Unconventional Monetary Policy Shocks in the Euro Area and the Sovereign-Bank Nexus*

Nikolay Hristov,[a] Oliver Hülsewig,[b] and Johann Scharler[c]
[a]Deutsche Bundesbank and CESifo
[b]Munich University of Applied Sciences and CESifo
[c]University of Innsbruck

We explore the effects of the ECB's unconventional monetary policy on the banks' sovereign debt portfolios. In particular, using panel vector autoregressive (VAR) models we analyze whether banks increased their domestic government bond holdings in response to nonstandard monetary policy shocks, thereby possibly promoting the sovereign-bank nexus, i.e., the exposure of banks to the debt issued by the national government. Our results suggest that euro-area crisis countries' banks enlarged their exposure to domestic sovereign debt after innovations related to unconventional monetary policy. Moreover, the restructuring of sovereign debt portfolios was characterized by a home bias.

JEL Codes: C32, E30, E52, G21, H63.

1. Introduction

The European Central Bank (ECB) responded to the global financial crisis by conducting a number of unconventional monetary policy measures in addition to lowering the policy rate. The aim of these measures was to reduce potential risks for price stability in the

*We thank an anonymous referee, Boris Hofmann, and Sandra Eickmeier for very helpful comments and suggestions. We are also grateful to the participants of the internal research seminars at the Deutsche Bundesbank and the ifo Institute for Economic Research Munich for fruitful discussions. The usual disclaimer applies. This paper reflects the authors' opinion and does not necessarily reflect the views of the Deutsche Bundesbank or the Eurosystem. Corresponding author (Hristov): Deutsche Bundesbank and CESifo, Wilhelm-Epstein-Strasse 14, 60431 Frankfurt am Main, Germany. Tel.: +49 (0)69 9566 7362. E-mail: nikolay.hristov@bundesbank.de.

euro area by counteracting distortions on the interbank market and reducing impairments in the monetary policy transmission induced by financial market fragmentation across member states during the sovereign debt crisis (ECB 2011, 2013).[1]

In this paper, we explore the effects of the ECB's unconventional monetary policy on the balance sheet exposure of a country's banking sector to the debt issued by the national government, i.e., the so-called *sovereign-bank nexus*. The nexus is considered of primary importance for the medium-term stability of the financial system (Battistini, Pagano, and Simonelli 2014; Brunnermeier et al. 2016; Basel Committee on Banking Supervision 2017; Farhi and Tirole 2018; International Monetary Fund 2018, among others). On the one hand, a higher share of bond holdings is typically associated with a better liquidity position of banks, thus being favorable for the soundness of the banking system (Walther 2016; Richter, Schularick, and Wachtel 2017; Hoerova et al. 2018), and may even reduce the incentives for the sovereign to default (Basel Committee on Banking Supervision 2017; Gennaioli, Martin, and Rossi 2018). On the other hand, a stronger nexus may harm financial stability by making the national banking sector more sensitive to deteriorations in the sovereign's creditworthiness and may even contribute to the emergence of *diabolic loops* as repeatedly observed since the outbreak of the global financial crisis (Brunnermeier et al. 2016; Dell'Ariccia et al. 2018; Farhi and Tirole 2018). For example, many euro-area countries experienced such a loop as the market value of banks' holdings of domestic government bonds dropped due to the deterioration in the sovereign's creditworthiness, thus putting a strain on the solidity of the banking sector. Governments responded by giving safety guarantees or even implementing substantial rescue packages, which, however, might potentially increase sovereign risk further

[1]In particular, the ECB switched to regular open market operations with fixed rates and full allotment that were provided with longer maturities, relaxed collateral requirements, changed the modalities of its long-term refinancing operations, and launched outright transactions, like the Securities Market Programme (SMP) in 2010 and the extended Asset Purchase Programme (APP) in 2015, or announced these—under the Outright Monetary Transaction (OMT) program in 2012. In addition, the central bank imposed a negative interest rate on its deposit facility. See section 3 for more details.

and reinforce the impairment of banks' balance sheets.[2] Meanwhile, Battistini, Pagano, and Simonelli (2014) and Brutti and Saure (2015) consider the distortion created and intensified by the nexus as one of the core problems associated with the euro crisis.

Against this background, we estimate panel vector autoregressive (VAR) models using Bayesian methods to assess how banks across euro-area member countries adjusted their domestic sovereign debt portfolios in response to a nonstandard monetary policy shock. We focus on the period 2007–14. The ratio of banks' domestic government bond holdings increased markedly during that time.[3]

Following Canova and de Nicolo (2002), Peersman (2005), Uhlig (2005), Rubio-Ramirez, Waggoner, and Zha (2010), or Arias, Rubio-Ramirez, and Waggoner (2014), we use sign restrictions on impulse responses to identify an unconventional monetary policy shock. In particular, in our benchmark model we refer to Boeckx, Dossche, and Peersman (2017) and relate a shock to nonstandard monetary policy to an unexpected increase in the Eurosystem's total assets that is accompanied by a decrease in the spread between the euro overnight index average (EONIA) and the policy rate as well as lower financial stress. We also assess alternative identification schemes that are related to the long-term refinancing operations, changes in the composition of open market operations, and the shadow rate of monetary policy.

Our results suggest the presence of a dichotomy between the core countries of the euro area, i.e., Austria, Belgium, Germany, Finland, France, and the Netherlands, and the crisis countries Italy, Spain, and Portugal. In particular, in the years 2007–14, the banking sectors of the crisis countries significantly shifted their asset portfolios toward domestic sovereign bonds in response to expansionary unconventional monetary shocks. These shocks appear to have been quantitatively important, as they explain around 19 percent of the variation in the national banking sectors' share of domestic

[2] According to Acharya, Drechsler, and Schnabl (2014), in industrial countries there was essentially no sign of sovereign credit risk before the onset of the global financial crisis. Hence, the nexus was not considered to be problematic due to the prevailing view that sovereign credit risk was unlikely to be a concern in the near future. Rather, sovereign defaults were regarded as a problem of emerging economies.

[3] See figure A.1 in the online appendix, available at http://www.ijcb.org.

government bonds in the group of distressed euro-area economies. Moreover, banks seemed to manage their sovereign debt portfolios actively in response to sudden unconventional monetary expansions, as the rising holdings of domestic government bonds were accompanied by a reduction in the balance sheet share of bonds issued by other euro-area member states. Thus, the reaction of banks' sovereign debt portfolios in the crisis countries was characterized by a home bias. By contrast, euro-area core countries' banks seemed not to significantly increase their domestic government bond holdings relative to total assets in response to innovations related to unconventional monetary policy. Core countries' banks rather restructured their sovereign bond portfolios by lowering their holdings of rest-of-EMU government bonds. Furthermore, estimations using the approach by Jarocinski (2010) also provide support for the presence of a significant dichotomy between core and crisis economies with regard to the response of their banking sectors to unconventional monetary policy shocks. While in Italy, Spain, and Portugal the change in the domestic government bond holdings ratio occurred swiftly, in none of the core countries can a significant response of the ratio be documented. Finally, a historical decomposition suggests that the ECB's asset purchases conducted within the SMP contributed to an increase in banks' sovereign debt portfolios. In Portugal, the effect was immediately observable after May 2010, while in Italy and Spain it arose after February 2012. Furthermore, in Italy the announcement of the OMT program in September 2012 seemed also to have contributed to a higher domestic government bond holdings ratio. Overall, we conclude that the crisis countries' banks enlarged their exposure to domestic sovereign debt in response to expansionary innovations stemming from unconventional monetary policy, which possibly made them more vulnerable to sovereign distress.

Our paper is related to several recent contributions that investigate the effects of the ECB's unconventional monetary policy on the sovereign-bank nexus by means of microeconometric methods (Drechsler et al. 2016; Altavilla, Pagano, and Simonelli 2017; Crosignani, Faria-e-Castro, and Fonseca 2017; Peydro, Polo, and Sette 2017; Jasova, Mendicino, and Supera 2018, among others).[4]

[4]We discuss these contributions in greater detail in section 2 below.

These studies have the advantage of exploiting the rich information revealed by the cross-sectional and time-series dimension of the large bank-level panels. The papers usually concentrate on the contemporaneous microeconomic effects of specific policy interventions on the individual bank, while largely abstracting from dynamic macroeconomic feedback effects. We contribute to the literature by basing our empirical analysis on aggregate data, thus taking a purely macroeconomic perspective and providing direct estimates of the reaction of the aggregate banking sector in several euro-area countries to unconventional monetary policy shocks. While acknowledging that the use of aggregate data comes at the cost of losing cross-sectional information, it allows us to capture—albeit only implicitly—many macro-level interlinkages between banks' behavior and the rest of the economy.

The paper is organized as follows. Section 2 gives an overview of the related literature. In section 3, we discuss our benchmark panel VAR model setup. We outline the model framework, introduce the data, and discuss the strategy to identify an unconventional monetary policy shock. In section 4, we summarize our results. We present impulse response analysis, a decomposition of the forecast error variance, discuss alternative schemes to identify unconventional monetary policy shocks, and also discuss the results for the single euro-area countries derived from a panel of VAR models that are estimated by means of a hierarchical Bayesian panel model estimator. Section 5 provides concluding remarks.

