The Tradeoff between Monetary Policy and Bank Stability*

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This paper investigates the transmission of monetary policy to systemic risk of euro-area and U.S. banks between 2008 and 2015. Using market measures of systemic risk and a VAR to obtain monetary policy shocks, we find that accommodative policy generally has a positive effect on bank stability in the euro area but a negative effect in the United States. Different transmission channels are at play: in the euro area the effect works mainly through a stealth recapitalization channel, while in the United States the effect is due to risk-shifting. Moreover, transmission of monetary policy differs across bank business models.

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1. Introduction

Since the major central banks have embarked on programs of unconventional monetary policy, the potential tradeoff between monetary

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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 tradeoff between the mandated monetary policy 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. To assess the relative importance of different transmission channels, we allow the impact of monetary policy actions to vary across banks. We therefore investigate how actions undertaken by the European Central Bank (ECB) and the Federal Reserve affect systemic risk of European and U.S. banks as perceived by stock markets.

Our analysis consists of three components. First, we obtain monetary policy shocks by estimating a structural vector autoregression (VAR). The monetary policy shock is identified by assuming that its variance increases on days on which there is a monetary policy announcement. This "identification-through-heteroskedasticity" approach, which was first proposed by Rigobon and Sack (2003, 2004), is ultimately based on the assumption that monetary policy announcements 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 one 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 need a measure that reflects bank systemic risk. As outlined in Bisias et al. (2012), more than thirty competing measures have been developed over the past years, ranging from network analysis to macroeconomic and illiquidity indicators. Some of these measures reflect the aggregate level of systemic risk in the financial system, while others assess the individual bank's systemic risk contribution. In line with most of the literature, we estimate bank systemic risk as contributions to systemic risk using financial market information (see, e.g., Acharya, Engle, and Richardson 2012, Billio et al. 2012, Huang, Zhou, and Zhu 2012, van Oordt and Zhou 2014, and Adrian and Brunnermeier 2016 for different approaches). The use of market data has several advantages. First, it allows us to calculate the cross-sectional, bank-specific, systemic risk contributions when the market is in the tail of its distribution. Second, market data enable a forward-looking assessment of banks and incorporate the expectations of market participants. Third, market data is available at a high frequency, which is not the case for accounting-based measures. This ensures that an unexpected increase in a bank's systemic risk contribution can quickly be identified. In this paper we follow Acharya et al. (2010) and use the long-run marginal expected shortfall (*LRMES*). Over the past years, the *LRMES* has received a lot of attention by academia and regulators, and it has become one of the most commonly used metrics in the literature. In this paper, we complement our measure of bank systemic risk with an additional dimension. In particular, we define bank systemic risk as a bank's vulnerability to systemwide stress as well as the ability of a bank to absorb losses. Although accommodating monetary policy can support bank stability through asset revaluations, the low interest rate environment can also induce risk-taking incentives. To account for this potential tradeoff, we construct a measure that incorporates both dimensions. We use the *LRMES* to capture a bank's vulnerability to large financial shocks and we use the market value of equity to capture the loss-absorbing capacity of the bank. This approach allows us to assess the tradeoff between increased bank vulnerability versus better shock absorbency capacity of banks caused by a monetary policy shock.

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 bank's business model, we can furthermore evaluate the relative importance of different transmission channels.

Our results indicate that expansionary monetary policy shocks affect bank systemic risk through different transmission channels in the euro area and the United States. First, consistent with Lambert and Ueda (2014), we find evidence that accommodative monetary policy may delay balance sheet repair in the banking sector by allowing banks more room to postpone recognizing bad loans. Second, our results are in line with the existence of a stealth recapitalization channel, both in the euro area and in the United States. Moreover, our findings indicate that the negative impact of a forbearance channel on bank systemic risk for the peripheral euro-area banks is counteracted by the increased value of the bank's net worth. For the United States we find evidence for the existence of a funding risk channel and a risk-shifting effect, indicating that highly capitalized banks and deposit-funded banks tend to increase systemic risk more than other banks. In general, our results emphasize the importance of the bank business model in the transmission of monetary policy to bank systemic risk.

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 (Paligorova and Santos 2012; Jiménez et al. 2014; Ioannidou, Ongena, and Peydró 2015; Dell'Ariccia, Laeven, and Suarez 2017).[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 as in Altunbas, Gambacorta, and Marques-Ibanez (2014). We furthermore argue that the impact of monetary policy interventions on banks may differ according to the business model following, among others, Brissimis and Delis (2010), Delis and Kouretas (2011), and Ricci (2015). Therefore we assess the importance of a set of bank characteristics that have been shown to determine the long-term profitability and

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

risk profile of the banks (Mergaerts and Vander Vennet 2016) in the transmission of monetary policy to systemic risk.

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, resulting in several testable hypotheses. In sections 3 and 4, we provide details on the methodology and 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 considerations.

2. Monetary Policy and Bank Systemic Risk

In this paper we investigate whether accommodative monetary policy promotes or deteriorates financial stability. Central bank interventions may ease financial conditions but may also affect risk-taking incentives. A negative impact would imply a tradeoff between stimulating the economy and avoiding the buildup of vulnerabilities within the financial system.

2.1 The Transmission of Monetary Policy to Bank Stability

We identify four channels through which monetary policy interventions can affect bank stability, namely (i) the net interest margin channel, (ii) the recapitalization channel, (iii) the funding risk channel, and (iv) the forbearance channel. First, an expansionary monetary policy action feeds through to bank profitability, as falling short-term interest rates are typically associated with increasing net interest margins. A rising net interest margin may affect banks' risk-taking incentives by increasing their payoff of monitoring borrowers (see, e.g., Dell'Ariccia, Laeven, and Marquez 2014). We expect that both improved profitability and lower risk-taking will translate into a higher stock market valuation and lower risk. However, to the extent that the continuous decline of long-term interest rates decreases banks' net interest margins, a further loosening of monetary policy may affect bank profitability negatively (Borio, Gambacorta, and Hofmann 2015; Busch and Memmel 2015) and increase banks' risk-taking, e.g., because of search for yield (Rajan 2005;

Chodorow-Reich 2014). Ex ante, it is unclear which of these effects dominates.

Second, expansionary monetary policy interventions tend to boost asset prices and can therefore be considered what Brunnermeier and Sannikov (2014) have labeled a stealth recapitalization channel, i.e., the increase of the value of (legacy) assets leading to a higher net worth of the bank. If 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.

Third, we distinguish a funding risk channel. In both the euro area and the United States the start of the financial crisis in 2008 was characterized by problems in wholesale funding markets. In response, monetary authorities have undertaken actions to improve liquidity in 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, Dossche, and Peersman 2017) and thereby increase profitability. These effects should translate into a decrease of systemic risk.

Finally, by improving banks' capitalization and lowering their funding risk, monetary policy actions have the potential to reduce bank systemic risk. However, improving profitability, net worth, and funding stability may also allow banks to postpone cleaning up their balance sheets by writing off non-performing loans (Peek and Rosengren 2005; Lambert and Ueda 2014; Acharya et al. 2019). Such a forbearance channel may increase uncertainty about potential future write-offs and hence depress market values and increase bank systemic risk.

2.2 Monetary Policy Transmission and Bank Heterogeneity

While monetary policy interventions are likely to affect bank systemic risk, each bank may be affected differently conditional on bank business model characteristics such as asset, funding, capital, and income structure.

A bank's asset structure, which encompasses both the composition and the quality of assets, may affect the transmission of monetary policy shocks to bank systemic risk through the net interest margin, the stealth recapitalization channel, and the forbearance channel. First, we hypothesize that banks with a higher loans-to-assets ratio react more strongly to monetary policy shocks, because they are more sensitive to changes in the net interest margin. However, the sign of this relationship remains an empirical question, as the impact of expansionary monetary policy on the net interest margin is ambiguous. Second, we expect that increasing collateral values and the improvement of economic and financial conditions is especially beneficial for banks with a riskier asset structure. Banks characterized by a loan-oriented asset composition, finally, may have stronger incentives to use the access to central bank liquidity to delay recognizing bad loans. According to this forbearance channel, markets may 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] With respect to asset risk, we expect that increasing asset prices and decreasing risk premiums through the stealth recapitalization channel may be especially beneficial for banks with a riskier asset structure.

