equity to assets	0.06	0.02	0.01	0.12	0.10	0.03	0.00	0.23
Share of non-interest income	0.37	0.15	0.03	0.86	0.26	0.16	0.01	0.97
Share of fee income					0.06	0.04	0.00	0.20
Share of fiduciary income					0.03	0.06	0.00	0.50
Share of trading income					0.01	0.03	0.00	0.33
Share of insurance income					0.01	0.03	0.00	0.17
$\Delta LRMES$	-0.002	0.10	-0.46	0.44	-0.001	0.18	-5.77	6.67
ΔMV	-0.004	0.14	-0.88	1.43	0.006	0.13	-0.75	1.69
ΔSMV	0.026	0.33	-0.91	9.97	0.039	0.31	-0.95	4.53
Observations		4502				24467		

Table 3: Baseline regression results. This table shows only the coefficients of the interaction effects β_i $(i = 0 \dots K)$ as presented in equation 6. The model is estimated using bank fixed effects. Standard errors in parentheses are clustered on both the bank and month level to control for within bank autocorrelation and common shocks. Stars indicate significance levels: *, **, *** represent significance at the 10%, 5%, and 1% level respectively.

	Euro Area			**United States**		
	ΔLRMES	**ΔMV**	**ΔSMV**	**ΔLRMES**	**ΔMV**	**ΔSMV**
	(1)	(2)	(3)	(4)	(5)	(6)
Loans to earning assets	-0.018	-0.065**	-0.127	-0.001	0.021	-0.025
	(0.032)	(0.032)	(0.163)	(0.019)	(0.020)	(0.033)
Non-performing loans to loans	-0.010	-0.152	0.005	0.025	-0.071	0.011
	(0.085)	(0.151)	(0.254)	(0.098)	(0.179)	(0.255)
RWA to earning assets	-0.043	0.147***	0.264**	-0.039*	0.077*	0.132*
	(0.035)	(0.052)	(0.118)	(0.020)	(0.044)	(0.068)
Size	-0.006**	0.014***	0.041***	0.001	0.003	-0.003
	(0.003)	(0.004)	(0.015)	(0.002)	(0.003)	(0.008)
Deposits to liabilities	-0.009	-0.052	0.199	0.034*	-0.060	-0.097*
	(0.033)	(0.036)	(0.227)	(0.018)	(0.037)	(0.054)
Equity to assets	0.067	-0.683	0.481	0.135*	-0.210	-0.465**
	(0.338)	(0.431)	(1.259)	(0.079)	(0.188)	(0.232)
Share of non-interest income	-0.040	-0.126***	0.064	0.005	-0.044*	-0.069
	(0.031)	(0.044)	(0.144)	(0.009)	(0.024)	(0.045)
Constant	0.154**	-0.058	-0.869*	-0.012	-0.019	0.069
	(0.068)	(0.079)	(0.466)	(0.031)	(0.033)	(0.097)
Observations	4502	4502	4502	24467	24467	24467
Banks	63	63	63	438	438	438
R^2 (within)	0.007	0.203	0.045	0.004	0.065	0.008

Table 4: Panel regression results in which we exploit the regional differences within the Euro Area to examine the transmission of monetary policy shocks. The periphery countries are Greece, Italy, Ireland, Portugal and Spain. This table shows only the coefficients of the interaction effects β_i $(i = 0 \dots K)$ as presented in equation 6. The model is estimated using bank fixed effects. Standard errors in parentheses are clustered on both the bank and month level to control for within bank autocorrelation and common shocks. Stars indicate significance levels: *, **, *** represent significance at the 10%, 5%, and 1% level respectively.

	Euro Area Periphery			**Euro Area Core**		
	ΔLRMES	**ΔMV**	**ΔSMV**	**ΔLRMES**	**ΔMV**	**ΔSMV**
	(1)	(2)	(3)	(4)	(5)	(6)
Loans to earning assets	0.074	-0.113**	-0.256***	-0.060**	-0.010	-0.413
	(0.045)	(0.046)	(0.092)	(0.025)	(0.052)	(0.529)
Non-performing loans to loans	-0.007	-0.122	-0.165	0.039	-0.517*	0.591
	(0.093)	(0.179)	(0.256)	(0.212)	(0.274)	(1.085)
RWA to earning assets	-0.084*	0.154**	0.241**	-0.016	0.194***	-0.230
	(0.051)	(0.069)	(0.094)	(0.050)	(0.067)	(0.328)
Size	-0.011***	0.016***	0.040***	-0.007***	0.018***	0.038*
	(0.003)	(0.004)	(0.005)	(0.003)	(0.006)	(0.021)
Deposits to liabilities	0.009	-0.049	-0.094	0.009	-0.098*	0.594
	(0.035)	(0.040)	(0.083)	(0.020)	(0.053)	(0.631)
Equity to assets	0.577	-1.066**	-1.925**	-0.595	-0.342	4.166
	(0.405)	(0.521)	(0.831)	(0.391)	(0.583)	(2.566)
Share of non-interest income	-0.071	-0.096	-0.035	-0.002	-0.169***	0.012
	(0.053)	(0.062)	(0.156)	(0.028)	(0.052)	(0.213)
Constant	0.167**	-0.060	-0.342**	0.194***	-0.169	-0.856
	(0.068)	(0.096)	(0.164)	(0.056)	(0.136)	(0.527)
Observations	2891	2891	2891	1611	1611	1611
Banks	37	37	37	26	26	26
R^2 (within)	0.016	0.189	0.108	0.012	0.311	0.041

Table 5: Panel regression results in which we exploit the granularity of the U.S. data to examine the transmission of monetary policy shocks. For comparison we also add the baseline results as presented in table 3. This table shows only the coefficients of the interaction effects β_i $(i = 0 \dots K)$ as presented in equation 6. The model is estimated using bank fixed effects. Standard errors in parentheses are clustered on both the bank and month level to control for within bank autocorrelation and common shocks. Stars indicate significance levels: *, **, *** represent significance at the 10%, 5%, and 1% level respectively.