2. Related Literature

Our work relates to a number of studies that use structural VAR models to investigate the effects of unconventional monetary policy shocks on the basis of aggregate data.[5] Most of the contributions focus on the transmission of such shocks to real activity and inflation and, in some cases, on credit market variables, e.g., different loan volumes and lending rates, or further financial market aggregates. Other papers take an explicit financial stability perspective by exploring

[5]See, for example, Baumeister and Benati (2013), Gambacorta, Hofmann, and Peersman (2014), Weale and Wieladek (2016), Boeckx, Dossche, and Peersman (2017), and Burriel and Galesi (2018).

how innovations to nonstandard monetary policy affect risk-taking behavior (risk-taking channel) or certain financial stress indicators.[6] The overall conclusion of the vast majority of these studies is that unexpected unconventional interventions induced by monetary policy tend to improve the cyclical situation as well as the refinancing conditions but might also be associated with an intensification of risk-taking in the economy. However, this literature does not discuss any possible effects on the sovereign-bank nexus.

A number of microeconometric studies explore the effects of the ECB's unconventional monetary policy on banks' sovereign debt portfolios using bank-level data. In particular, these papers focus on how certain bank-specific and/or country-specific characteristics affect the behavior of the individual bank. Most contributions focus on the episodes immediately following the introduction of the ECB's long-term refinancing operations (LTROs) conducted with extended maturities between 2011 and 2012 and between 2013 and 2014. These studies mainly test (i) the *carry-trade* hypothesis (Acharya and Steffen 2015), according to which banks go long on high-risk, high-yield sovereign debt, which they fund either by borrowing from the ECB or by going short on low-yield debt, and/or (ii) the *moral suasion* hypothesis (Ongena, Popov, and Van Horen 2019), according to which banks hold domestic government debt partly due to political pressure. Acharya and Steffen (2015) find support for the carry-trade hypothesis as, during 2007–12, particularly large banks and those with low tier 1 capital ratios and high risk-weighted assets exploited government guarantees, arbitrage in regulatory risk weights, and access to central bank funding. Ongena, Popov, and Van Horen (2019) show that during the euro-area sovereign debt crisis, banks in fiscally stressed countries were considerably more

[6]See, for example, Angeloni, Faia, and Lo Duca (2015), Neuenkirch and Nöckel (2018), or Lewis and Roth (2019). Adrian and Liang (2018) provide a comprehensive review of the risk-taking channel of monetary policy. However, most of the empirical contributions dealing with the risk-taking channel are microeconometric in nature and focus on conventional monetary policy (Maddaloni and Peydro 2011; Altunbas, Gambacorta, and Marques-Ibanez 2014; Jimenez et al. 2014, for example). Delis, Hasan, and Mylonidis (2017) and Dell'Ariccia, Laeven, and Suarez (2017) are examples of microeconometric studies also covering episodes of unconventional monetary interventions.

likely than foreign banks to increase their holdings of domestic sovereign bonds in months with relatively high domestic sovereign bond issuance. Since the effect seemed not to be triggered by the ECB's liquidity provision, they conclude that their results reflect a moral suasion behavior.[7] Furthermore, according to Altavilla, Pagano, and Simonelli (2017) publicly owned, bailed-out, and poorly capitalized banks responded to sovereign stress by scaling up their holdings of domestic sovereign debt by more relative to other banks. This pattern turns out to be especially pronounced for public-owned banks at the time of large liquidity injections by the ECB in December 2011 and March 2012. These results show support for both a carry-trade and moral suasion behavior. Evidence provided by Drechsler et al. (2016) suggests that weakly capitalized banks in particular reacted to the ECB's liquidity injections during the euro-area sovereign debt crisis by investing a substantially higher fraction of the additional liquidity in domestic government bonds.[8] Peydro, Polo, and Sette (2017) look at Italian banks and find a positive relationship between the ECB's liquidity injections and the accumulation of domestic sovereign bonds, which is mostly driven by less well-capitalized banks. However, the latter tend to increase their holdings of relatively safe bonds instead of riskier assets, which suggests that the reach for liquidity and safety are much more important drivers than risk-shifting or regulatory arbitrage. Unlike our study, these studies do not explore how the *aggregate* banking sector's sovereign bond portfolio changes in response to unconventional monetary policy surprises.

Finally, Battistini, Pagano, and Simonelli (2014) and Colangelo et al. (2017) also built empirical macroeconomic models to study the

[7]Uhlig (2014) shows in a theoretical model that governments potentially facing refinancing difficulties typically have an incentive to allow domestic banks to accumulate more risky domestic bonds. The opposite is the case when public finances are healthy. Battistini, Pagano, and Simonelli (2014) argue that sovereign stress strengthens this incentive, leading to a positive relationship between sovereign yields and the stock of domestic government bonds held by banks.

[8]Crosignani, Faria-e-Castro, and Fonseca (2017) and Jasova, Mendicino, and Supera (2018) report that Portuguese banks also used the funds obtained via the ECB's LTROs conducted between 2011 and 2012 to buy domestic government debt which was then offered as collateral to obtain short-run liquidity. Carpinelli and Crosignani (2017) derive similar evidence for Italian banks.

sovereign-bank nexus in the euro area. Colangelo et al. (2017) employ the VAR methodology and report that after 2011 banks tended to increase the home bias in their government bond portfolios. Battistini, Pagano, and Simonelli (2014) resort to a vector error-correction model (VECM) and explore how banks' domestic sovereign debt portfolios in euro-area countries are related to changes in the *common risk* and the *country-specific risk* components of sovereign yields.[9] Nevertheless, unlike us, Battistini, Pagano, and Simonelli (2014) and Colangelo et al. (2017) do not discuss the response of banks' sovereign debt portfolios to shocks triggered by nonstandard monetary policy.

3. Panel VAR with Sign Restrictions

3.1 Benchmark Specification

Consider a panel VAR model in reduced form:

$$y_{k,t} = \sum_{j=1}^{p} B_j y_{k,t-j} + \tilde{c}_k + \varepsilon_{k,t}, \tag{1}$$

where $y_{k,t}$ is a vector of endogenous variables for country k, B_j is a matrix of autoregressive coefficients for lag j, p is the number of lags, and $\tilde{c}_k$ is a vector of country-specific intercepts, which accounts for possible heterogeneity across the units. Furthermore, $\varepsilon_{k,t}$ is a vector of reduced-form residuals. In our benchmark model, the vector $y_{k,t}$ consists of industrial production as a measure for real activity; core Harmonised Index of Consumer Prices[10] (core HICP); the Eurosystem's amount of total assets; the policy rate on the main refinancing operations; the level of financial stress, which is approximated by the Country-Level Index of Financial Stress (CLIFS); the spread between EONIA and the policy rate; and the monetary

[9]Battistini, Pagano, and Simonelli (2014) observe that in most countries an increase in the common-risk component is associated with a rise in banks' domestic exposures. In periphery countries, this positive relationship is also present in the case of the country-specific risk component.

[10]The core HICP covers all items (consumer goods) excluding energy and unprocessed food.

financial institutions' (MFI) domestic government bond holdings relative to total assets. The Eurosystem's amount of total assets, the policy rate, and the interest spread are aggregate variables, i.e., identical for all countries, while the remaining variables are country specific. Each variable is linearly detrended at the country level over the sample period. For each element of $y_{k,t}$ we use a pooled set of $M \cdot T$ observations, where M denotes the number of countries and T denotes the number of observations corrected for the number of lags p. The reduced-form residuals $\varepsilon_{k,t}$ are stacked into a vector $\varepsilon_t = [\varepsilon'_{1,t} \dots \varepsilon'_{M,t}]'$, which is normally distributed with mean zero and variance-covariance matrix Σ.

Since our sample is short, we follow Ciccarelli, Maddaloni, and Peydro (2015) by using a panel of euro-area countries that comprises the crisis countries Italy (IT), Spain (ES), and Portugal (PT) as well the core countries Austria (AT), Belgium (BE), Germany (DE), Finland (FI), France (FR), and the Netherlands (NL).[11] The panel approach allows us to pool the diverse information from the countries, while controlling for heterogeneity in the constant term. A main advantage of the approach is that it increases the efficiency of the statistical inference. However, this comes at the cost of disregarding cross-country differences by imposing the same underlying structure for each cross-section unit. We take account of this shortcoming by distinguishing between the crisis countries and the core countries. Additionally, we adopt the hierarchical prior approach of Jarocinski (2010), which allows us to explore the reaction of individual euro-area economies to innovations related to unconventional monetary policy.

3.2 Data

The data are taken from the ECB and collected on a monthly basis covering the period from 2007:M1 to 2014:M12.[12] The beginning of

[11] Note that we exclude Ireland from our analysis, because compared with the other countries the Irish series on industrial production is characterized by a marked volatility. Nevertheless, including Ireland in our panel of countries has virtually no effect on the adjustment of the MFIs' domestic government bond holdings ratio to shocks related to unconventional monetary policy, but on the response of industrial production.