The extent to which the net interest margin channel affects the pass-through of monetary policy interventions to bank systemic risk furthermore depends on a bank's income structure. 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 when long-term rates decrease as well, e.g., as a result of central bank asset purchases.

The impact of a bank's funding structure on the transmission of monetary policy shocks operates mainly through the funding risk channel. We expect that banks that rely more on wholesale

[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, rising to a proportion of 18 percent of total outstanding loans by December 2015. Garrido, Kopp, and Weber (2016) suggest that write-offs may have taken too long because of economic and legal obstacles.

funding may benefit more from accommodative monetary policy actions because access to central bank funding can decrease a bank's vulnerability to liquidity shocks by reducing its dependence on more volatile wholesale markets. Moreover, a high reliance on retail funding may weaken private monitoring because customer deposits are typically covered by deposit insurance. This feature may intensify agency problems (see, e.g., Demirgüç-Kunt and Detragiache 2002, and Demirgüç-Kunt and Huizinga 2004). Mamatzakis and Bermpei (2016) indeed 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 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 effect of monetary policy shocks, the banking literature advances divergent theories. On the one hand, poorly capitalized banks stand to gain most from asset revaluation, especially if they are exposed to a high level of distressed assets. Brunnermeier and Sannikov (2014) therefore use the term stealth recapitalization to describe the impact of improving asset values. 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 (Madura and Schnusenberg 2000; Yin and Yang 2013; Ricci 2015). On the one hand, depressed net interest margins can damage a bank's profitability and thereby increase moral hazard and risk-taking incentives, particularly for banks with lower capital ratios. The search-for-yield hypothesis implies that banks increase risk-taking when interest rates decline and that the strength of this effect increases with the prevalence of agency problems. On the other hand, risk shifting suggests that, as far as expansionary monetary policy increases banks' net interest margins, the incentives to monitor are strengthened and should hence result in lower risk (Dell'Ariccia, Laeven, and Marquez 2014). 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, Laeven, and Suarez (2017) provide evidence supporting the existence of a risk-shifting effect in the United States. In the next sections we investigate the relative strength of these hypotheses.

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.

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). As a result, 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, Gilchrist and Zakrajsek (2013), Rogers, Scotti, and Wright (2014), and Arai (2017).

Estimating the monetary policy shock this way has some advantages over alternative approaches. First, while event studies are often

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

used to identify the impact of monetary policy announcements on bond yields and financial markets (e.g., Taylor and Williams 2009, Gagnon et al. 2011, Joyce et al. 2011, Krishnamurthy and Vissing-Jorgensen 2011, Swanson 2011, and Neely 2015), 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. Event studies moreover 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 United States, adjustment periods may be longer and would hence require longer event windows (Meaning and Zhu 2011; Neely 2015). Finally, some announcements may have been largely anticipated, leading to 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 than 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 (Gambacorta, Hofmann, and Peersman 2014; Garcia Pascual and Wieladek 2016; Boeckx, Dossche, and Peersman 2017), the interbank interest rate (Gambacorta and Shin 2018), long-term interest rates (Chen et al. 2012, 2016; Gilchrist, Lopez-Salido, and Zakrajsek 2015) 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.

[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 quantitative easing (Meinusch and Tillmann 2016).

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 is 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

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

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 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:

(i) 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

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

value 1 on announcement days and 0 on other days, we can write

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

(ii) Using our estimates for V_t, we minimize the following loss function to obtain the estimates for R and Ω_t:

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

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

Steps (ii) and (iii) are iterated until convergence. Using $\hat{R}$ and the GLS 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:

$$\begin{cases} H_0 : \omega_1 = \omega_1^* \\ H_1 : \omega_1 \neq \omega_1^*. \end{cases} \quad (5)$$

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.

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

Table 1. The Financial Market Variables Used in the VAR Model to Obtain the Monetary Policy Shock

Euro Area	United States
Germany Ten-Year Bond Rate	U.S. Trasury Ten-Year Rate
Expected Five-Year Inflation	Expected Five-Year Inflation
Datastream EMU Broad Market Index	S&P 500
VSTOXX	VIX
Spanish Five-Year CDS Spread	

Notes: Inflation expectations are based on inflation swap rates. Data are obtained from Datastream.

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, Scotti, and Wright (2014), we select those variables that are expected to respond most to a monetary policy shock. For both the euro area and the United States we include a 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, specifically the Spanish five-year credit default swap (CDS) spread.[7] Details of the specific variables can be found in table 1. A VAR of order 2 is estimated over a sample period from October 1, 2008 to December 31, 2015.[8]

[7]The rationale for using the Spanish five-year CDS spread is that Spain is the prototypical euro-area periphery country which was hit by the banking crisis, a real estate crisis, and by the sovereign crisis and it was not rescued with loans from the European Financial Stability Facility/European Stability Mechanism (unlike, e.g., Portugal, Ireland, or Greece). However, as a robustness check, we also experimented with other sovereign stress indicators: the five-year CDS spreads of Italy and France, an index of European five-year sovereign CDS spreads, and an index based on the five-year CDS spreads of Spain, Portugal, Italy, and Ireland. Our findings do not appear to be driven by the choice of the sovereign stress indicator.

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

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 (LTROs), central bank funding conditions, forward guidance, and new swap arrangements with other central banks.[9] Federal Reserve announcement dates include interest rate decisions as well as announcements regarding asset purchase programs, lending facility conditions, forward guidance, and swap agreements.[10] This selection procedure leads to a set of ninety-three announcements in the euro area and seventy-four in the United States.[11] While the specific choice of announcement dates is of course open for debate, we find that our results are robust to different sets of announcement dates.[12]

[9]Interest rate announcements also include the ECB Governing Council's decisions to leave the interest rate unchanged so that all Governing Council meetings are present in the set of announcement dates. Asset purchase program 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.

[10]In line with our choice of announcement dates of the ECB, we include all announcements following Federal Open Market Committee (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.

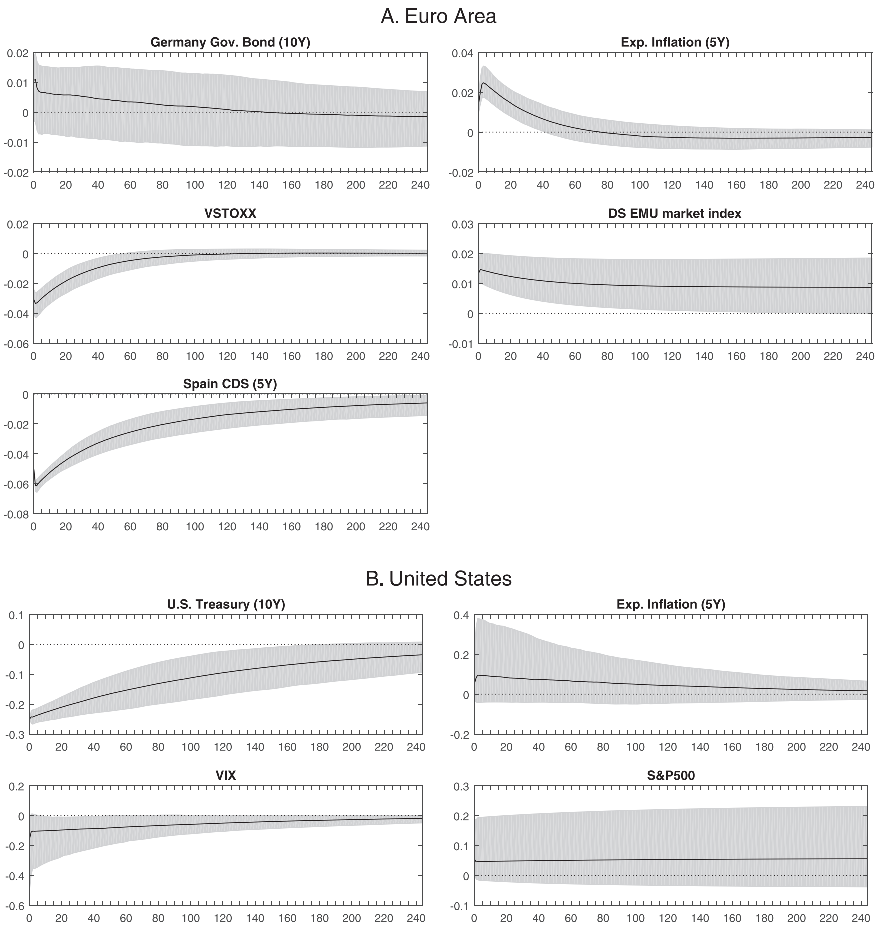
[11]Details on the specific dates and announcements can be found in the appendix.