	ΔLRMES		**ΔMV**		**ΔSMV**	
	(1)	(2)	(3)	(4)	(5)	(6)
Loans to earning assets	-0.001		0.021		-0.025	
	(0.019)		(0.020)		(0.033)	
Cons. loans to earning assets		0.029		0.025***		-0.038
		(0.022)		(0.003)		(0.047)
RE loans to earning assets		-0.001		0.017***		-0.014
		(0.014)		(0.005)		(0.023)
Bus. loans to earning assets		0.010		-0.033*		-0.115**
		(0.033)		(0.019)		(0.049)
Non-performing loans to loans	0.025	0.065	-0.071	-0.158	0.011	-0.123
	(0.098)	(0.104)	(0.179)	(0.187)	(0.255)	(0.261)
RWA to earning assets	-0.039*	-0.040*	0.077*	0.080*	0.132*	0.139**
	(0.020)	(0.024)	(0.044)	(0.042)	(0.068)	(0.060)
Size	0.001	0.001	0.003	0.001	-0.003	-0.005
	(0.002)	(0.002)	(0.003)	(0.003)	(0.008)	(0.007)
Deposits to liabilities	0.034*		-0.060		-0.097*	
	(0.018)		(0.037)		(0.054)	
Share of core funding		0.043***		-0.063*		-0.114**
		(0.017)		(0.034)		(0.051)
NSFR		0.001		-0.022		-0.022
		(0.011)		(0.022)		(0.037)
Equity to assets	0.135*	0.079	-0.210	-0.083	-0.465**	-0.283
	(0.079)	(0.072)	(0.188)	(0.133)	(0.232)	(0.185)
Share of non-interest income	0.005		-0.044*		-0.069	
	(0.009)		(0.024)		(0.045)	
Share of fee income		-0.052		0.259*		0.240
		(0.060)		(0.137)		(0.192)
Share of fiduciary income		-0.007		0.014		-0.012
		(0.019)		(0.022)		(0.041)
Share of trading income		0.004		0.062		0.084
		(0.029)		(0.071)		(0.183)
Share of insurance income		0.024		-0.088		-0.159**
		(0.033)		(0.060)		(0.070)
Constant	-0.012	-0.004	-0.019	-0.011	0.069	0.064
	(0.031)	(0.032)	(0.033)	(0.036)	(0.097)	(0.118)
Observations	24467	24467	24467	24467	24467	24467
Banks	438	438	438	438	438	438
R^2 (within)	0.004	0.005	0.065	0.070	0.008	0.011