[12] See the online appendix for a description of the data.

the sample period is determined by the launch of the ECB's unconventional monetary policy measures that started during 2007 before the financial crisis intensified. In particular, the central bank conducted supplementary long-term refinancing operations (LTROs) in August 2007 in response to the financial turmoil. The switch to main refinancing operations (MROs) with fixed rates and full allotment occurred in October 2008 and was accompanied by the implementation of LTROs with a maturity of 6 and 12 months, respectively, which were also offered at fixed rates with full allotment (ECB 2011). At the same time, government-guaranteed own-use bonds were accepted as collateral and the collateral rating for central bank refinancing was reduced. The SMP was launched in May 2010 in response to the sovereign debt crisis and supported the effects of two covered bond purchasing programs (CBPPs). The announcement of the OMT in September 2012 contributed to a lowering of sovereign bond yields, although the program itself was not activated (Altavilla, Giannone, and Lenza 2016).[13] Meanwhile, LTROs were offered with a maturity of up to 36 months, which were followed by a series of TLTROs (targeted LTROs) with a maturity of 45 and 48 months, respectively. Additionally, the interest rate on the deposit facility was cut to become negative. Finally, the ECB modified its communication policy by intensifying its *forward guidance*. The end of the sample period is related to the ECB's launch of the extended Asset Purchase Programme (APP) that was announced in January 2015 (Breckenfelder et al. 2016). The reason for excluding the APP from our analysis is that the path of the corresponding asset purchases was to a large degree anticipated by economic agents. In fact, the central bank published precisely the monthly volumes of its asset purchases, the structure of the purchases, as well as the duration of the program. Later information on the extension of the program as well as on the modalities of the end of the net purchases were released. Thus, the APP generated much of its effects through announcement by signaling that the future path of interest rates will be low, which is akin to forward guidance, i.e., the announcement that policy interest rates will remain at the lower bound over a

[13]See also Dell'Ariccia, Rabanal, and Sandri (2018) or Hristov et al. (2019), among others, for a discussion.

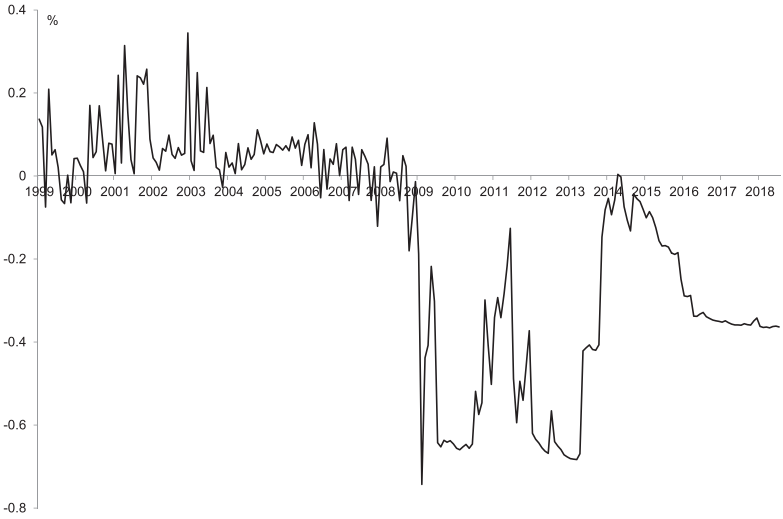
longer period (Breckenfelder et al. 2016).[14] Accordingly, if anything, the 2015–18 episode is likely characterized by, at most, negligible monetary shocks. Thus, simply extending our sample beyond 2014 could bias our estimates and inference. Although the launch of the APP came with the implementation of a second series of TLTROs, it seems that the program reflects a structural break in the conduct of unconventional monetary policy due to its differences compared with earlier nonstandard measures.

The main variable of interest is the ratio of MFIs' holdings of domestic government bonds to total assets.[15] Besides this ratio, the selection of variables refers to Gambacorta, Hoffman, and Peersman (2014) and Boeckx, Dossche, and Peersman (2017) and aims to capture the main economic interactions after the financial crisis. Industrial production and the dynamics of prices are supposed to reflect the macroeconomic development. The Eurosystem's volume of total assets serves as a measure of unconventional monetary policy (ECB 2015). Other studies such as Weale and Wieladek (2016), Gambetti and Musso (2017), or Hesse, Hofmann, and Weber (2018) use the central bank's asset purchases as a measure of nonstandard monetary policy. However, in the case of the ECB's unconventional monetary policy conducted over the period 2007–14, focusing only on asset purchases might be too narrow because it neglects the monetary policy effects that arose in the wake of open market operations with full allotment or the relaxing of collateral requirements. Alternatively, the effects of unconventional monetary policy may be measured by an expanding monetary base (Schenkelberg and Watzka 2013). However, monetary policy measures like the SMP would then not be considered, since the asset purchases conducted under this program were sterilized (Boeckx, Dossche, and Peersman 2017). The MRO

[14] A large quantity of asset purchases by the central bank under a program like the APP can be seen as a credible commitment by monetary policy to keep interest low in the future. Following Krishnamurthy and Vissing-Jorgensen (2011), this transmission channel of monetary policy is denoted as the signaling channel. Note that the OMT, in contrast to the APP, was only announced but not activated.

[15] Note that we only consider the exposures of banks to sovereign debt that are directly observable as explicit balance sheet positions. Beyond that, banks are also exposed to sovereign risk through positions in various derivatives or potentially through offshore institutions. However, we abstract from such exposure due to the very limited availability of suitable data (Koijen et al. 2017).

Figure 1. Interest Rate Spread



Notes: Data are taken from the ECB. Own calculations. Spread is the difference between EONIA and the policy rate on main refinancing operations.

rate is included to facilitate the distinction between conventional and unconventional monetary policy shocks. The interest spread is included as an additional indicator of nonstandard monetary policy. Figure 1 displays that the spread was relatively close to zero in normal times, indicating that EONIA was sticking closely to the policy rate.[16] Essentially, the provision of open market operations with full allotment widened the interest rate spread.

Finally, the CLIFS indicator is a measure of financial stress. By conditioning on it, we control for possible endogenous reactions of the Eurosystem's balance sheet to financial turbulence. More precisely, given the ECB's full allotment policy, changes in the Eurosystem's balance sheet might be demand induced in the case of elevated financial stress (Boeckx, Dossche, and Peersman 2017). Industrial production, the price level, the Eurosystem's volume of total assets,

[16]The banks' usage of the marginal lending facility at the end of a minimum reserve maintenance period mainly caused the shifts of the spread between 1999 and 2003.

and the CLIFS are in logs, while the MFIs' domestic government bond holdings ratio, the policy rate, and the interest rate spread are expressed in percent.

3.3 Identification of Unconventional Monetary Policy Shock

The VAR model (1) is estimated with Bayesian methods using—as proposed by Uhlig (2005)—a normal-Wishart prior.[17] In the model of the crisis countries, the lag order is set to $p = 3$. The selection of the lag length is based on a number of diagnostic tests on the disturbances.[18] While the Bayesian information criterion (BIC) indicates a lag length of two, the results of Lagrange multiplier (LM) tests for autocorrelation and different tests for heteroskedasticity rather suggest to use three lags. Nonetheless, our findings proved robust against alternative lag lengths, e.g., lag orders of $p = 2$ and $p = 4$, respectively. In the model of the core countries the lag order is set to $p = 4$, which is also derived on the basis of diagnostic tests on the error terms. However, to facilitate comparison with the results reported for the crisis countries, we also consider a lag length of three. Based on the outcome of the estimated models, we generate impulse responses of the variables to structural shocks η_t.[19] We identify the structural shocks through sign restrictions using the algorithm of Arias, Rubio-Ramirez, and Waggoner (2014), which allows for imposing sign restrictions as well as zero restrictions on the impulse responses to a structural shock.

[17] In particular, the prior is rather *weak* (non-informative). Accordingly, our results are titled toward the information contained in the data itself. See also Canova (2007, chapter 10) for a discussion. As a robustness check, we also considered a Minnesota-type prior that imposes a stronger structure (shrinkage) over the parameters of the model. The results derived on the basis of that prior are similar to those reported below.

[18] The results of the diagnostic tests on the error terms are not reported here but are available upon request.

[19] Moreover, we assessed all estimated models with respect to parameter stability by conducting a number of Chow tests for different breakpoints. The results of these tests point in the direction of supporting the assumption of constant parameters. However, in spite of these findings, our results reported subsequently should be interpreted with a certain degree of caution due to possible instabilities arising over our sample period. Note, that the Chow-test results are not reported here, but they are available upon request.