[12]As a robustness check, we experiment with different choices for the set of announcement dates. For the euro area, we find that a more strict choice of thirty-six policy dates, leaving out the ECB Governing Council meetings that produced no interest rate changes or unconventional monetary policy actions, leads to an increase of the variance change of the monetary policy shock on announcement days, yielding a variance multiplier of 11.52. For the United States, a more strict choice of fifty policy dates, leaving out the FOMC meetings that produced no interest rate changes or unconventional monetary policy (UMP) actions, leads to an increase of the variance change of the monetary policy shock on announcement days, yielding a variance multiplier of 7.39. However, it does not affect any of our further results, as the correlation with the baseline shock remains 0.99 in both cases.

The estimation of the model yields variance multipliers of 4.91 and 5.39 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 177.55 for the euro area and 169.19 for the United States, 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 1 we present the impulse response functions of the variables to a unit monetary policy shock. Our identification strategy is not able to identify the sign and specific scale of the shock. We therefore define a unit expansionary monetary policy shock as a shock that decreases the Spanish five-year CDS spread by 5 percent upon impact for the euro area and as a shock that decreases the ten-year Treasury-bill yield by 25 basis points for the United States, in line with Wright (2012) and Rogers, Scotti, and Wright (2014). In the euro area (figure 1A) we find that an expansionary monetary policy shock increases long-term inflation expectations and the value of the broad stock market index, while decreasing marketwide 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 yield of the long-term safe asset, 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 Altavilla, Giannone, and Lenza 2014 and Rogers, Scotti, and Wright 2014). For the United States the effects are very similar: we observe a positive effect on long-term inflation expectations and the value of the S&P 500 stock market index and a negative effect on marketwide implied volatility (VIX). As expected, for the United States the effect of an expansionary monetary policy shock on the long-term safe asset yield is significantly negative over the entire horizon.

As a check of the soundness of our methodology and in line with Boeckx, Dossche, and Peersman (2017), we plot the time series of the cumulative monetary policy shock for both the euro area and the United States in figures 2 and 3, respectively. A sequence of positive monetary policy shocks indicates that monetary policy is

Figure 1. Impulse Response Function of the Variables to a Unit Monetary Policy Shock



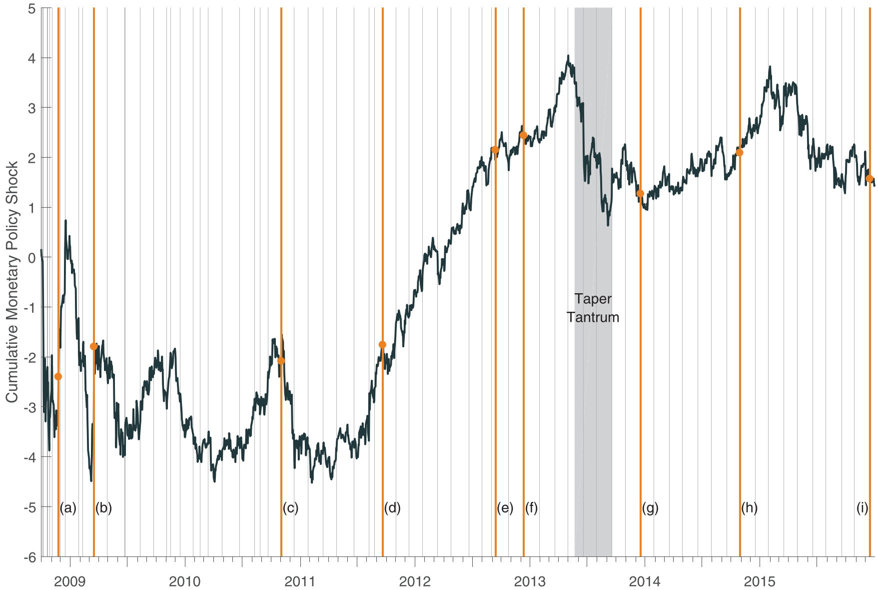
Notes: Gray areas represent 68 percent confidence intervals that are obtained through a stationary bootstrap with expected block length 10 for non-announcement days. Announcement-day residuals are bootstrapped separately. The horizontal axis represents the horizon of the impulse response function in working days, i.e., the IRFs are plotted for a horizon of 240 days.

becoming more expansionary and therefore the cumulative series reflects the monetary policy stance with respect to the prevailing economic environment and expectations of financial markets. As a consequence, a drop in the series can reflect a tightening of

Figure 2. Time Series of the Cumulative Monetary Policy Shocks for the Euro Area

Notes: An increase of the cumulative shock series reflects an expansionary monetary policy announcement. Vertical lines represent the set of announcement dates used in the estimation of the shock. We highlight some of these announcement dates: (a) the ECB starts its first covered bond purchase program (CBPP1) and announces a one-year LTRO; (b) the ECB announces its Securities Markets Program; (c) the ECB increases its MRO interest rate; (d) the ECB activates the SMP for Italy and Spain; (e) the ECB announces its second covered bond purchase program (CBPP2) and the provision of two additional one-year LTROs; (f) the ECB announces the provision of two LTROs with a maturity of three years; (g) ECB President Mario Draghi states that the ECB "is ready to do whatever it takes to preserve the euro"; (h) introduction of the Outright Monetary Purchases (OMT) program; (i) the ECB offers forward guidance by stating that interest rates will "remain at present or lower levels for an extended period of time"; (j) the ECB lowers the deposit facility rate to −0.10 percent and announces the start of an ABS purchase program (ABSPP) and a series of targeted LTROs; (k) ECB President Mario Draghi states that the ECB "will use all the available instruments needed to ensure price stability over the medium term," which is interpreted as hinting at QE; (l) the ECB starts its third covered bond purchase program (CBPP3); (m) the ECB announces it will start buying public-sector securities (EUR 60 billion per month until September 2016); (n) the ECB extends its asset purchase program to March 2017.

Figure 3. Time Series of the Cumulative Monetary Policy Shocks for the United States



Notes: An increase of the cumulative shock series reflects an expansionary monetary policy announcement. Vertical lines represent the set of announcement dates used in the estimation of the shock. We highlight some of these announcement dates: (a) the Fed creates the Term ABS Loan Facility (TALF) and starts purchasing Agency MBS and debt (QE1); (b) the Fed expands its purchases of Agency MBS and debt and starts buying longer-term Treasury securities; (c) the Fed announces that it will again start buying longer-term Treasury securities (QE2); (d) the Fed announces that it will extend the average maturity of its securities holdings ("Operation Twist"); (e) the Fed decides to start purchasing Agency MBS (QE3); (f) the Fed again starts purchasing additional longer-term Treasury securities after the conclusion of its program to extend the average maturity of its securities holdings; (g) the monthly purchases of Agency MBS and Treasury securities are reduced for the first time; (h) the Agency MBS and Treasury purchase programs are discontinued and the Fed signals that a rate increase is possible in the near future "if incoming information indicates faster progress toward the Committee's employment and inflation objectives than the Committee now expects"; (i) the Fed increases the federal funds rate. The period commonly known as the taper tantrum is indicated by a shaded area.

monetary policy but also the lack of monetary action or even that there were expansionary announcements that failed to live up to financial market expectations. The figures show that the shocks are able to capture important monetary policy announcements, as well as the anticipation of some measures. For the euro area, the one-year LTRO/CBPP1 announcement in May 2009 and the Securities Market Program (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 (outright monetary transactions) announcement of September 2012 appears to have been largely anticipated following the speech by ECB President Mario Draghi in which he alluded to 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 reflects the buildup of the accommodative monetary policy stance before the announcements of the QE2, Operation Twist, and QE3 programs. The cumulative shock gradually decreases following the taper announcement in May 2013. As such, the inspection of the cumulative monetary policy shock series further supports the appropriateness of our identification strategy.