Figures

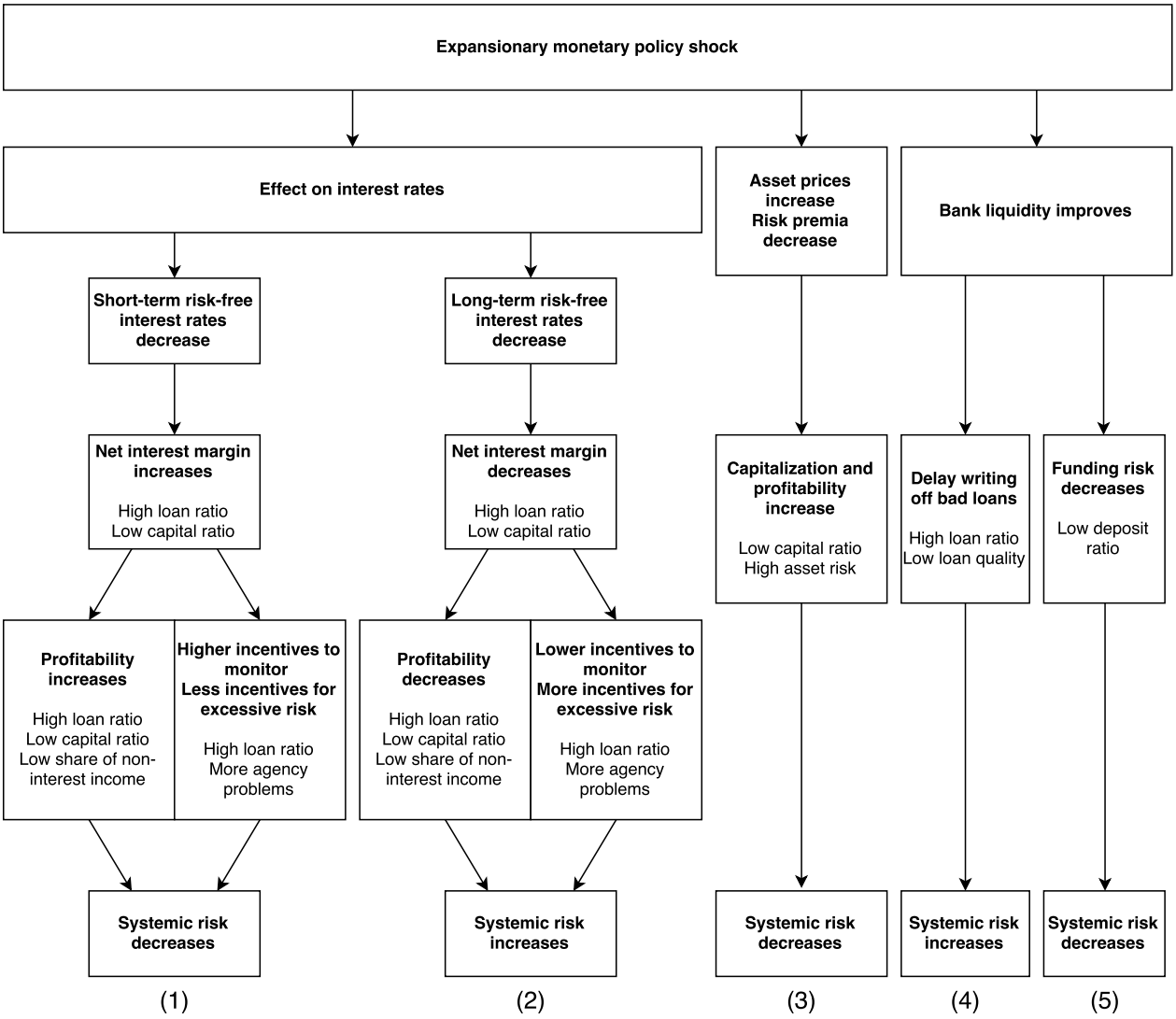
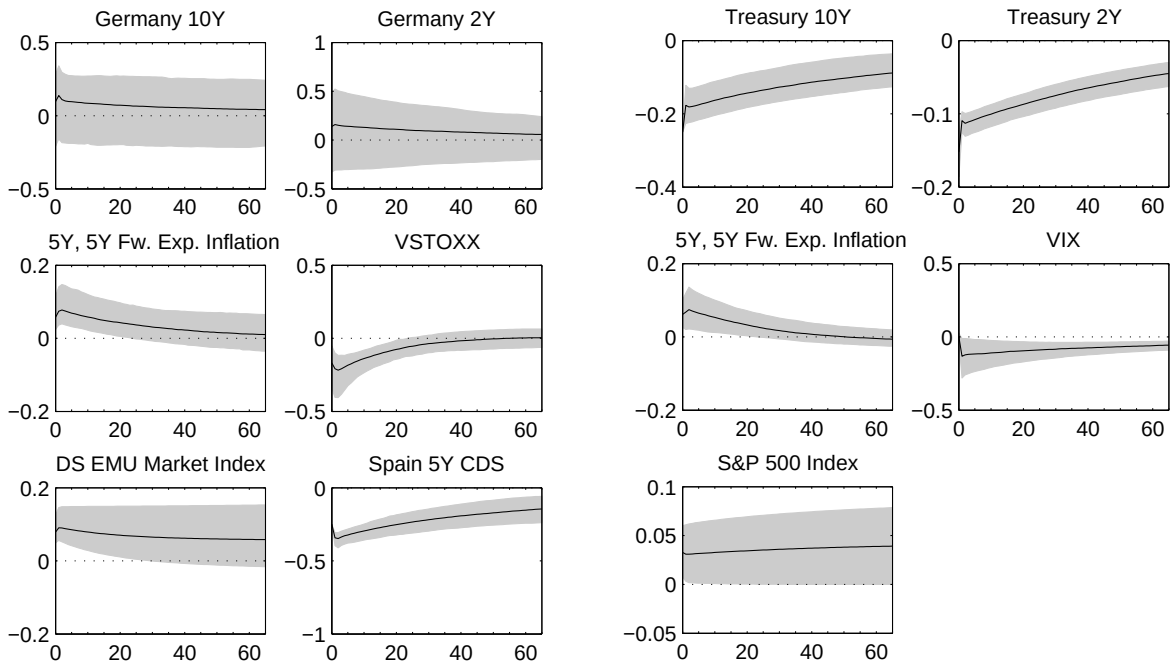
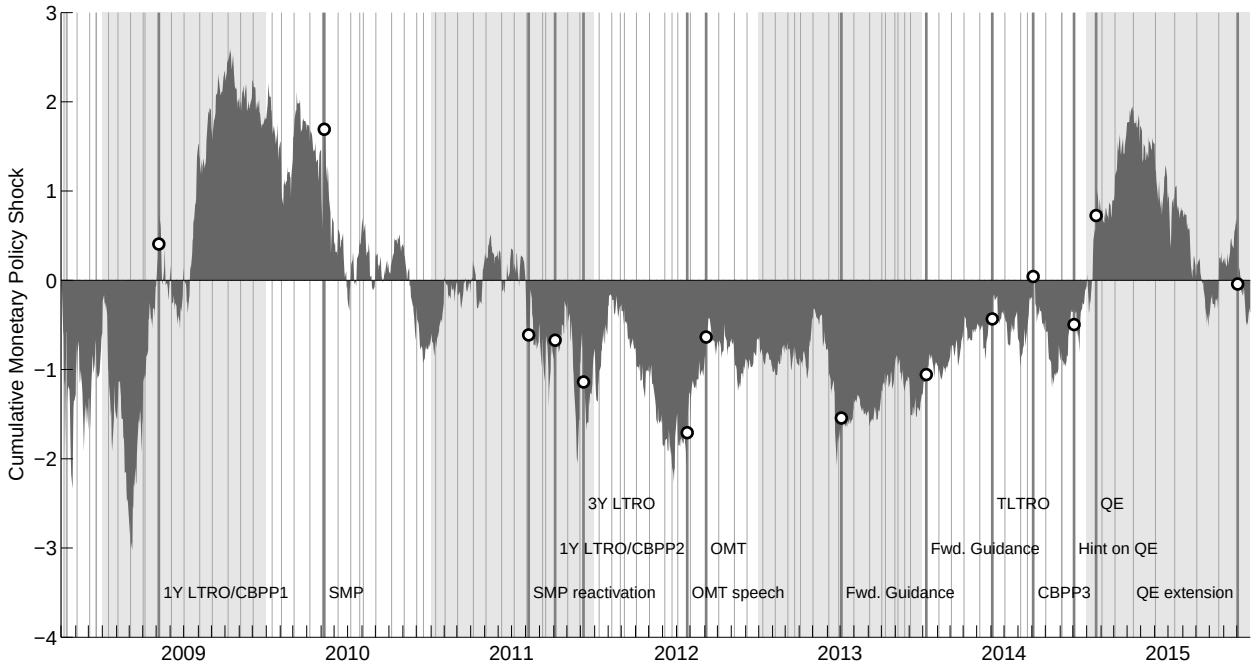


Figure 1: Diagram summarizing the heterogeneous transmission of monetary policy to bank systemic risk.