The structural representation of the VAR model (1) can be expressed as

$$A_0 y_{k,t} = \sum_{j=1}^{p} A_j y_{k,t-j} + c_k + \eta_{k,t}, \tag{2}$$

with $\eta_{k,t} \sim N(0, I)$, where I is the identity matrix. The reduced-form representation of the SVAR is derived by multiplying both sides of (2) with A_0^{-1}. The structural shocks $\eta_{k,t}$ relate to the reduced-form residuals $\epsilon_{k,t}$ according to $\epsilon_{k,t} = A_0^{-1}\eta_{k,t}$, where $\epsilon_{k,t} \sim N(0, \Sigma)$. The identification of the structural parameters of the model is equivalent to finding the appropriate matrix $\tilde{A} = A_0^{-1}$, which is done by means of sign and zero restrictions. The algorithm of Arias, Rubio-Ramirez, and Waggoner (2014) uses the fact that the Cholesky decomposition of the covariance matrix of the reduced-form residuals $\Sigma = PP'$, where P' is lower triangular, can be extended by any orthogonal matrix Q as follows: $\Sigma = PP' = P'Q'QP$, where $QQ' = I$. As the algorithm further requires that Q has a uniform distribution with respect to the Haar measure, Q can be generated by means of a QR factorization of a random matrix W of proper dimensions, where each element of W follows an independent standard normal distribution. A particular Q is considered a solution to the identification problem if the impulse responses implied by $\tilde{A} = P'Q'$ satisfy a set of sign restrictions. To estimate the posterior of the structural model, we follow the steps suggested by Arias, Rubio-Ramirez, and Waggoner (2014): (i) we draw from the posterior of the reduced-form model, (ii) then we draw an orthogonal matrix Q, (iii) we keep the draw if the combination of reduced-form parameters and Q satisfies the sign and zero restrictions, and discard it otherwise, and (iv) we return to (i) until the required number of draws satisfying the restrictions is obtained. Our results are based on 10,000 draws consistent with the imposed sign restrictions. The latter are discussed subsequently.[20]

[20]It has to be noted that sign restriction relying on the Haar measure regarding the rotation matrix Q could lead to implicit priors on the impact impulse responses (Baumeister and Hamilton 2015, 2018).

3.3.1 Identification of Unconventional Monetary Policy Shocks in the Literature

Following Curdia and Woodford (2011), a number of studies have extended dynamic stochastic general equilibrium (DSGE) models by incorporating unconventional monetary policy (Chen, Curdia, and Ferrero 2012; Falagiarda 2014; Le, Meenagh, and Minford 2016; Quint and Rabanal 2017; Hohberger, Priftis, and Vogel 2019). Although these studies differ in their conclusion regarding the effectiveness of disturbances related to nonstandard measures of monetary policy, they all show that output is stimulated in response to an unconventional monetary policy shock, which is conducted in terms of a quantitative easing, i.e., through the purchase of sovereign bonds that induces the level of base money to rise. Simultaneously, they report that inflation rises after the shock, whereas the government bond yield, the spread between the bond rate and the short-term rate or the risk premium on credit, decline. Table 1 summarizes the findings.

In addition, Gertler and Karadi (2011) analyze the effects of nonstandard monetary policy conducted by the central bank in terms of a credit injection in reaction to a capital quality shock. Unconventional monetary policy significantly moderates the recession induced by an adverse shock, because it dampens the rise in the interest spread, which in turn dampens the investment decline. The central bank's balance sheet rises, but decreases slowly thereafter over time. Inflation remains largely benign.

Using VAR models, Baumeister and Benati (2013), Schenkelberg and Watzka (2013), Gambacorta, Hofmann, and Peersman (2014), Weale and Wieladek (2016), Boeckx, Dossche, and Peersman (2017), Burriel and Galesi (2018), and Hesse, Hofmann, and Weber (2018) explore empirically the macroeconomic effects across countries of an innovation related to nonstandard monetary policy. The latter is identified by imposing sign restrictions.[21] Table 2 summarizes the different identification schemes which comprise a shock to a central bank's total assets (Gambacorta, Hofmann, and Peersman 2014; Boeckx, Dossche, and Peersman 2017), a quantitative easing (QE)

[21] Weale and Wieladek (2016) also identify an unconventional monetary policy shock by adopting a Cholesky ordering.

Table 1. Theoretical Effects of an Unconventional Monetary Policy Shock

	Real Output	Inflation Rate	Government Bond Purchases	Government Bond Yield	Risk Premium	Interest Rate Spread
Falagiarda (2014)	↑	↑	↑	↓		
Chen, Curdia, and Ferrero (2012)	↑	↑			↓	
Le, Meenagh, and Minford (2016)	↑	↑	↑		↓	
Quint and Rabanal (2017)	↑	↑	↑			↓
Hohberger, Priftis, and Vogel (2019)	↑	↑	↑	↓		

Notes: Chen, Curdia, and Ferrero (2012) report impulse responses to a simulated shock to market value of long-term debt. Regarding Quint and Rabanal (2017), we report the case when the stock of assets held by the central bank follows an AR(2) process and the unconventional monetary policy shock is conducted by purchasing government bonds. The interest rate spread denotes the difference between the government bond rate and the short-term rate.

Table 2. Identification of an Unconventional Monetary Policy Shock in the Empirical Literature

Study	Model	Restrictions Imposed
Gambacorta, Hofmann, and Peersman (2014)	Panel VAR for nine advanced economies. 2008:M1–2011:M6	Output: 0 on impact; price level: 0 on impact; financial stress: ≤ 0; central bank total assets: ≥ 0.
Boeckx, Dossche, and Peersman (2017)	VAR model for the euro area. 2007:M1–2014:M12	Output: 0 on impact; price level: 0 on impact; central bank total assets: ≥ 0; financial stress: ≤ 0; spread between EONIA and policy rate: ≤ 0; policy rate: 0 on impact.
Burriel and Galesi (2018)	GVAR for euro-area countries. 2007:M1–2015:M9	Output: 0 on impact; price level: 0 on impact; central bank total assets: ≥ 0; CISS: ≤ 0; spread between EONIA and policy rate: ≤ 0; policy rate: 0 on impact; new credit growth: 0 on impact.
Hesse, Hofmann, and Weber (2018)	VAR models for the United States and the United Kingdom. 2008:M11–2014:M10	Output: 0 on impact; price level: 0 on impact; bond yield: ≤ 0; stock prices ≥ 0; asset purchase announcements: ≥ 0.
Weale and Wieladek (2016)	VAR model for the United States. 2009:M3–2014:M5	Output: unrestricted; price level: unrestricted; central bank asset purchases: ≥ 0, bond yield: ≤ 0, and real equity prices: ≥ 0.
Schenkelberg and Watzka (2013)	VAR model for Japan. 1995:M1–2010:M9	Output: 0 on impact; price level: 0 on impact and ≥ 0 thereafter; central bank reserves: > 0.
Baumeister and Benati (2013)	TVP-VAR models for the United States and the United Kingdom. 1965:Q4–2011:Q4 and 1975:Q2–2011:Q4	Output: ≥ 0; price level: ≥ 0; short-term rate: 0 on impact; interest rate spread: ≤ 0.

shock related to the central bank's asset purchases (Weale and Wieladek 2016; Hesse, Hofmann, and Weber 2018), or an increase in reserves (Schenkelberg and Watzka 2013), as well as an interest spread shock induced by nonstandard interventions of monetary policy (Baumeister and Benati 2013).[22]

In general, the results of these studies indicate that the estimated response of output to a nonstandard monetary policy shock is positive and similar to the one found in the literature on the effects of *conventional* monetary policy. Simultaneously, the price level rises in response to a disturbance to unconventional monetary policy, whereas the bond yield, the spread between the government bond rate and the short-term rate, as well as financial stress decline.[23]

3.3.2 Sign Restrictions

In our benchmark specification, we follow Boeckx, Dossche, and Peersman (2017) regarding the identification of a shock to unconventional monetary policy. Table 3 summarizes our set of restrictions, which comprises both zero restrictions and sign restrictions.[24]

Industrial production, prices, and the policy rate are restricted to a zero response on impact after the shock. Furthermore, the Eurosystem's total assets are assumed to increase, whereas the interest rate spread, i.e., the spread between EONIA and the policy rate, as well as financial stress are supposed not to rise. Finally, the reaction of

[22]Kapetanios et al. (2012) and Hristov et al. (2019) adopt the identification scheme of Baumeister and Benati (2013) to identify unconventional monetary policy shocks in the United Kingdom and the euro area.

[23]Alternatively, a number of studies seek to identify the effects of unconventional monetary policy by using an *event-study* approach that is based on high-frequency data and focuses on a narrow window around the policy announcement. See Dell'Ariccia, Rabanal, and Sandri (2018) for an overview and discussion.

[24]Recently, a controversy has surrounded the identification strategy adopted by Boeckx, Dossche, and Peersman (2017). In particular, Elbourne and Ji (2019) have argued that this strategy does not identify shocks to unconventional monetary policy. They argue that one basically obtains very similar impulse responses even without the main identifying restriction—that imposed upon the ECB's total assets. However, Boeckx et al. (2019) demonstrate through a number of empirical exercises that the approach by Boeckx, Dossche, and Peersman (2017) indeed successfully identifies unconventional monetary policy shocks.

Table 3. Identification of an Unconventional Monetary Policy Shock

	Benchmark Model
Output	0
Price Level	0
Eurosystem's Total Assets	≥ 0
Policy Rate	0
Interest Rate Spread	≤ 0
CLIFS	≤ 0
MFIs' Bond Holdings Ratio	?

Notes: Restrictions are set in accordance with Boeckx, Dossche, and Peersman (2017). Interest rate spread denotes the spread between EONIA and the policy rate. Zero restrictions are denoted by 0. Sign restrictions are imposed as ≥ 0 or ≤ 0 and are binding over a period of four months. Unrestricted responses are denoted by "?."

the MFIs' domestic government bond holdings ratio to an unconventional monetary policy shock is unrestricted. The sign restrictions are imposed as $\leq$ or $\geq$ and are binding over a period of four months.[25]

According to Boeckx, Dossche, and Peersman (2017), the set of restrictions is rich enough to ensure that the unconventional monetary policy shock is orthogonal to real economy disturbances, shocks in financial markets, and conventional innovations to monetary policy. Typically, output and prices move in opposite directions after an aggregate supply shock. An aggregate demand shock is characterized by an immediate reaction of monetary policy, whereby the spread between EONIA and the policy rate normally does not widen.[26] A shock to standard monetary policy also causes an immediate response of the policy rate, which exerts direct influence on

[25]Note that the choice of the period over which the sign restrictions are binding is arbitrary. Thus, we also considered a period of two months over which the restrictions are binding. The results are very similar to those reported below.