3.2 Bank Systemic Risk

Now that we have obtained a measure that reflects exogenous monetary policy shocks, we turn to the measurement of bank systemic risk. In line with Acharya et al. (2010), Acharya, Engle, and Richardson (2012), and Adrian and Brunnermeier (2016), we base our measure of bank systemic risk on financial market data. The definition of bank systemic risk used in this paper encompasses two complementary dimensions. First, an increase in systemic risk indicates that a bank 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.

We estimate the first dimension, a bank's vulnerability to large financial shocks, using the long-run marginal expected shortfall (*LRMES*) following Acharya et al. (2010). The *LRMES* is defined as the expected loss of a bank's market value when a large downturn, or crisis, occurs. For our analysis we use the proxied *LRMES* measure of the NYU Stern Volatility Institute:

$$LRMES_{i,t} = 1 - \exp\left\{\log\left(1 - C\right) \times \beta_{i,t}\right\},$$

where $LRMES_{i,t}$ is the long-run marginal expected shortfall for bank i at time t, C is the threshold for defining a crisis, and $\beta_{i,t}$ is the time-varying beta coefficient of the bank. In line with Acharya, Engle, and Richardson (2012) and the NYU Stern Volatility Institute, the threshold that defines a crisis is set at a 40 percent loss in the relevant market index over a six-month time period.[13] To construct the series of time-varying correlations yielding the beta estimates $\beta_{i,t}$, we use an asymmetric dynamic conditional correlation (ADCC) model as in Cappiello, Engle, and Sheppard (2006). The ADCC model is estimated over the period January 2008 to December 2015.

The second component, the perception of the stock market of a bank's capacity to absorb unexpected losses, is reflected by the total market value of its equity (MV). Finally, to analyze systemic risk, we need to consider the potential tradeoff 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

[13] Our results were not affected by alternative choices of the six-month crisis threshold.

on a regular basis by bank supervisors in Europe, the United States, and other jurisdictions.[14] 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 tradeoff 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 tradeoff.

3.3 Transmission of Monetary Policy and Bank Heterogeneity

In the last step we look at the impact of monetary policy on the market's perception of banks' systemic risk. As the impact is likely to be different for different types of banks, we estimate a panel model in which we allow for bank heterogeneity. Concretely, we estimate the following panel model using variables at monthly frequency:

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

where $Y_{i,t}$ 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. 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 *LRMES* and in market valuation. 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

[14]The relationship between marginal expected shortfall and stress-testing scenarios is documented in more detail by Acharya, Engle, and Pierret (2014).

new issuance or share buybacks. We therefore measure MV using 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 with 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 monthly monetary policy shock is calculated as the sum of the daily *absolute* shocks within each 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 international securities identification number (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 the Center for Research in Security Prices (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.[15] Finally, because the *LRMES* 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 percent 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 percent of trading days.[16] After the application of this data selection procedure, we end up with sixty-three euro-area banks resulting in 4,502 observations and 438 U.S. bank holding companies for a total of 24,508 monthly observations.

On the basis of the accounting data, we construct a set of business model variables to 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.[17]

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

[15] We control for business model changes through mergers by creating a new bank identifier when a bank's size increases by more than 50 percent (otherwise it is classified as an acquisition). Similarly, we also create a new identifier when the bank's size decreases by more than 50 percent in one quarter to control for large divestments that may fundamentally 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.

[16] 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.

[17] The U.S. data are winsorized at the percent 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.

Table 2. Descriptive Statistics

	Euro Area					United States				
	Mean	**SD**	**Min.**	**Med.**	**Max.**	**Mean**	**SD**	**Min.**	**Med.**	**Max.**
Loans to Earning Assets	0.63	0.19	0.12	0.67	0.88	0.72	0.15	0.07	0.74	0.98
Cons. Loans to Earning Assets						0.04	0.06	0.00	0.02	0.44
RE Loans to Earning Assets						0.54	0.18	0.00	0.56	0.93
Bus. Loans to Earning Assets						0.15	0.10	0.00	0.13	0.69
Non-perf. Loans to Loans	0.09	0.08	0.00	0.06	0.41	0.03	0.03	0.00	0.03	0.21
RWA to Earning Assets	0.59	0.19	0.20	0.59	1.11	0.81	0.12	0.42	0.81	1.18
Size	18.04	1.83	14.14	18.15	21.47	10.60	1.59	8.45	10.19	16.58
Deposits to Liabilities	0.48	0.17	0.06	0.48	0.91	0.85	0.13	0.09	0.88	0.99
Share of Core Funding						0.70	0.17	0.06	0.74	0.97
NSFR						1.09	0.15	0.57	1.08	1.80
Equity to Assets	0.06	0.02	0.01	0.07	0.12	0.10	0.03	0.00	0.10	0.23
Share of Non-interest Income	0.37	0.15	0.03	0.35	0.86	0.26	0.16	0.01	0.23	0.97
Share of Fee Income						0.06	0.04	0.00	0.06	0.20
Share of Fiduciary Income						0.03	0.06	0.00	0.01	0.50
Share of Trading Income						0.01	0.03	0.00	0.00	0.33
Share of Insurance Income						0.01	0.03	0.00	0.00	0.17
$\Delta LRMES$	0.00	0.11	−0.54	0.00	0.48	0.00	0.12	−0.67	0.00	0.53
ΔMV	0.00	0.14	−0.88	−0.01	1.43	0.01	0.12	−0.69	0.01	1.35
ΔSMV	0.03	0.32	−0.91	−0.01	5.76	0.03	0.29	−0.87	0.00	2.70
Observations	4,502					24,508				

Note: Data are obtained from Bankscope and Datastream for the euro area and from the FR Y-9C reports and CRSP for the United States.

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 the banks' income structure, 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.[18]

5. Results

In section 5.1 we discuss the results for the euro area; next we examine the results for the sample of U.S. banks. In section 5.3 we analyze the total impact of an expansionary monetary policy shock in both regions in order to assess the economic impact of monetary policy actions on bank stability.

5.1 Euro Area

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 two 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)). However, to more easily assess the importance of allowing for bank heterogeneity, we also show for each regression an

[18]Because non-interest income has in some cases become negative during the financial crisis, 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).