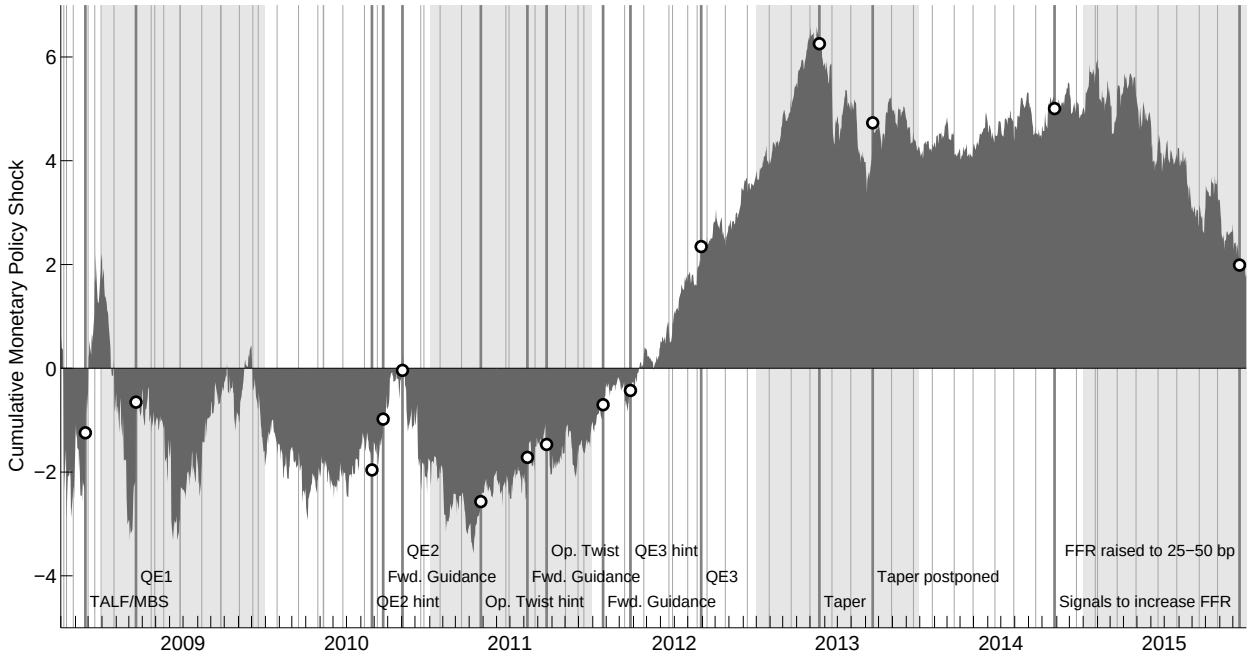


(a) Euro Area **(b)** United States

Figure 2: Impulse response function of the variables to a unit monetary policy shock. Gray areas represent 68% confidence intervals that are obtained through a stationary bootstrap with expected block length 10 for non-announcement days. Announcement day residuals are bootstrapped separately. The horizontal axis represents the horizon of the impulse response function in working days, i.e. the IRF's are plotted for a horizon of one quarter (13 weeks).



(a) Euro Area



(b) United States

Figure 3: Time series of the cumulative monetary policy shocks for the Euro Area and the United States. An increase of the cumulative shock series reflects an expansionary monetary policy announcement. The shocks have been standardized so that a unit increase corresponds to a 25 basis point decrease on impact of the Spanish 5 year CDS spread and the 10 year treasury bill yield for Euro Area and the the United States, respectively. Vertical lines represent the set of announcement dates used in the estimation of the shock. Circles indicate the highlighted announcement days.

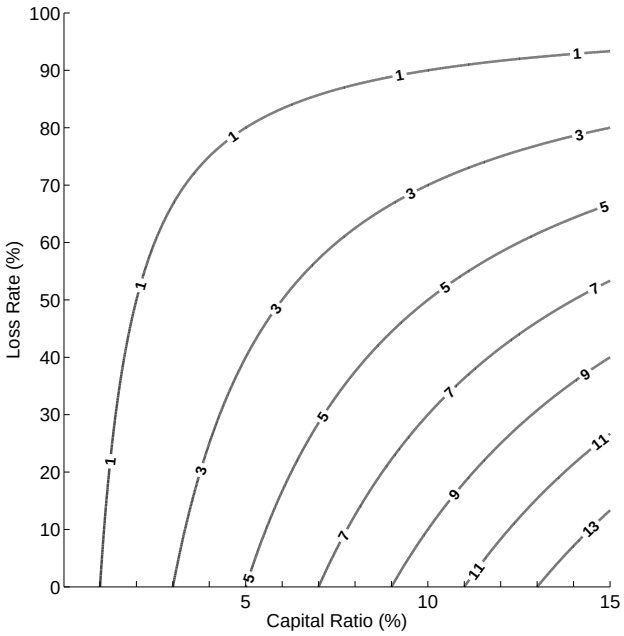
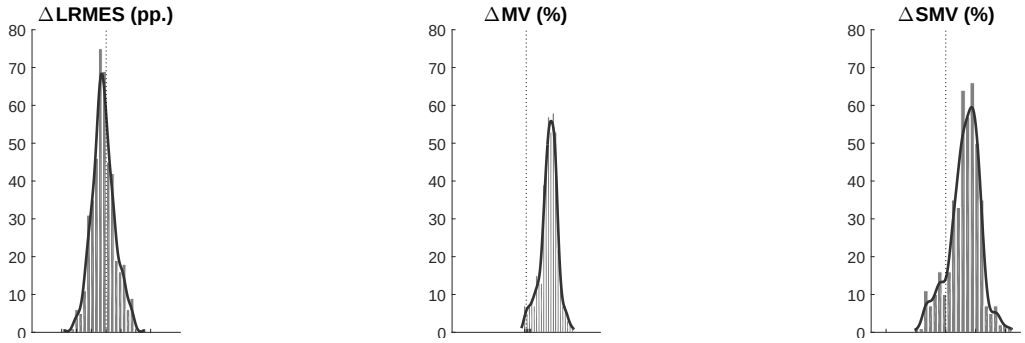
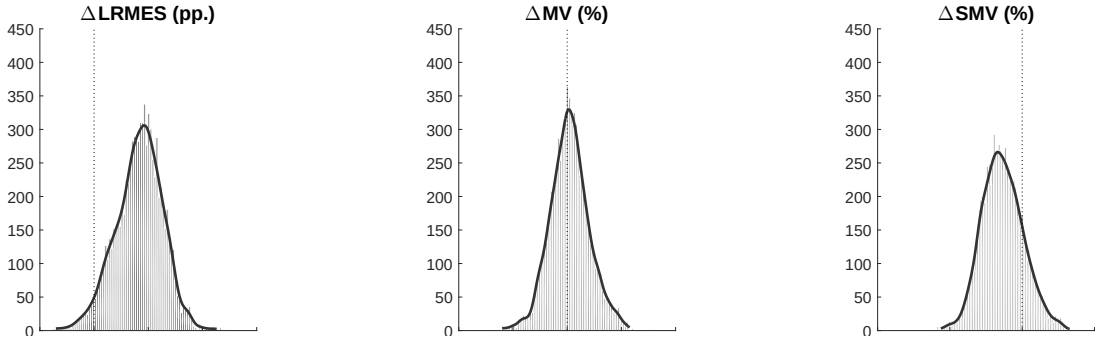