[26]Indeed, VAR models estimated in normal times to investigate the macroeconomic effects of a monetary policy shock frequently use the EONIA as a proxy for conventional monetary policy. See Ciccarelli, Maddaloni, and Peydro (2015) as an example.

output and the price level. Ultimately, adverse disturbances in financial markets increase financial stress, thereby causing a recession that is followed by an immediate expansionary response of monetary policy.

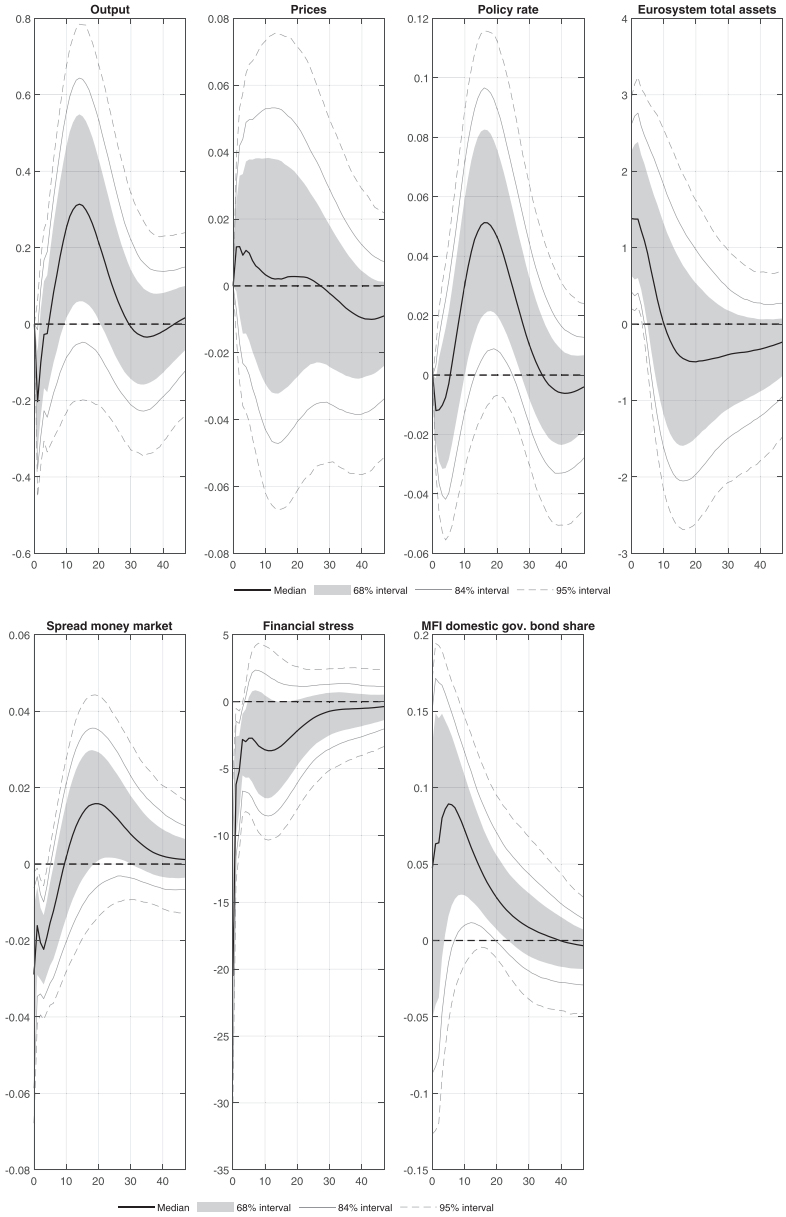
4. Results

In our analysis, we estimate separate panel VARs for each of the following two groups of euro-area member countries: (i) the *crisis countries*, comprising Italy, Spain, and Portugal, and (ii) the *core countries*, consisting of Austria, Belgium, Germany, Finland, France, and the Netherlands. In doing so, we allow for possible structural heterogeneities across the two groups. Such heterogeneities appear a priori very likely given the differences between the groups in terms of historical experience during the period of the European sovereign debt crisis, i.e., 2010–13. In particular, crisis countries' sovereigns faced difficulties in tapping international capital markets, leading to extraordinary fiscal distress. As explained in the introduction, the unfavorable situation was likely exaggerated by the emergence of *doom loops* due to the sovereign-bank nexus. All these culminated in outright financial and banking crises. As a consequence, Italy, Spain, and Portugal found themselves forced to initiate substantial recapitalizations and restructurings of their banking sectors, adopt massive cyclical and structural adjustments in fiscal policy, and start launching far-reaching structural reforms in labor and good markets. In contrast, the core countries faced moderate recessions over the years 2011–13. Since they had no crisis-like eruptions, they were not forced to undertake substantial structural adjustments, and even benefited from being accepted as *safe havens* by international investors.

4.1 Benchmark Model

Figure 2 shows the average reaction of a euro-area crisis country to an expansionary unconventional monetary policy shock. The black solid lines are the median impulse responses of the posterior distribution. The shaded areas correspond to the 68 percent posterior credibility bounds, while the thin gray lines refer to the

Figure 2. Euro-Area Crisis Countries Impulse Responses to a UMP Shock



Notes: "UMP Shock" denotes an unconventional monetary policy shock. Industrial production, prices, the Eurosystem's volume of total assets, and the CLIFS are in logs, while the remaining variables are in percent. The unconventional monetary policy shock is identified as in Boeckx, Dossche, and Peersman (2017) by using the same set of zero and sign restrictions.

84 percent and the thin gray dashed lines to the 95 percent credible sets, respectively.[27] The simulation horizon covers 48 months.

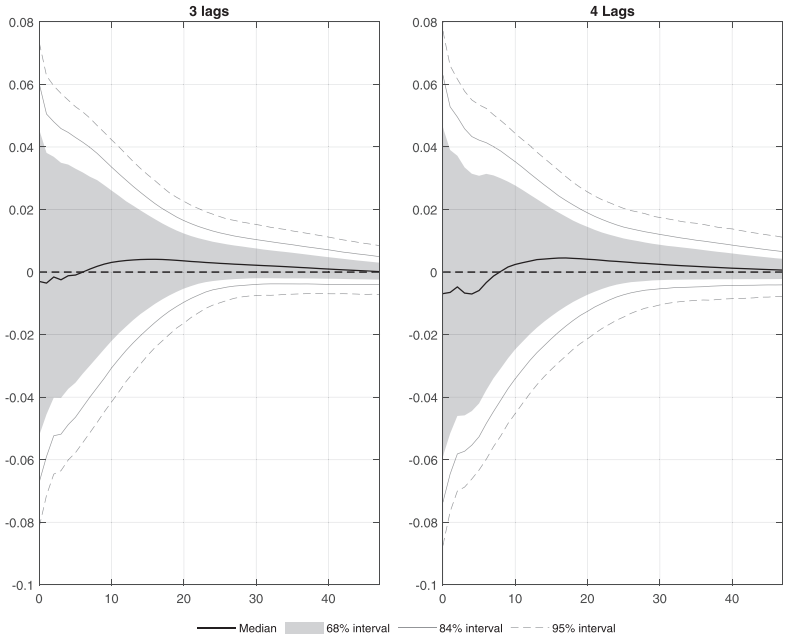
We see that the economy in the euro-area crisis countries is stimulated by a sudden unconventional monetary policy loosening. Output rises, reaching a peak around 14 months after the shock. The reaction of prices is sticky. Monetary policy starts to tighten the policy rate with a delay. These results are in line with the findings of Boeckx, Dossche, and Peersman (2017), who also report a boom of the economy after a positive central bank balance sheet innovation that is followed by a tightening of standard monetary policy. The spread between EONIA and the policy rate remains negative for about six months. The CLIFS financial stress indicator declines. Banks respond to the favorable unconventional monetary policy shock by adjusting their sovereign debt portfolios. The MFIs' domestic government bond holdings ratio exhibits a sizable increase. In particular, our results suggest a maximum median increase in the MFI ratio by 0.089 percentage point after a rise in the ECB's total assets by 1 percent. The peak effect is reached after five months. We find that the MFI ratio increases by 1.29 percent in Italy (from 6.94 percent on average to 7.03 percent), by 1.68 percent in Spain (from 5.34 percent of average to 5.43 percent), and by 2.52 percent in Portugal (from 3.56 percent on average to 3.67 percent).[28]

The reaction of the MFIs' domestic government bond holdings ratio in the core countries to an unconventional monetary policy shock is shown in figure 3, which displays the results derived from both a model estimated with three lags and four lags. The results indeed indicate that, on average, the banking sector in the core countries responds very differently from that in the crisis economies. In particular, we observe that the core countries' MFI ratio hardly responds at all to an unconventional monetary policy shock.