Table 3. Baseline Regression Results

	Euro Area						United States					
	ΔLong-Run MES		**ΔMarket Value**		**ΔStressed *MV***		**ΔLong-Run MES**		**ΔMarket Value**		**ΔStressed *MV***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Constant	0.003	0.019*	0.020***	−0.011	0.012**	−0.099*	0.028***	−0.091***	0.017	−0.009	−0.036	0.197**
	(0.003)	(0.011)	(0.002)	(0.012)	(0.005)	(0.053)	(0.009)	(0.033)	(0.012)	(0.038)	(0.022)	(0.082)
Loans to		−0.004		−0.015***		−0.018		0.021		0.012		−0.031
Assets		(0.005)		(0.005)		(0.021)		(0.021)		(0.021)		(0.041)
NPL to		−0.013		−0.019		0.026		−0.049		−0.052		−0.087
Loans		(0.019)		(0.030)		(0.049)		(0.171)		(0.189)		(0.346)
RWA to		−0.010		0.025***		0.041***		−0.055***		0.065*		0.147***
Assets		(0.007)		(0.009)		(0.015)		(0.020)		(0.035)		(0.050)
Size		−0.000		0.002***		0.005**		0.006***		0.004		−0.011*
		(0.000)		(0.001)		(0.002)		(0.002)		(0.003)		(0.006)
Dep. to		−0.002		−0.004		0.022		0.063**		−0.057**		−0.161***
Liabilities		(0.006)		(0.006)		(0.027)		(0.025)		(0.026)		(0.051)
Equity to		0.064		−0.130*		−0.061		0.287***		−0.148		−0.647***
Assets		(0.066)		(0.074)		(0.195)		(0.086)		(0.155)		(0.205)
Share of		−0.006		−0.024***		0.002		0.014		−0.051***		−0.079**
NII		(0.005)		(0.007)		(0.018)		(0.011)		(0.020)		(0.036)
R^2 (within)	0.006	0.008	0.181	0.204	0.018	0.024	0.033	0.042	0.019	0.027	0.013	0.022
Wald (χ^2_7)	–	21.11***	–	54.70***	–	27.96***	–	22.02***	–	10.94	–	16.86**
Obs.	4,502						24,508					
Banks	63						438					

Notes: This table shows only the coefficients of the interaction effects β_i $(i = 0 \ldots K)$ as presented in equation (6). The model is estimated using bank fixed effects. A Wald test is used to test the joint significance of the interaction effects (β_1 to β_K). Standard errors in parentheses are clustered on both the bank and month level to control for within-bank autocorrelation and common shocks. *, **, and *** represent significance at the 10 percent, 5 percent, and 1 percent level, respectively.

intercept-only model and a Wald test for the joint significance of the interaction effects, i.e., β_1 to β_K.

In the "Euro Area" columns of table 3 we present the baseline results for the euro area. With respect to the constant-only regressions, we find that the impact of an expansionary monetary policy shock on *LRMES* and *MV* is mainly positive, implying that for most banks accommodative monetary policy actions increase banks' systemic vulnerability as well as the market value of their equity capital. More specifically, an expansionary unit monetary policy shock is associated with an increase in *LRMES* of 0.3 percentage points and the *MV* of 2 percent. The average change in *SMV* is positive, because the positive impact on the market value dominates, resulting in an average effect of 1.2 percent.

Next, we analyze the heterogeneous impact of monetary policy across bank business models. With respect to asset structure, the results in table 3 show that an expansionary monetary policy shock reduces systemic risk more for banks with higher asset risk. The interaction term of the monetary policy shock with the RWA density is negative for *LRMES* and positive for the market value and stressed market value, although the effect on *LRMES* is not statistically significant. This result is consistent with an expansionary monetary policy shock improving the financial environment, since increasing security prices cause a positive revaluation of the banks' securities portfolios. Moreover, improved collateral values may furthermore decrease the probability of default within the banks' loan portfolios. Our results indicate that the stock market acknowledges 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. However, easing liquidity and financing conditions could also allow banks to defer acknowledging bad loans, i.e., a forbearance channel. 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. 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.

In order to discriminate between the two hypotheses, we use the regional heterogeneity in the euro area. Doubts about the quality of banks' loan books are likely to be stronger in euro-area periphery countries, since 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, negatively affect current profitability and lead to future loan impairments (see Peek and Rosengren 2005). Acharya et al. (2019) 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 for the core countries.

Going back to table 3, we do not find any statistically significant results with regard to the funding structure. However, concerning the capital structure, we find that the MV of the highly capitalized banks decreases more than that of the lowly capitalized banks. The subsample analysis comparing the core and the periphery euro-area countries presented in table 4 indicates that this effect is only present in the euro-area periphery: the effects on both the market value and stressed market value are significantly negative. Because funding conditions worsened more for banks in periphery countries,

Table 4. Panel Regression Results: Exploiting the Regional Differences within the Euro Area to Examine the Transmission of Monetary Policy Shocks

	Euro Periphery[a]						Euro Core					
	ΔLong-Run MES		ΔMarket Value		ΔStressed *MV*		ΔLong-Run MES		ΔMarket Value		ΔStressed *MV*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Constant	0.002	0.014	0.019***	−0.010	0.017***	−0.033	0.005**	0.035***	0.020***	−0.034	0.003	−0.127*
	(0.003)	(0.011)	(0.003)	(0.017)	(0.006)	(0.032)	(0.002)	(0.012)	(0.003)	(0.021)	(0.007)	(0.072)
Loans to		0.008		−0.021***		−0.038***		−0.012		−0.005		−0.040
Assets		(0.008)		(0.007)		(0.015)		(0.007)		(0.010)		(0.061)
NPL to		−0.014		−0.010		0.011		−0.012		−0.086*		0.077
Loans		(0.019)		(0.038)		(0.051)		(0.044)		(0.046)		(0.151)
RWA to		−0.015		0.024*		0.040**		−0.002		0.035***		−0.023
Assets		(0.009)		(0.013)		(0.019)		(0.011)		(0.010)		(0.052)
Size		−0.001*		0.003***		0.005***		−0.001		0.003***		0.006*
		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)		(0.003)
Dep. to		0.004		−0.006		−0.019		−0.004		−0.010		0.075
Liabilities		(0.007)		(0.007)		(0.017)		(0.005)		(0.010)		(0.069)
Equity to		0.130*		−0.185**		−0.360**		−0.052		−0.074		0.437
Assets		(0.074)		(0.094)		(0.157)		(0.080)		(0.085)		(0.316)
Share of		−0.006		−0.019		−0.006		−0.003		−0.032***		0.003
NII		(0.010)		(0.012)		(0.028)		(0.006)		(0.009)		(0.028)
R^2 (within)	0.003	0.007	0.167	0.184	0.032	0.042	0.023	0.033	0.274	0.325	0.007	0.033
Wald (χ^2_7)	–	5.84	–	37.29***	–	35.61***	–	56.03***	–	34.63***	–	8.38
Obs.	2,891						1,611					
Banks	37						26					

[a]The periphery countries are Greece, Italy, Ireland, Portugal, and Spain.

Notes: This table shows only the coefficients of the interaction effects $\beta_i (i = 0 \ldots K)$ as presented in equation (6). The model is estimated using bank fixed effects. A Wald test is used to test the joint significance of the interaction effects (β_1 to β_K). Standard errors in parentheses are clustered on both the bank and month level to control for within-bank autocorrelation and common shocks. *, **, and *** represent significance at the 10 percent, 5 percent, and 1 percent level, respectively.

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, results in the "Euro Area" columns of table 3 indicate that bank size, which we include as a control variable, affects the transmission of monetary policy to bank systemic risk. We find that larger banks benefit more from monetary policy shocks in terms of market value and stressed market value. These findings are consistent with Buch, Eickmeier, and Prieto (2014) and Dell'Ariccia, Laeven, and Marquez (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.

5.2 United States

The "United States" columns of table 3 present the intercept-only regressions for the United States and indicate that expansionary monetary policy on average increases $LRMES$ by 3 percentage points but that there is no significant impact on the change in MV and SMV. Regarding the heterogeneous impact of monetary policy, we find that most interaction terms are significant and somewhat larger in size compared with the euro-area results. Similar to the euro area, we find that an expansionary monetary policy shock reduces systemic risk more for banks with higher asset risk. This indicates that a recapitalization effect is also present in the transmission of U.S. monetary policy.