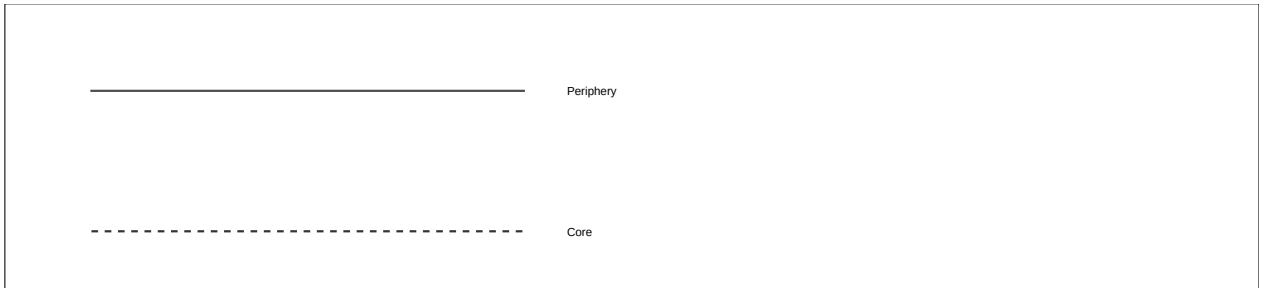
Figure 4: Isoquants for equal levels of systemic risk. The horizontal axis represents the *pre-shock* level of the capital ratio, while the vertical axis reflects the proportion of equity capital that would be lost in the event of a severe system-wide financial shock. The labels on the isoquants indicate the *post-shock* capital ratios, so that a lower level reflects higher systemic riskiness.



(a) Euro Area



(b) United States



(c) Euro Area core and periphery

Figure 5: Histograms and estimated kernel densities for the total impact of a unit monetary policy shock on $\Delta LRMES$ (in percentage points), ΔMV and ΔSMV (both as percentages) over a one-month horizon. Figures 5a and 5b are based on the results presented in table 3, while figure 5c is constructed using the results of table 4, in which we perform separate estimations for Euro Area core and periphery countries. The periphery countries are Greece, Italy, Ireland, Portugal and Spain.

AppendixA. Details of monetary policy announcements

Table A.1: ECB announcement dates and content.

Date	Details of announcement
08/10/2008	MRO rate decreased to 3.75% + The GovC decided to adopt a fixed rate tender procedure with full allotment
13/10/2008	The GovC decided to conduct U.S. dollar liquidity-providing operations at FRFA
15/10/2008	The GovC decided to expand the list of assets eligible as collateral, enhance the provision of longer-term refinancing operations, and provide U.S. dollar liquidity through foreign exchange swaps
06/11/2008	MRO rate decreased to 3.25%
04/12/2008	MRO rate decreased to 2.50%
18/12/2008	The GovC decided that the main refinancing operations will continue to be carried out through a fixed rate tender procedure with full allotment for as long as needed
19/12/2008	The GovC decided to continue conducting U.S. dollar liquidity-providing operations
15/01/2009	MRO rate decreased to 2.00%
05/02/2009	Interest rates remain unchanged
05/03/2009	The GovC decided to continue the fixed rate tender procedure with full allotment for all main refinancing operations, special-term refinancing operations and supplementary and regular longer-term refinancing operations for as long as needed + MRO rate decreased to 1.50%
02/04/2009	MRO rate decreased to 1.25%
06/04/2009	The GovC decided to establish a temporary reciprocal currency arrangement (swap line) with the Fed
07/05/2009	The GovC decided to proceed with the ECS. In particular, the GovC decided to purchase euro-denominated covered bonds issued in the Euro Area, and to conduct liquidity-providing longer-term refinancing operations with a maturity of one year, MRO rate decreased to 1%
04/06/2009	The GovC decided upon the technical modalities of the CBPP1
02/07/2009	Interest rates remain unchanged
06/08/2009	Interest rates remain unchanged
03/09/2009	Interest rates remain unchanged
08/10/2009	Interest rates remain unchanged
05/11/2009	Interest rates remain unchanged
03/12/2009	The GovC decided to continue conducting its main refinancing operations as fixed rate tender procedures with full allotment for as long as is needed, and to enhance the provision of longer-term refinancing operations (no interest changes)
14/01/2010	Interest rates remain unchanged
04/02/2010	Interest rates remain unchanged
04/03/2010	The GovC decided to continue conducting its main refinancing operations as fixed rate tender procedures with full allotment for as long as is needed, and to return to variable rate tender procedures in the regular 3-month longer-term refinancing operations
08/04/2010	Interest rates remain unchanged
06/05/2010	Interest rates remain unchanged
10/05/2010	The GovC decided to proceed with the SMP, to reactivate the temporary liquidity swap lines with the Fed, to adopt a fixed-rate tender procedure with full allotment in the regular 3-month longer-term refinancing operations, and to conduct new special longer-term refinancing operations
10/06/2010	The GovC decided to adopt a fixed rate tender procedure with full allotment in the regular 3-month longer-term refinancing operations
08/07/2010	Interest rates remain unchanged
28/07/2010	Collateral rules tightened, revised haircuts
05/08/2010	Interest rates remain unchanged
02/09/2010	The GovC decided to continue to conduct its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, and to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment (no interest changes)
07/10/2010	Interest rates remain unchanged
04/11/2010	Interest rates remain unchanged
02/12/2010	The GovC decided to continue to conduct its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, and to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment (no interest changes)
17/12/2010	The ECB announced a temporary swap facility with the Bank of England

Table A.1: ECB announcement dates and content.