[27] A number of studies—for example, Peersman (2005), Uhlig (2005), Scholl and Uhlig (2008), Hofmann, Peersman, and Straub (2012), Sa, Towbin, and Wieladek (2014), Boeckx, Dossche, and Peersman (2017), and many others—report the 68 percent posterior credibility intervals.

[28] In absolute figures our results suggest that a rise in the ECB's total assets by €10 billion is followed by an increase in MFIs' domestic government bond holdings by €728,870 million in Italy, €631,416 million in Spain, and €97,192 million euro in Portugal. However, note that these figures are calculated on the basis of averages and are, thus, only an approximation.

Figure 3. Reaction of the Core Countries' MFI Ratio to a UMP Shock



Notes: See figure 2. The core countries comprise Austria, Belgium, Germany, Finland, France, and the Netherlands. "MFI Ratio" denotes the MFIs' domestic government bond holdings ratio.

4.2 Forecast Error Variance Decomposition for the Crisis Countries

In order to understand the quantitative importance of the unconventional monetary policy shock for the crisis countries, we compute the forecast error variance decomposition (FEVD), which in contrast to the impulse response analysis takes into account the estimated magnitude of the shock. Table 4 reports the forecast error variance decomposition of each variable at different forecast horizons.

We find that fluctuations in output in the crisis countries are hardly explained by the unconventional monetary policy shock. The same holds true for the evolution of prices with a maximum share of only about 3 percent. In contrast, the variation of the

Table 4. Crisis Countries Forecast Error Variance Decomposition

Month	Output	Price Level	Eurosystem's Total Assets	Policy Rate	Interest Rate Spread	CLIFS	MFIs' Bond Holdings Ratio
1st	—	—	14.13	—	8.76	30.09	13.36
2nd	0.35	0.13	13.06	0.12	9.31	25.91	13.36
3rd	0.47	0.32	12.20	0.24	10.91	23.45	13.28
6th	0.87	0.72	9.82	0.59	13.99	18.85	15.27
12th	2.16	1.46	8.05	2.39	11.45	16.41	19.32
24th	3.78	2.63	8.93	6.93	12.07	16.26	21.63
36th	4.23	3.21	9.66	7.60	12.68	16.28	21.37
48th	4.40	3.67	10.02	7.75	12.79	16.22	21.14

Notes: Quantitative importance of unconventional monetary policy shock measured in percent. Crisis countries include Italy, Spain, and Portugal. Zero restrictions set on output, prices, and the policy rate are imposed over one month. In this respect, "—" signals impact of zero restriction. Sign restrictions set on remaining variables are imposed over the first four months. The reaction of the MFIs' domestic government bond holdings ratio to an unconventional monetary policy shock is unrestricted.

MFIs' domestic government bond holdings ratio triggered by a shock to nonstandard policy is considerably larger. On average, the shock explains around 19 percent of the fluctuation. Moreover, the contribution of the fluctuation of the CLIFS indicator of financial stress caused by disturbances related to nonstandard monetary policy is also notable, fluctuating on average also around 20 percent.

4.3 Alternative Model Specifications

We assess the robustness of our results by considering three alternative models in which we adopt different schemes to identify a nonstandard monetary policy innovation.

4.3.1 Alternative A

In the first alternative specification we exclude the policy rate on the main refinancing operations from the model, and include another variable instead—the volume of liquidity provided via the MROs relative to total assets. The ECB's main refinancing operations were in normal times the most important open market operations through which the bulk of liquidity was provided. They played a pivotal role in signaling the stance of monetary policy and managing the liquidity situation in the money market. Figure 4 shows that the share of liquidity provided via the MROs relative to all liquidity-providing open market operations amounted to about 75 percent on average between 1999 and 2007, i.e., before the onset of the financial crisis.

However, the share of the MROs dropped markedly after the intensification of the financial crisis in 2008 as longer-term refinancing operations, targeted longer-term refinancing operations, and outright purchases became more and more important. Hence, the ECB's unconventional monetary policy measures are characterized not only by causing an extension in the central bank balance sheet but also by causing a change in its composition. Accordingly, to identify an unconventional monetary policy shock, we assume that it is associated with a nonpositive response of the ratio of MRO volume to the Eurosystem's total assets. The column labeled "Alternative A" in table 5 displays the set of restrictions imposed to identify the

Figure 4. Share of Main Refinancing Operations Relative to All Liquidity-Providing Open Market Operations

Notes: Data are taken from the ECB. Own calculations. Liquidity-providing open market operations include the main refinancing operations, longer-term refinancing operations, and other liquidity-providing operations such as outright purchases, structural operations, and fine-tuning operations.

unconventional monetary policy shock. The restrictions regarding the Eurosystems's total assets, industrial production, the price level, the money market spread, and the CLIFS indicator are the same as in our benchmark specification.

4.3.2 Alternative B

In our second alternative specification we replace the Eurosystem's total assets by the volume of liquidity provided by the LTROs. The latter were used by banks to fund their assets.[29] To identify an unconventional monetary policy shock, we assume that it induces an increase in the volume of LTROs. The remaining variables are

[29]The provision of the LTROs is frequently associated with the term "Sarko trade." Former French president Nicolas Sarkozy suggested that each government in the euro area may borrow from their own commercial banks, which in turn could use the LTROs to gain access to central bank refinancing.

Table 5. Alternative Identification Schemes

	Alternative A	**Alternative B**	**Alternative C**
Output	0	0	0
Price Level	0	0	0
Policy Rate	•	0	0
Eurosystem's Total Assets	≥ 0	•	•
Volume LTROs	•	≥ 0	•
Shadow Rate	•	•	≤ 0
Volume MROs to Total Assets	≤ 0	•	•
Interest Rate Spread	≤ 0	≤ 0	≤ 0
CLIFS	≤ 0	≤ 0	≤ 0
MFIs' Bond Holdings Ratio	?	?	?

Notes: "Interest Rate Spread" denotes the spread between EONIA and the policy rate. Zero restrictions on impact are denoted by 0. Sign restrictions are imposed as ≥ 0 or ≤ 0 and are binding over a period of six months. Unrestricted responses are denoted by "?". Finally "•" denotes that the variable is not included in the respective model.

subject to the same sign and zero restrictions as in our baseline specification. The column in table 5 labeled "Alternative B" summarizes restrictions imposed.

4.3.3 Alternative C

Finally, in our third alternative specification we replace the Eurosystem's total assets with a shadow rate. In particular, we resort to the shadow rate constructed by Krippner (2013), which is derived from a term structure model and attempts to proxy the true stance of monetary policy in times when conventional monetary policy is constrained by the zero lower bound and nonstandard measures of monetary policy are adopted.[30]

We identify the shock related to an expansionary unconventional monetary policy by restricting the shadow rate to decrease while

[30]Leo Krippner's shadow rate series for the euro area is available under https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures. Figure A.2 in the online appendix displays the shadow rate for the euro area together with the policy rate.

the remaining variables are again subject to the same sign and zero restrictions as in the benchmark specification (see the column labeled "Alternative C" in table 5).[31]

4.3.4 Impulse Responses Based on the Alternative Specifications

We estimate the alternative models for the euro-area crisis countries using each time a lag order of three. Figure 5 summarizes the reactions of the MFIs' domestic government bond holdings ratio to an innovation to unconventional monetary policy.

As can be seen, the impulse responses confirm those implied by our benchmark specification, albeit in alternative A the response of the MFI ratio to the shock is less pronounced.[32] Thus, banks in the crisis countries seemed to increase their fraction of domestic sovereign bonds in their balance sheets in response to the nonstandard monetary policy measures. Regarding the core countries, each of the three alternative models indicates a reaction of the MFI ratio to an unconventional monetary policy shock that is hardly notable.[33]

4.4 Cross-Country Heterogeneity

Next, we assess possible heterogeneity across the euro-area economies.

4.4.1 Impulse Response Analysis

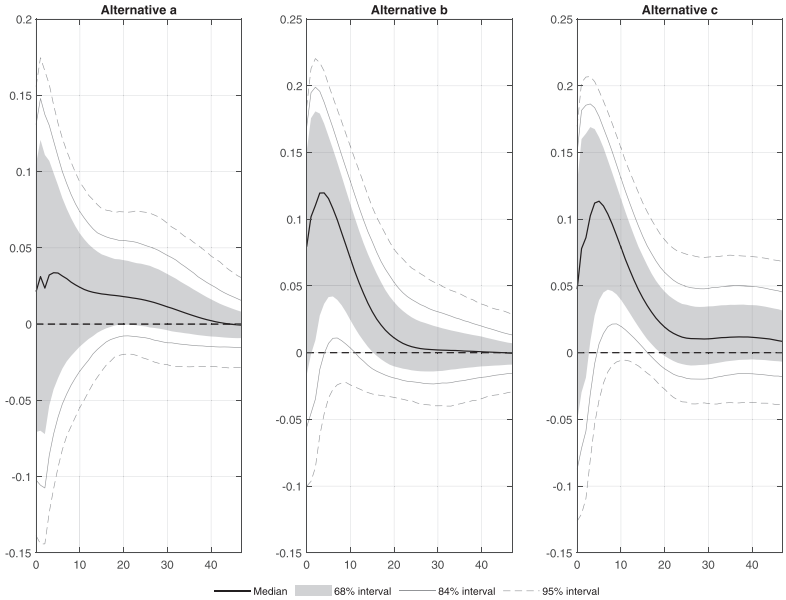
Following Jarocinski (2010), we estimate a panel of VAR models for both groups of euro-area countries, i.e., the crisis economies and

[31]In addition, we performed several further experiments with models including a shadow rate. First, replacing Krippner's shadow rate with the one proposed by Wu and Xia (2016) leaves the results unchanged. Second, irrespective of the shadow rate used, replacing the zero restrictions on industrial production and prices with "$\geq$" sign restrictions or excluding the CLIFS and the money market spread from the model delivers qualitatively similar impulse responses. The results obtained in these robustness checks are available upon request.