Consistent with euro-area results, we find that the interaction term of the non-interest income share and the monetary policy shock negatively affects market value, implying that net interest income benefits from expansionary monetary policy actions. However, we do not find immediate evidence for a forbearance channel, as the loan ratio does not significantly affect the transmission of monetary policy. To further investigate the presence of a forbearance channel, we exploit the higher granularity of the U.S. accounting data in table 5. Forbearance incentives may be larger for banks that rely more on consumer loans or business loans, rather than real estate

Table 5. Panel Regression Results: Exploiting the Granularity of U.S. Data to Examine the Transmission of Monetary Policy Shocks[a]

	ΔLong-Run MES		ΔMarket Value		ΔStressed *MV*	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.091***	−0.089*	−0.009	0.013	0.197**	0.204**
	(0.033)	(0.050)	(0.038)	(0.044)	(0.082)	(0.104)
Loans to Earning Assets	0.021		0.012		−0.031	
	(0.021)		(0.021)		(0.041)	
Cons. Loans to Earning Assets		0.020		−0.003		−0.042
		(0.018)		(0.026)		(0.043)
RE Loans to Earning Assets		0.025**		−0.001		−0.045
		(0.012)		(0.019)		(0.030)
Bus. Loans to Earning Assets		0.064***		−0.054*		−0.180***
		(0.017)		(0.028)		(0.039)
Non-Perf. Loans to Loans	−0.049	0.020	−0.052	−0.131	−0.087	−0.285
	(0.171)	(0.179)	(0.189)	(0.190)	(0.346)	(0.354)
RWA to Earning Assets	−0.055***	−0.059***	0.065*	0.067*	0.147***	0.160***
	(0.020)	(0.019)	(0.035)	(0.034)	(0.050)	(0.046)
Size	0.006***	0.007***	0.004	0.002	−0.011*	−0.014**
	(0.002)	(0.002)	(0.003)	(0.003)	(0.006)	(0.006)
Deposits to Liabilities	0.063**		−0.057**		−0.161***	
	(0.025)		(0.026)		(0.051)	
Share of Core Funding		0.064***		−0.050**		−0.154***
		(0.021)		(0.025)		(0.046)
NSFR		0.014		−0.037*		−0.055
		(0.021)		(0.022)		(0.043)
Equity to Assets	0.287***	0.186***	−0.148	−0.032	−0.647***	−0.378*
	(0.086)	(0.062)	(0.155)	(0.136)	(0.205)	(0.195)
Share of Non-interest Income	0.014		−0.051***		−0.079**	
	(0.011)		(0.020)		(0.036)	
Share of Fee Income		−0.116*		0.254**		0.394***
		(0.066)		(0.115)		(0.137)
Share of Fiduciary Income		−0.027		0.026		0.054
		(0.028)		(0.037)		(0.062)
Share of Trading Income		−0.029		−0.014		0.044
		(0.048)		(0.066)		(0.160)
Share of Insurance Income		0.036		−0.069		−0.130**
		(0.029)		(0.054)		(0.060)
R^2 (within)	0.042	0.046	0.027	0.033	0.022	0.027
Wald	22.02***	41.90***	10.94	31.93***	16.86**	73.17***
Observations	24,508					
Banks	438					

[a]For comparision, we also add the baseline results as presented in table 3.

Notes: This table shows only the coefficients of the interaction effects $\beta_i (i = 0 \ldots K)$ as presented in equation (6). The model is estimated using bank fixed effects. A Wald test is used to test the joint significance of the interaction effects (β_1 to β_K). Standard errors in parentheses are clustered on both the bank and month level to control for within-bank autocorrelation and common shocks. *, **, and *** represent significance at the 10 percent, 5 percent, and 1 percent level, respectively.

loans, because the Federal Reserve explicitly supported the valuation of the latter.[19] Different studies furthermore indicate that these programs indeed had a positive impact on house prices (Gabriel and Lutz 2015; Rahal 2016). However, the results in table 5 are not in line with the forbearance hypothesis. While we do find that a stronger reliance on business loans increases *LRMES* and decreases *MV* and *SMV*, we also find that banks that rely more on real estate loans experience a more positive impact on their *LRMES*. The coefficient is, however, smaller than that of the ratio of business loans.

Apart from asset and income structure, the transmission of monetary policy shocks to bank systemic risk may also be influenced by the way a bank funds its activities, i.e., through customer deposits, wholesale debt, or 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, in contrast to the euro-area banks, where no significant results are found. 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 markets' concerns about banks' funding risk or by incentivizing banks with high deposit ratios to take more risk.

To examine this question further, we 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 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 with the ratio of core funding to total funding to better capture the share of insured deposits. The coefficients

[19] In its November 25, 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."

for the share of core funding are in line with the results in table 3. However, we also find suggestive evidence that the *NSFR*, and thus banks' funding risk, negatively affects the impact of monetary policy shocks on market value. As such, these results provide support to both the funding risk hypothesis and 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.

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 *LRMES* and a negative impact on the stressed market value (columns 4 and 6). 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, Laeven, and Suarez 2017) and also in line with the results of Madura and Schnusenberg (2000), Yin and Yang (2013), and Ricci (2015).

Contrary to the euro area, we do not find that larger U.S. banks benefit more in terms of market value, but rather that they become more systemically vulnerable following an expansionary monetary policy shock, which also translates into a negative impact on *SMV*.

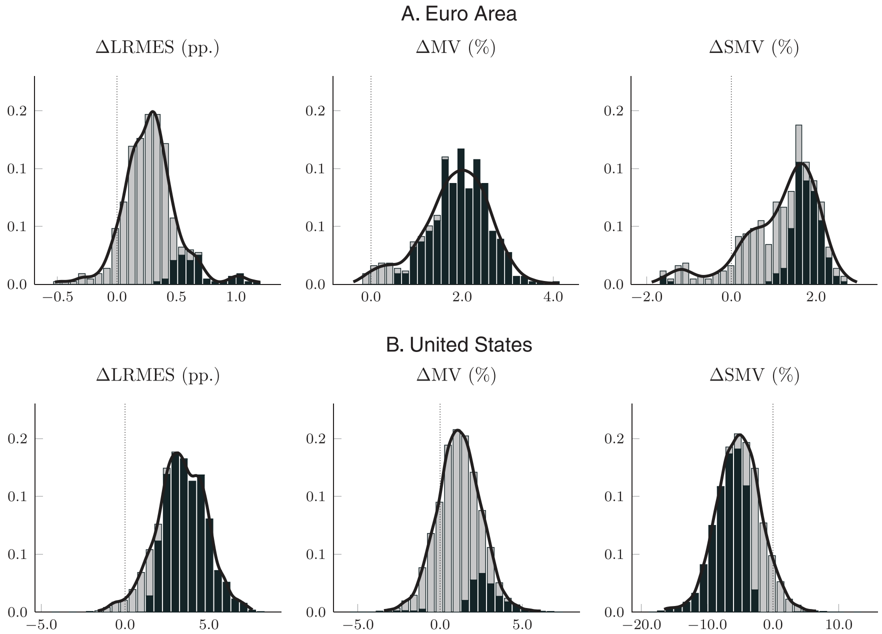
5.3 Total Impact

After analyzing the transmission channels separately, we now discuss the total effect of monetary policy shocks on bank systemic risk in order to assess the economic relevance of monetary policy for bank systemic risk. This enables us to verify which of the transmission channels is dominant in the euro area and the United States. 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:

$$\frac{\partial Y_{i,t}}{\partial Shock_t} = \hat{\beta}_0 + \sum_{k=1}^{K} \hat{\beta}_k BM_{k,i,t}.$$

In figure 4 we show histograms for both the euro area and the United States of the total impact of monetary policy shocks on each dependent variable, based on the estimation results in table 3. We

Figure 4. Histograms and Estimated Kernel Densities for the Total Impact of a Unit Monetary Policy Shock on Δ*LRMES* (in percentage points), Δ*MV*, and Δ*SMV* (both as percentages) over a One-Month Horizon



Notes: Graphs in this figure are based on the results presented in table 3. The dark parts of the histogram bars represent the proportion of statistically significant (at the 10 percent level) total impacts.

highlight the proportion of impacts that were found to be statistically significant (at the 10 percent level) by using a dark bar, and the proportion that were not found to be significant with a lighter bar. We confirm that the impact of an expansionary monetary policy shock on *LRMES* and *MV* is mainly positive for both the euro area and the United States, implying that for most banks accommodative monetary policy actions increase banks' systemic vulnerability as well as the market value of their equity capital. However, the impact of a monetary policy shock on *LRMES* in the United States tends to be larger than in the euro area. This finding is consistent with the presence of a funding risk channel and risk shifting as the dominating channels operating in the United States. On the contrary, the transmission channels active in the euro area are the forbearance channel and the stealth recapitalization channel. The smaller impact on *LRMES* indicates the dominance of the stealth recapitalization channel which tempers the negative effects of the forbearance channel on bank systemic risk.