Date	Details of announcement
13/01/2011	Interest rates remain unchanged
03/02/2011	Interest rates remain unchanged
03/03/2011	The GovC decided to continue to conduct its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, and to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment (no interest changes)
07/04/2011	MRO rate increased to 1.25%
05/05/2011	Interest rates remain unchanged
09/06/2011	The GovC decided to continue to conduct its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, and to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment (no interest changes)
07/07/2011	MRO rate increased to 1.50%
04/08/2011	The GovC decided to continue conducting its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment, and to conduct a liquidity-providing supplementary longer-term refinancing operation with a maturity of six months as a fixed rate tender procedure with full allotment,SMP covers Spain and Italy (no interest changes)
08/08/2011	The GovC decided to actively implement its Securities Markets Programme for Italy and Spain
08/09/2011	Interest rates remain unchanged
15/09/2011	The GovC decided to conduct three U.S. dollar liquidity-providing operations in coordination with other central banks
06/10/2011	The GovC decided to continue conducting its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment, to conduct two liquidity-providing supplementary longer-term refinancing operation with a maturity of twelve and thirteen months as a fixed rate tender procedure with full allotment, and to launch a new covered bond purchase program (CBPP2)
03/11/2011	The GovC decided upon the technical modalities of CBPP2, MRO rate decreased 1.25% (marginal lending facility:2%, deposit facility: 0.5%)
30/11/2011	The GovC decided in cooperation with other central banks the establishment of a temporary network of reciprocal swap lines
08/12/2011	The GovC decided to conduct two longer-term refinancing operations with a maturity of three years and to increase collateral availability,reserve ratio to 1%, MRO rate to 1%
12/01/2012	Interest rates remain unchanged
09/02/2012	The GovC approved specific national eligibility criteria and risk control measures for the temporary acceptance in a number of countries of additional credit claims as collateral in Eurosystem credit operations (no interest changes)
28/02/2012	The Governing Council of the European Central Bank (ECB) has decided to temporarily suspend the eligibility of marketable debt instruments issued or fully guaranteed by the Hellenic Republic for use as collateral in Eurosystem monetary policy operations.
08/03/2012	Interest rates remain unchanged
04/04/2012	Interest rates remain unchanged
03/05/2012	Interest rates remain unchanged
06/06/2012	The GovC decided to continue to conduct its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, and to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment
22/06/2012	The GovC took further measures to increase collateral availability for counterparties
05/07/2012	MRO rate decreased to 0.75%, deposit facility rate to 0
26/07/2012	Draghi's London speech ("...the ECB is ready to do whatever it takes to preserve the euro.")
02/08/2012	Interest rates remain unchanged
06/09/2012	The GovC announced the technical details of OMT (no ex-ante size limit) and decided on additional measures to preserve collateral availability (no interest changes)
04/10/2012	Interest rates remain unchanged
08/11/2012	Interest rates remain unchanged
06/12/2012	The GovC decided to continue conducting its main refinancing operations as fixed rate tender procedures with full allotment for as long as necessary, and to conduct 3-month longer-term refinancing operations as fixed rate tender procedures with full allotment
10/01/2013	Interest rates remain unchanged

Table A.1: ECB announcement dates and content.

Date	Details of announcement
07/02/2013	Interest rates remain unchanged
07/03/2013	Interest rates remain unchanged
22/03/2013	ECB announces changes to the use as collateral of certain uncovered government-guaranteed bank bonds
04/04/2013	Interest rates remain unchanged
02/05/2013	ECB announces change in eligibility of marketable debt instruments issued or guaranteed by the Cypriot government ,MRO rate to 0.5%, FRFA extended to July 2014
06/06/2013	Interest rates remain unchanged
28/06/2013	Eligibility of marketable debt instruments issued or guaranteed by the Republic of Cyprus
04/07/2013	The Governing Council expects the key ECB interest rates to remain at present or lower levels for an extended period of time .
01/08/2013	Interest rates remain unchanged
05/09/2013	Interest rates remain unchanged
02/10/2013	Interest rates remain unchanged
10/10/2013	ECB and the People's Bank of China establish a bilateral currency swap agreement
31/10/2013	ECB establishes standing swap arrangements with other central banks
07/11/2013	MRO rate decreases to 0,25%
22/11/2013	ECB suspends early repayments of the three-year LTRO's during the year-end period
05/12/2013	Interest rates remain unchanged
09/01/2014	Interest rates remain unchanged, the ECB emphasized the importance of the forward guidance through the sentence "we firmly reiterate our forward guidance "
06/02/2014	Interest rates remain unchanged
06/03/2014	Interest rates remain unchanged
03/04/2014	Interest rates remain unchanged
08/05/2014	Interest rates remain unchanged
05/06/2014	ECB decides to conduct a series of targeted longer-term refinancing operations (TLTRO's) aimed at improving bank lending and to intensify preparatory work related to outright purchases of asset-backed securities (ABS). , ECB introduces a negative deposit facility interest rate , MRO rate decreases to 0,15%
03/07/2014	ECB announces further details of the targeted longer-term refinancing operations
07/08/2014	Interest rates remain unchanged
22/08/2014	Draghi hints on QE (Jackson Hole speech)
04/09/2014	ECB modifies loan-level reporting requirements for some asset-backed securities/MRO rate decreases to 0,05%
02/10/2014	ECB announces operational details of asset-backed securities and covered bond purchase programs (no interest changes)
06/11/2014	Interest rates remain unchanged
07/11/2014	ECB suspends early repayments of the three-year LTRO's during the year-end period
04/12/2014	Interest rates remain unchanged
22/01/2015	ECB announces a modification to the interest rate applicable to future targeted longer-term refinancing operations, ECB announces expanded asset purchase program
04/02/2015	Eligibility of Greek bonds used as collateral in Eurosystem monetary policy operations
05/03/2015	Interest rates remain unchanged
15/04/2015	Interest rates remain unchanged
03/06/2015	Interest rates remain unchanged
16/07/2015	Interest rates remain unchanged
03/09/2015	Interest rates remain unchanged
22/10/2015	Interest rates remain unchanged
03/12/2015	Deposit facility rate decreases to -0,3% + extension of QE "until end March 2017"

Table A.2: Federal Reserve announcement dates and content.