[32]The responses of the remaining variables in the alternative models are similar to those in the benchmark specification. They are not shown here but are available upon request.

[33]The corresponding impulse responses are available upon request.

Figure 5. Reaction of the Crisis Countries' MFI Ratios to a UMP Shock



Notes: The MFI ratio impulse responses are calculated on the basis of the alternative model specifications A–C. The black solid lines are the median impulse responses of the posterior distribution. The shaded areas correspond to the 68 percent posterior credibility bounds. The thin gray lines refer to the 84 percent and the thin gray dashed lines to the 95 percent credible sets, respectively.

the core economies, by using a hierarchical Bayesian panel model estimator. The VAR model for country k reads as follows:

$$y_{k,t} = \sum_{j=1}^{p} B_{k,j} y_{k,t-j} + \tilde{c}_k + \varepsilon_{k,t}, \tag{3}$$

where the matrices of autoregressive coefficients $B_{k,j}$ are now country specific. The Bayesian estimation is conducted with the prior that the countries in every group do not differ in terms of their macroeconomic dynamics. Hence, the countries are assumed to be special cases of the same underlying economic model, which implies that the matrices B_j tend to be similar across the economies. This

prior results in the posterior which pools information across countries (Jarocinski 2010). The models for the crisis countries are estimated with a lag length of three, while for the models for the core countries four lags are used. We identify the unconventional monetary policy shock as in the benchmark model, i.e., by imposing the same zero restrictions and sign restrictions.[34]

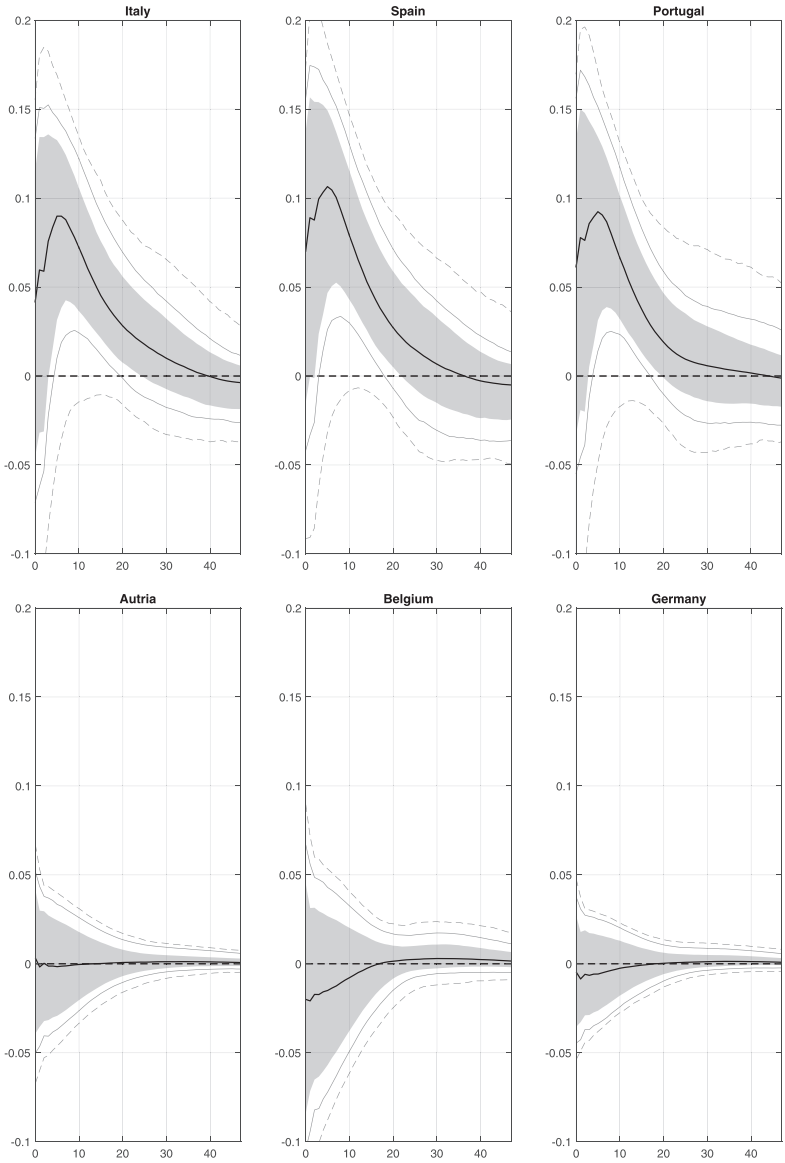
Figure 6 summarizes the responses of the MFIs' domestic government bond holdings ratios across the countries in both groups to an expansionary shock to nonstandard monetary policy. In the crisis countries, the ratios increase significantly. The adjustment across the countries appears to be qualitatively and quantitatively quite similar. By contrast, in all core countries the reaction of the ratios turns out to be insignificant.

4.4.2 Historical Decomposition

On the basis of the VAR models (3) estimated for the crisis countries, we compute a historical decomposition. While the FEVD sheds some light on the quantitative importance of the structural shocks over the entire sample period, the historical decomposition allows to figure out the relevance of a shock for each month within the sample period. We base our calculation of the historical decomposition on the models estimated in the spirit of Jarocinski (2010) because the approach allows for differences across countries by imposing only the restriction that the mean of the slope coefficients are identical for each unit.

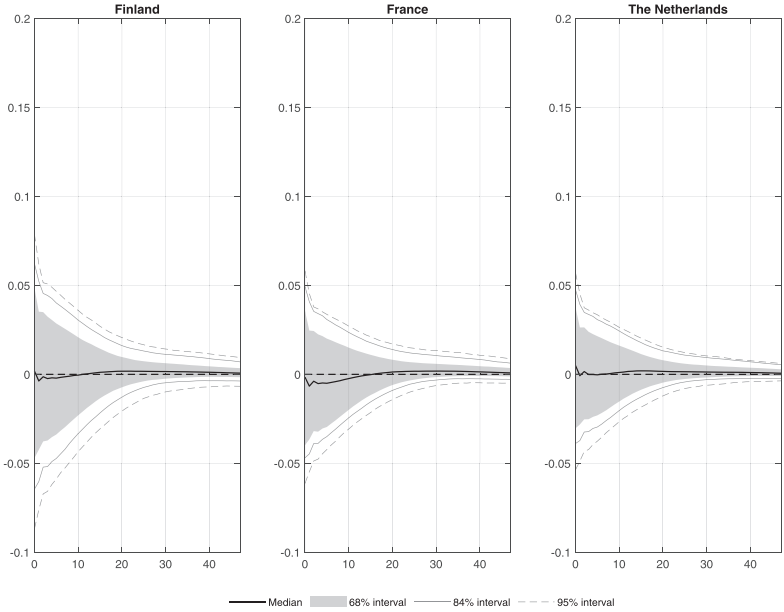
[34]We resort to the BEAR (Bayesian estimation, analysis and regression) toolbox of Dieppe, van Roye, and Legrand (2016) for estimation. The estimation requires Gibbs sampling. We perform the algorithm 10,000 times, discarding the first 5,000 samples as burn-in. The standard priors are set according to the following: For the overall tightness—a parameter strongly affecting the degree of cross-sectional heterogeneity—we set the starting value to $\lambda_1 = 0.1$, and assume the following inverse-gamma prior $\lambda_1 \sim IG(s_0/2, v_0/2)$ with $s_0 = 0.001$ and $v_0 = 0.001$. For the country-specific vector of slope coefficients we have a normal prior, i.e., $\beta_i \sim \mathcal{N}(b, \Sigma_b)$ with a diffuse prior for the overall mean b, and a Minnesota-type prior for the covariance matrix Σ_b, i.e., $\Sigma_b = (\lambda_1 \otimes I_q)\Omega_b$, where the matrix Ω_b is defined in standard Minnesota-style manner while λ_1 is the overall-tightness parameter. Furthermore, a diffuse prior is used for the covariance matrix Σ_i of the reduced-form residuals of cross-sectional unit i. Finally, we set the priors for cross-variable weighting to 1, for lag decay to 0, and for exogenous variable tightness to 100 (Jarocinski 2010).