We remark that the difference in transmission channels can also be explained by the different sample of banks across both regions. The U.S. banks in our sample are smaller, have a higher capital ratio and lower non-performing loans, and operate in a more traditional business model characterized by a higher loan ratio, more deposit funding, and less reliance on sources of non-interest income than their European counterparts. These banking characteristics are of particular importance in enabling a risk-shifting effect and the funding risk channel.

The results regarding the impact of monetary policy interventions on market value indicate that in the euro area the total impact is statistically significant for most bank-year observations, while this is not the case for the United States. Again, we take this as evidence that the stealth recapitalization channel is more important than and even dominates the forbearance channel for the euro-area banks. For the United States, the total effect of a monetary policy shock on MV is not significant for most observations, indicating that the recapitalization effect is seemingly of lesser importance than the risk-shifting and funding risk effect. Finally, our SMV measure captures the tradeoff between a bank's perceived systemic risk versus its resilience to shocks based on its equity market value. For the euro area the majority of bank-year observations exhibit a positive effect on SMV, because the positive impact on market value dominates through the stealth recapitalization channel. In contrast, for most U.S. bank-year observations the impact on *LRMES* is larger than that on MV, resulting in a significantly negative total impact on SMV because of the funding risk channel and risk-shifting effect.

6. Conclusion and Policy Considerations

In this paper we investigate the impact of monetary policy on bank systemic risk in the euro area and the United States and we disentangle the different transmission channels through which monetary policy can affect financial stability. To do so, we first estimate a monetary policy shock for both monetary regimes using the identification-through-heteroskedasticity approach. In a second stage, we use this monetary policy shock to explore how bank systemic risk is affected across different bank business models.

For the euro area, we find evidence suggesting that expansionary monetary policy actions have given banks more room to delay balance sheet repair. Our results also support the existence of a recapitalization channel both in the euro area and in the United States, indicating that accommodative monetary policy actions increase the value of bank (legacy) assets, leading to a higher net worth of the bank. Considering the total effect of expansionary monetary policy, the results suggest that the stealth recapitalization channel dominates the forbearance channel in the euro area, and in particular in the euro-zone periphery. For the United States, we find evidence for a risk-shifting effect. Moreover, the choice of funding also seems to play a role in the transmission of monetary policy for U.S. banks, since banks that rely on deposit funding experience a larger increase in bank systemic risk. This is in line with the hypothesis that a higher proportion of insured deposits can decrease monitoring incentives and increase agency problems.

In the euro area, expansionary monetary policy has supported the banks in the periphery more than those in the core. In this sense, monetary policy has contributed to an increase in financial stability by decreasing regional asymmetries within the euro zone. This also suggests that the switch from monetary policy accommodation to a tightening stance should be gradual and carefully guided in order to avoid disruptions in monetary policy transmission. Since our results indicate the existence of a forbearance channel, it is recommended that the cleanup of bank balance sheets proceed in a swift manner, so that legacy and forbearance issues can be avoided.

References

Acharya, V. V., T. Eisert, C. Eufinger, and C. Hirsch. 2019. "Whatever It Takes: The Real Effects of Unconventional Monetary Policy." Forthcoming in *Review of Financial Studies*. Available at https://doi.org/10.1093/rfs/hhz005.

Acharya, V. V., R. F. Engle, and D. Pierret. 2014. "Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights." *Journal of Monetary Economics* 65 (July): 36–53.

Acharya, V. V., R. F. Engle, and M. Richardson. 2012. "Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks." *American Economic Review* 102 (3): 59–64.

Acharya, V. V., L. H. Pedersen, T. Philippon, and M. Richardson. 2010. "Measuring Systemic Risk." Working Paper No. 10-02, Federal Reserve Bank of Cleveland.

Adrian, T., and M. K. Brunnermeier. 2016. "CoVaR." *American Economic Review* 106 (7): 1705–41.

Adrian, T., and N. Liang. 2016. "Monetary Policy, Financial Conditions, and Financial Stability." Staff Report No. 690, Federal Reserve Bank of New York.

Altavilla, C., D. Giannone, and M. Lenza. 2014. "The Financial and Macroeconomic Effects of OMT Announcements." Working Paper No. 1707, European Central Bank.

Altunbas, Y., L. Gambacorta, and D. Marques-Ibanez. 2014. "Does Monetary Policy Affect Bank Risk?" *International Journal of Central Banking* 10 (1): 95–135.

Arai, N. 2017. "The Effects of Monetary Policy Announcements at the Zero Lower Bound." *International Journal of Central Banking* 13 (2): 159–96.

Baumeister, C., and L. Benati. 2013. "Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound." *International Journal of Central Banking* 9 (2): 165–212.

Billio, M., M. Getmansky, A. W. Lo, and L. Pelizzon. 2012. "Econometric Measures of Connectedness and Systemic Risk in the Finance and Insurance Sectors." *Journal of Financial Economics* 104 (3): 535–59.

Bisias, D., M. Flood, A. W. Lo, and S. Valavanis. 2012. "A Survey of Systemic Risk Analytics." *Annual Review of Financial Economics* 4 (1): 255–96.

Boeckx, J., M. Dossche, and G. Peersman. 2017. "Effectiveness and Transmission of the ECB's Balance Sheet Policies." *International Journal of Central Banking* 13 (1): 297–333.

Borio, C., L. Gambacorta, and B. Hofmann. 2015. "The Influence of Monetary Policy on Bank Profitability." Working Paper No. 514, Bank for International Settlements.

Brissimis, S. N., and M. D. Delis. 2010. "Bank Heterogeneity and Monetary Policy Transmission." Working Paper No. 1233, European Central Bank.

Brunnermeier, M. K., and Y. Sannikov. 2014. "A Macroeconomic Model with a Financial Sector." *American Economic Review* 104 (2): 379–421.

Buch, C. M., S. Eickmeier, and E. Prieto. 2014. "In Search for Yield? Survey-Based Evidence on Bank Risk Taking." *Journal of Economic Dynamics and Control* 43 (June): 12–30.

Busch, R., and C. Memmel. 2015. "Banks' Net Interest Margin and the Level of Interest Rates." Discussion Paper No. 16/2015, Deutsche Bundesbank.

Cappiello, L., R. F. Engle, and K. Sheppard. 2006. "Asymmetric Dynamics in the Correlations of Global Equity and Bond Returns." *Journal of Financial Econometrics* 4 (4): 537–72.

Chen, Q., A. J. Filardo, D. He, and F. Zhu. 2012. "International Spillovers of Central Bank Balance Sheet Policies." *BIS Papers* 66 (September): 230–74.

———. 2016. "Financial Crisis, US Unconventional Monetary Policy and International Spillovers." *Journal of International Money and Finance* 67 (October): 62–81.

Chodorow-Reich, G. 2014. "Effects of Unconventional Monetary Policy on Financial Institutions." *Brookings Papers on Economic Activity* (Spring): 155–228.

De Nicolò, G., G. Dell'Ariccia, L. Laeven, and F. Valencia. 2010. "Monetary Policy and Bank Risk-Taking." Staff Position Note No. 10/09, International Monetary Fund.

Delis, M. D., and G. P. Kouretas. 2011. "Interest Rates and Bank Risk-taking." *Journal of Banking and Finance* 35 (4): 840–55.

Dell'Ariccia, G., L. Laeven, and R. Marquez. 2014. "Real Interest Rates, Leverage, and Bank Risk-taking." *Journal of Economic Theory* 149 (January): 65–99.