Date	Details of announcement
08/10/2008	The Federal Open Market Committee has decided to lower its target for the federal funds rate 50 basis points to 1-1/2 percent.
14/10/2008	FOMC authorizes an increase in the size of its temporary reciprocal currency arrangement with the Bank of Japan
29/10/2008	The Federal Open Market Committee decided today to lower its target for the federal funds rate 50 basis points to 1 percent.
25/11/2008	Federal Reserve announces the creation of the Term Asset-Backed Securities Loan Facility (TALF) and will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises (GSE's)–Fannie Mae, Freddie Mac, and the Federal Home Loan Banks–and mortgage-backed securities (MBS) backed by Fannie Mae, Freddie Mac, and Ginnie Mae.
01/12/2008	Bernanke, speaking in Austin, indicates that the Fed may engage in future QE actions -specifically mentioning long-term Treasuries
16/12/2008	The Federal Reserve cuts the target Federal Funds rate to zero
30/12/2008	Federal Reserve announces details of program to purchase mortgage-backed securities
28/01/2009	FOMC keeps rates low, confirms future actions could include QE expansion
18/03/2009	Expansion of QE, more than doubling agency purchases and adding $300 billion in long-term Treasuries, for a total commitment of $1.2T, the Committee decided to purchase up to an additional $750 billion of agency mortgage-backed securities, and to increase its purchases of agency debt this year by up to $100 billion to a total of up to $200 billion.
29/04/2009	The Federal Reserve will purchase a total of up to $1.25 trillion of agency mortgage-backed securities and up to $200 billion of agency debt by the end of the year. In addition, the Federal Reserve will buy up to $300 billion of Treasury securities by autumn
19/05/2009	Federal Reserve announces that certain high-quality commercial mortgage-backed securities will become eligible collateral under the Term Asset-Backed Securities Loan Facility (TALF)
24/06/2009	The Federal Reserve will purchase a total of up to $1.25 trillion of agency mortgage-backed securities and up to $200 billion of agency debt by the end of the year. In addition, the Federal Reserve will buy up to $300 billion of Treasury securities by autumn.
25/06/2009	The Federal Reserve on Thursday announced extensions of and modifications to a number of its liquidity programs.
12/08/2009	Fed funds to be held near zero, finished purchasing agency assets by October
23/09/2009	Finished purchasing Treasuries in "next few months":As previously announced, the Federal Reserve's purchases of $300 billion of Treasury securities will be completed by the end of October 2009.the Federal Reserve will purchase a total of $1.25 trillion of agency mortgage-backed securities and up to $200 billion of agency debt.
24/09/2009	The Federal Reserve on Thursday announced schedules for operations under the Term Auction Facility (TAF) and the Term Securities Lending Facility (TSLF) through January 2010 and other information related to those facilities
04/11/2009	The amount of agency debt purchases, while somewhat less than the previously announced maximum of $200 billion, is consistent with the recent path of purchases and reflects the limited availability of agency debt. In order to promote a smooth transition in markets, the Committee will gradually slow the pace of its purchases of both agency debt and agency mortgage-backed securities and anticipates that these transactions will be executed by the end of the first quarter of 2010
16/12/2009	The Committee and the Board of Governors anticipate that most of the Federal Reserve's special liquidity facilities will expire on February 1, 2010. The amounts provided under the Term Auction Facility will continue to be scaled back in early 2010. The anticipated expiration dates for the Term Asset-Backed Securities Loan Facility remain set at June 30, 2010, for loans backed by new-issue commercial mortgage-backed securities and March 31, 2010, for loans backed by all other types of collateral
27/01/2010	To provide support to mortgage lending and housing markets and to improve overall conditions in private credit markets, the Federal Reserve is in the process of purchasing $1.25 trillion of agency mortgage-backed securities and about $175 billion of agency debt.
16/03/2010	To provide support to mortgage lending and housing markets and to improve overall conditions in private credit markets, the Federal Reserve has been purchasing $1.25 trillion of agency mortgage-backed securities and about $175 billion of agency debt
28/04/2010	The Committee will maintain the target range for the federal funds rate at 0 to 1/4 percent and continues to anticipate that economic conditions, including low rates of resource utilization, subdued inflation trends, and stable inflation expectations, are likely to warrant exceptionally low levels of the federal funds rate for an extended period. The Committee will continue to monitor the economic outlook and financial developments and will employ its policy tools as necessary to promote economic recovery and price stability.

Table A.2: Federal Reserve announcement dates and content.

Date	Details of announcement
09/05/2010	FOMC statement: Federal Reserve, European Central Bank, Bank of Canada, Bank of England, and Swiss National Bank announce reestablishment of temporary U.S. dollar liquidity swap facilities
10/05/2010	FOMC statement: FOMC authorizes re-establishment of temporary U.S. dollar liquidity swap arrangement with the Bank of Japan
11/05/2010	Federal Reserve releases agreements with foreign central banks to reestablish temporary dollar swap facilities
23/06/2010	The Committee will maintain the target range for the federal funds rate at 0 to 1/4 percent and continues to anticipate that economic conditions, including low rates of resource utilization, subdued inflation trends, and stable inflation expectations, are likely to warrant exceptionally low levels of the federal funds rate for an extended period.
10/08/2010	The Committee will maintain the target range for the federal funds rate at 0 to 1/4 percent and continues to anticipate that economic conditions, including low rates of resource utilization, subdued inflation trends, and stable inflation expectations, are likely to warrant exceptionally low levels of the federal funds rate for an extended period. The Fed will begin reinvesting earnings from agency purchases back into Treasuries to maintain the balance sheet
27/08/2010	Bernanke Speech at Jackson Hole: Bernanke hints on QE2
08/09/2010	The Federal Reserve Board on Wednesday announced that it has authorized ongoing small-value offerings of term deposits under the Term Deposit Facility (TDF).
21/09/2010	The Committee will maintain the target range for the federal funds rate at 0 to 1/4 percent and continues to anticipate that economic conditions, including low rates of resource utilization, subdued inflation trends, and stable inflation expectations, are likely to warrant exceptionally low levels of the federal funds rate for an extended period + Fed commits to maintaining reinvestment of earnings
03/11/2010	The Committee intends to purchase a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011, a pace of about $75 billion per month.
14/12/2010	The Committee will maintain its existing policy of reinvesting principal payments from its securities holdings. In addition, the Committee intends to purchase $600 billion of longer-term Treasury securities by the end of the second quarter of 2011, a pace of about $75 billion per month.
21/12/2010	FOMC statement: Federal Reserve, European Central Bank, Bank of Japan, Bank of Canada, Bank of England, and Swiss National Bank announce extension of temporary U.S. dollar liquidity swap facilities
26/01/2011	The Committee is maintaining its existing policy of reinvesting principal payments from its securities holdings and intends to purchase $600 billion of longer-term Treasury securities by the end of the second quarter of 2011
15/03/2011	The Committee is maintaining its existing policy of reinvesting principal payments from its securities holdings and intends to purchase $600 billion of longer-term Treasury securities by the end of the second quarter of 2012
27/04/2011	Fed hints at Maturity Extension Program ("Operation twist") and announces end of QE2 as planned + the Committee is maintaining its existing policy of reinvesting principal payments from its securities holdings and will complete purchases of $600 billion of longer-term Treasury securities by the end of the current quarter.
22/06/2011	The Committee will complete its purchases of $600 billion of longer-term Treasury securities by the end of this month and will maintain its existing policy of reinvesting principal payments from its securities holdings.
29/06/2011	Federal Reserve and other central banks announce an extension of the existing temporary U.S. dollar liquidity swap arrangements through August 1, 2012
09/08/2011	The Committee also will maintain its existing policy of reinvesting principal payments from its securities holdings to warrant exceptionally low levels for the federal funds rate at least through mid-2013.
26/08/2011	Bernanke Speech at Jackson Hole: The Fed chairman did not announce third round of QE, but reiterated the "range of tools" available to the Fed
21/09/2011	The Committee decided today to extend the average maturity of its holdings of securities. The Committee intends to purchase, by the end of June 2012, $400 billion of Treasury securities with remaining maturities of 6 years to 30 years and to sell an equal amount of Treasury securities with remaining maturities of 3 years or less.
02/11/2011	The Committee decided today to continue its program to extend the average maturity of its holdings of securities and to warrant exceptionally low levels for the federal funds rate at least through mid-2013.
30/11/2011	Coordinated central bank action to address pressures in global money markets : liquidity swap agreements

Table A.2: Federal Reserve announcement dates and content.