Dell'Ariccia, G., L. Laeven, and G. Suarez. 2017. "Bank Leverage and Monetary Policy's Risk-taking Channel: Evidence from the United States." *Journal of Finance* 72 (2): 613–54.

Demirgüç-Kunt, A., and E. Detragiache. 2002. "Does Deposit Insurance Increase Banking System Stability? An Empirical Investigation." *Journal of Monetary Economics* 49 (7): 1373–1406.

Demirgüç-Kunt, A., and H. Huizinga. 2004. "Market Discipline and Deposit Insurance." *Journal of Monetary Economics* 51 (2): 375–99.

DeYoung, R., and K. Y. Jang. 2016. "Do Banks Actively Manage Their Liquidity?" *Journal of Banking and Finance* 66 (May): 143–61.

Gabriel, S. A., and C. Lutz. 2015. "The Impact of Unconventional Monetary Policy on Real Estate Markets." Mimeo.

Gagnon, J., M. Raskin, J. Remache, and B. P. Sack. 2011. "Large-Scale Asset Purchases by the Federal Reserve: Did They Work?" *Economic Policy Review* (Federal Reserve Bank of New York) 17 (1): 41–59.

Gambacorta, L., B. Hofmann, and G. Peersman. 2014. "The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis." *Journal of Money, Credit and Banking* 46 (4): 615–42.

Gambacorta, L., and H. S. Shin. 2018. "Why Bank Capital Matters for Monetary Policy." *Journal of Financial Intermediation* 35 (Part B): 17–29.

Garcia Pascual, A., and T. Wieladek. 2016. "The European Central Bank's QE: A New Hope." CESifo Working Paper No. 5946.

Garrido, J., E. Kopp, and A. Weber. 2016. "Cleaning-up Bank Balance Sheets: Economic, Legal, and Supervisory Measures for Italy." Working Paper No. 16/135, International Monetary Fund.

Gilchrist, S., D. Lopez-Salido, and E. Zakrajsek. 2015. "Monetary Policy and Real Borrowing Costs at the Zero Lower Bound." *American Economic Journal: Macroeconomics* 7 (1): 77–109.

Gilchrist, S., and E. Zakrajsek. 2013. "The Impact of the Federal Reserve's Large-Scale Asset Purchase Programs on Corporate Credit Risk." *Journal of Money, Credit and Banking* 45 (s2): 29–57.

Huang, X., H. Zhou, and H. Zhu. 2012. "Systemic Risk Contributions." *Journal of Financial Services Research* 42 (1–2): 55–83.

Ioannidou, V., S. Ongena, and J. L. Peydró. 2015. "Monetary Policy, Risk-taking, and Pricing: Evidence from a Quasi-natural Experiment." *Review of Finance* 19 (1): 95–144.

Jiménez, G., S. Ongena, J. L. Peydró, and J. Saurina. 2014. "Hazardous Times for Monetary Policy: What Do Twenty Three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk Taking?" *Econometrica* 82 (2): 463–505.

Joyce, M., A. Lasaosa, I. Stevens, and M. Tong. 2011. "The Financial Market Impact of Quantitative Easing in the United Kingdom." *International Journal of Central Banking* 7 (3): 113–61.

Joyce, M., and M. Tong. 2012. "QE and the Gilt Market: A Disaggregated Analysis." *Economic Journal* 122 (564): 348–84.

Köhler, M. 2015. "Which Banks Are More Risky? The Impact of Business Models on Bank Stability." *Journal of Financial Stability* 16 (February): 195–212.

Krishnamurthy, A., and A. Vissing-Jorgensen. 2011. "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy." *Brookings Papers on Economic Activity* 2 (Fall): 215–87.

Lambert, F., and K. Ueda. 2014. "The Effects of Unconventional Monetary Policies on Bank Soundness." Working Paper No. 14/152, International Monetary Fund.

Lanne, M., and H. Lütkepohl. 2008. "Identifying Monetary Policy Shocks via Changes in Volatility." *Journal of Money, Credit and Banking* 40 (6): 1131–49.

Lombardi, M. J., and F. Zhu. 2014. "A Shadow Policy Rate to Calibrate US Monetary Policy at the Zero Lower Bound." Working Paper No. 452, Bank for International Settlements.

Maddaloni, A., and J. L. Peydró. 2013. "Monetary Policy, Macroprudential Policy, and Banking Stability: Evidence from the Euro Area." *International Journal of Central Banking* 9 (1): 121–69.

Madura, J., and O. Schnusenberg. 2000. "Effect of Federal Reserve Policies on Bank Equity Returns." *Journal of Financial Research* 23 (4): 421–47.

Mamatzakis, E., and T. Bermpei. 2016. "What Is the Effect of Unconventional Monetary Policy on Bank Performance?" *Journal of International Money and Finance* 67 (October): 239–63.

Meaning, J., and F. Zhu. 2011. "The Impact of Recent Central Bank Asset Purchase Programmes." *BIS Quarterly Review* (4, December): 73–83.

Meinusch, A., and P. Tillmann. 2016. "The Macroeconomic Impact of Unconventional Monetary Policy Shocks." *Journal of Macroeconomics* 47 (Part A): 58–67.

Mergaerts, F., and R. Vander Vennet. 2016. "Business Models and Bank Performance: A Long-Term Perspective." *Journal of Financial Stability* 22 (February): 57–75.

Neely, C. J. 2015. "Unconventional Monetary Policy Had Large International Effects." *Journal of Banking and Finance* 52 (March): 101–11.

Paligorova, T., and J. A. C. Santos. 2012. "When Is It Less Costly for Risky Firms to Borrow? Evidence from the Bank Risk-Taking Channel of Monetary Policy." Staff Working Paper No. 2012-10, Bank of Canada.

Peek, J., and E. S. Rosengren. 2005. "Unnatural Selection: Perverse Incentives and the Misallocation of Credit in Japan." *American Economic Review* 95 (4): 1144–66.

Rahal, C. 2016. "Housing Markets and Unconventional Monetary Policy." *Journal of Housing Economics* 32 (June): 67–80.

Rajan, R. G. 2005. "Has Financial Development Made the World Riskier?" In *The Greenspan Era: Lessons for the Future*. Proceedings of the 2005 Economic Symposium sponsored by the Federal Reserve Bank of Kansas City, held in Jackson Hole, Wyoming, August 25–27.

Ricci, O. 2015. "The Impact of Monetary Policy Announcements on the Stock Price of Large European Banks during the Financial Crisis." *Journal of Banking and Finance* 52 (March): 245–55.

Rigobon, R., and B. Sack. 2003. "Measuring the Reaction of Monetary Policy to the Stock Market." *Quarterly Journal of Economics* 118 (2): 639–69.

———. 2004. "The Impact of Monetary Policy on Asset Prices." *Journal of Monetary Economics* 51 (8): 1553–75.

Rogers, J. H., C. Scotti, and J. H. Wright. 2014. "Evaluating Asset-Market Effects of Unconventional Monetary Policy: A Multi-country Review." *Economic Policy* 29 (80): 749–99.

Smets, F. 2014. "Financial Stability and Monetary Policy: How Closely Interlinked?" *International Journal of Central Banking* 10 (2): 263–300.

Swanson, E. T. 2011. "Let's Twist Again: A High-Frequency Event-Study Analysis of Operation Twist and Its Implications for

QE2." *Brookings Papers on Economic Activity* 42 (1, Spring): 151–207.

Taylor, J. B., and J. C. Williams. 2009. "A Black Swan in the Money Market." *American Economic Journal: Macroeconomics* 1 (1): 58–83.

van Oordt, M., and C. Zhou. 2014. "Systemic Risk and Bank Business Models." Working Paper No. 442, De Nederlandsche Bank.

Wright, J. H. 2012. "What Does Monetary Policy Do to Long-term Interest Rates at the Zero Lower Bound?" *Economic Journal* 122 (564): 447–66.

Yin, H., and J. Yang. 2013. "Bank Characteristics and Stock Reactions to Federal Funds Rate Target Changes." *Applied Financial Economics* 23 (23): 1755–64.