Date	Details of announcement
13/12/2011	The Committee is maintaining its existing policies of reinvesting principal payments from its holdings of agency debt and agency mortgage-backed securities and to warrant exceptionally low levels for the federal funds rate at least through mid-2013.
25/01/2012	The Committee expects to maintain a highly accommodative stance for monetary policy and to warrant exceptionally low levels for the federal funds rate at least through late 2014.
13/03/2012	The Committee expects to maintain a highly accommodative stance for monetary policy and to warrant exceptionally low levels for the federal funds rate at least through late 2014.
25/04/2012	The Committee expects to maintain a highly accommodative stance for monetary policy and to warrant exceptionally low levels for the federal funds rate at least through late 2014.
20/06/2012	MEP is expanded by an additional $267 billion
28/06/2012	The Federal Reserve Board on Thursday announced that it agreed with the Treasury Department that it was appropriate to reduce from $4.3 billion to $1.4 billion the credit protection Treasury is providing for the Term Asset-Backed Securities Loan Facility (TALF).
01/08/2012	The Committee expects to maintain a highly accommodative stance for monetary policy and to warrant exceptionally low levels for the federal funds rate at least through late 2014.
22/08/2012	FOMC minutes: the FED will take new measures if necessary
31/08/2012	Bernanke Speech at Jackson Hole: Bernanke hints on QE3
13/09/2012	The Committee agreed today to increase policy accommodation by purchasing additional agency mortgage-backed securities at a pace of $40 billion per month. the Committee also decided today to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that exceptionally low levels for the federal funds rate are likely to be warranted at least through mid-2015.
24/10/2012	The Committee will continue purchasing additional agency mortgage-backed securities at a pace of $40 billion per month
12/12/2012	The Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal + QE3 Expansion: adding $45 billion per month in Treasury purchases
30/01/2013	The Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal,
20/03/2013	The Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal,
01/05/2013	The Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal,
22/05/2013	Bernanke's actual testimony admits the possibility of tapering in the near future ("taper tantrum" event)
19/06/2013	The Fed will continue purchases in near future; Bernanke's accompanying comments discuss tapering purchases later that year and ceasing by following summer
31/07/2013	The Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal,
18/09/2013	FED decides not to tamper: improvement but the Committee decided to await more evidence that progress will be sustained before adjusting the pace of its purchases
30/10/2013	FED decides not to tamper: the Committee decided to await more evidence that progress will be sustained before adjusting the pace of its purchases
18/12/2013	The Committee decided to modestly reduce the pace of its asset purchases.

Table A.2: Federal Reserve announcement dates and content.

Date	Details of announcement
29/01/2014	The Committee decided to make a further measured reduction in the pace of its asset purchases. Beginning in February, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $30 billion per month rather than $35 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $35 billion per month rather than $40 billion per month.
19/03/2014	The Committee will add to its holdings of agency mortgage-backed securities at a pace of $25 billion per month rather than $30 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $30 billion per month rather than $35 billion per month.
30/04/2014	the Committee will add to its holdings of agency mortgage-backed securities at a pace of $20 billion per month rather than $25 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $25 billion per month rather than $30 billion per month.
18/06/2014	The Committee will add to its holdings of agency mortgage-backed securities at a pace of $15 billion per month rather than $20 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $20 billion per month rather than $25 billion per month.
30/07/2014	The Committee will add to its holdings of agency mortgage-backed securities at a pace of $10 billion per month rather than $15 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $15 billion per month rather than $20 billion per month.
17/09/2014	The Committee will add to its holdings of agency mortgage-backed securities at a pace of $5 billion per month rather than $10 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $10 billion per month rather than $15 billion per month+the Federal Open Market Committee (FOMC) discussed ways to normalize the stance of monetary policy and the Federal Reserve's securities holdings.
29/10/2014	However, if incoming information indicates faster progress toward the Committee's employment and inflation objectives than the Committee now expects, then increases in the target range for the federal funds rate are likely to occur sooner than currently anticipated. Conversely, if progress proves slower than expected, then increases in the target range are likely to occur later than currently anticipated.
17/12/2014	The committee judges that it can be patient in beginning to normalize the stance of monetary policy
28/01/2015	The Committee judges that it can be patient in beginning to normalize the stance of monetary policy.
02/02/2015	The Federal Reserve plans to conduct a series of three weekly TDF operations in February that offer 21-day term deposits with an early withdrawal feature
18/03/2015	The Committee judges that an increase in the target range for the federal funds rate remains unlikely at the April FOMC meeting.
29/04/2015	The Committee anticipates that it will be appropriate to raise the target range for the federal funds rate when it has seen further improvement in the labor market and is reasonably confident that inflation will move back to its 2 percent objective over the medium term.
17/06/2015	The Committee anticipates that it will be appropriate to raise the target range for the federal funds rate when it has seen further improvement in the labor market and is reasonably confident that inflation will move back to its 2 percent objective over the medium term.
29/07/2015	The Committee anticipates that it will be appropriate to raise the target range for the federal funds rate when it has seen further improvement in the labor market and is reasonably confident that inflation will move back to its 2 percent objective over the medium term.
17/09/2015	The Committee anticipates that it will be appropriate to raise the target range for the federal funds rate when it has seen further improvement in the labor market and is reasonably confident that inflation will move back to its 2 percent objective over the medium term.
28/10/2015	The Committee anticipates that it will be appropriate to raise the target range for the federal funds rate when it has seen further improvement in the labor market and is reasonably confident that inflation will move back to its 2 percent objective over the medium term.
16/12/2015	The Committee decided to raise the target range for the federal funds rate to 1/4 to 1/2 percent.