Figure 6. Impulse Responses of MFIs' Ratios across Euro-Area Countries to a UMP Shock



(*continued*)

Figure 6. (Continued)

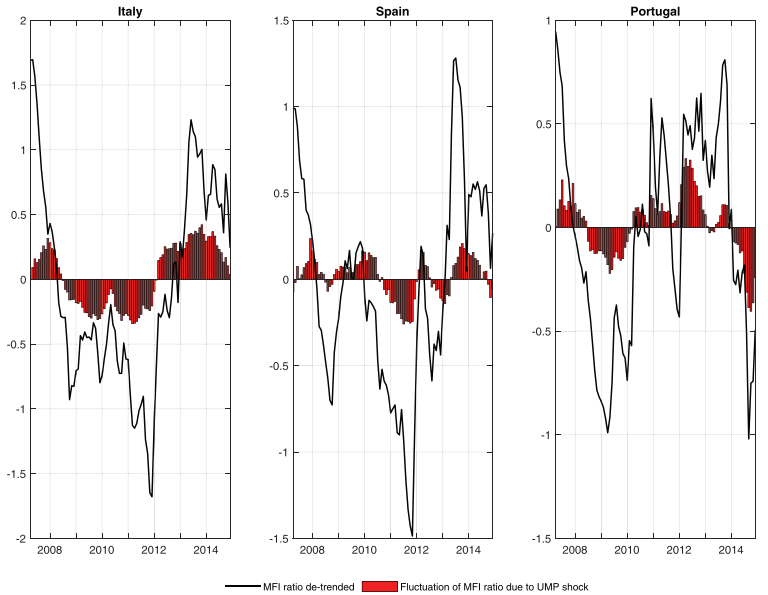


Notes: Impulse responses are derived from a panel of VAR models using a hierarchical Bayesian panel model estimator. The black solid lines are the median impulse responses of the posterior distribution. The shaded areas correspond to the 68 percent posterior credibility bounds. The thin gray lines refer to the 84 percent and the thin gray dashed lines to the 95 percent credible sets, respectively.

For every crisis country, figure 7 displays the detrended MFIs' domestic government bond holdings ratio and the historical contributions to its variation by shocks to unconventional monetary policy. A positive value signals a stimulating effect on the MFI ratios, whereas a negative value reflects a contracting impact.

Our findings suggest that the variation of banks' domestic government bond holdings ratios was affected by nonstandard monetary policy shocks. The MFI ratios fell below their trend in response to the ECB's unconventional monetary policy measures conducted between 2008 and 2009. Since the aim of these policy measures was to support the banking sector by serving as a lender of last resort, the drop in the ratios may be explained by a rise in total assets. While banks had almost unlimited access to liquidity provided through

Figure 7. Historical Decomposition



Notes: The black solid lines reflect the detrended MFIs' domestic government bond holdings ratio. The bars display the fluctuation of the MFI ratios due to an unconventional monetary policy shock.

open market operations with full allotment, they used the deposit facility as a store of liquidity due to the massive distortions on the interbank money market. Subsequently, the ECB's launch of the SMP seemed to generate a positive effect on the share of domestic government debt in banks' balance sheets between 2010 and 2012, which, however, can be decomposed into two parts. In Portugal, the asset purchases contributed to a rise in the MFI ratio in May 2010, while in Italy and Spain they initially had a contracting effect, which possibly arose because both countries were not included in the first wave of purchases. The asset purchases conducted between August 2011 and February 2012 also comprised Italian and Spanish sovereign bonds. Consequently, the MFI ratios in Italy and Spain started to rise. The ECB's announcement of the OMT program in September 2012 also seemed to stimulate the accumulation of domestic sovereign debt, possibly by removing distortions in government bond

markets that were reflected by a severe rise in sovereign risk premiums. However, in Spain the effect appeared with a delay. Finally, the ECB conducted LTROs with extended maturities between 2013 and 2014, started to implement forward guidance, and set a negative interest rate on the deposit facility.[35] In response, especially in Italy and Spain, the variation of the domestic government debt ratios appeared to be stimulated by these measures.

4.5 Sovereign Debt Portfolio Adjustment

So far, our results suggest that euro-area crisis countries' banks increase their holdings of domestic government bonds relative to total assets after unconventional monetary policy shocks. However, this finding does not allow us to infer whether banks indeed increased the home bias of their sovereign bond portfolios. The reason is that the decline in the share of domestic government debt in total assets might purely mechanically reflect a reduction in the stock of outstanding loans and, thus, in total assets, without any active adjustments of the bond portfolio. In this case, the share in total assets of sovereign bonds issued by other euro-area countries and by countries outside the currency union should exhibit a similar increase in response to the monetary shock.

Therefore, we seek to shed some light on the MFIs' decisions in managing their sovereign debt portfolio. To this purpose, we estimate additional models for both groups, i.e., the crisis countries and the core countries, which differ from our benchmark specification in that the MFIs' domestic government bond holdings ratio is replaced by alternative ratios. In particular, we investigate the response to unconventional monetary policy shocks of (i) the holdings of government bonds issued in the rest of EMU relative to total assets, (ii) the ratio of domestic government bonds to those from the rest of EMU, (iii) the holdings of government bonds issued outside the EMU relative to total assets, and (iv) the ratio of domestic government bonds to those issued outside the EMU. Note that due to data availability, when working with banks' holdings of bonds from issuers outside

[35]The ECB introduced its forward guidance on July 4, 2013 when President Mario Draghi stated: "The Governing Council expects key ECB interest rates to remain at present or lower levels for an extended period of time." See also Dell'Ariccia, Rabanal, and Sandri (2018) for a discussion.

the currency union, we have to switch from a monthly to a quarterly frequency.

For the crisis countries, figure 8 summarizes the impulse responses of the alternative MFIs' ratios to an innovation related to unconventional monetary policy.

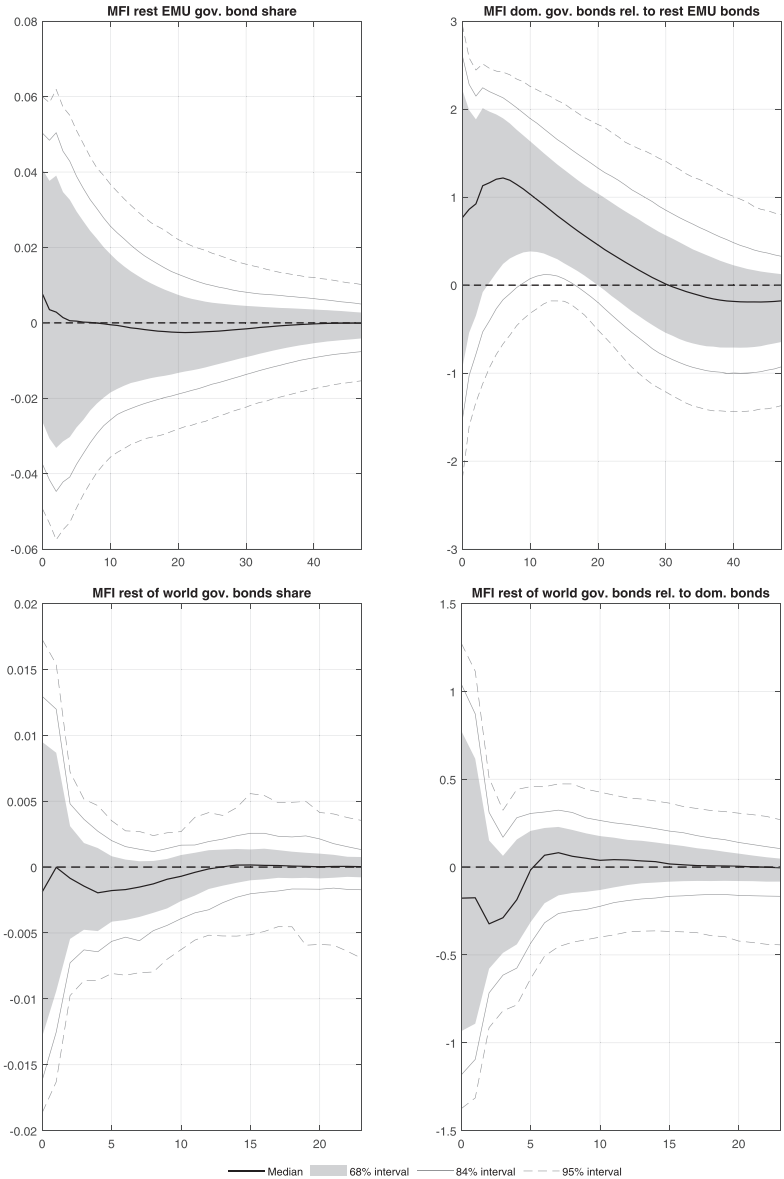
We observe that banks hardly reduced their holdings of rest-of-EMU government bonds relative to total assets. However, the management of the sovereign debt portfolios appears to be home biased, as the ratio of domestic to rest-of-EMU government bond holdings rises. Thus, the adjustment of both ratios suggests that the home bias is triggered by a notable increase in domestic government bonds rather than a reduction in the holdings of rest-of-EMU government bonds. By contrast, the share of banks' holdings of sovereign bonds issued by countries outside the EMU does not change in response to the unconventional monetary policy shock.

In the core countries, banks also seemed to adjust their sovereign debt portfolios after the nonstandard monetary policy disturbances, but in a different manner (see figure 9). Banks' holdings of rest-of-EMU bonds relative to total assets appear to decline. Additionally, the ratio of home-issued sovereign bonds to rest-of-EMU bonds rises. Hence, the rise in the ratio appears to be triggered by a drop in the holdings of rest-of-EMU bonds sovereign bonds rather than a rise in the holdings of domestic government bonds. By contrast, the holdings of sovereign bonds issued by countries outside the EMU seem not to be affected by disturbances related to unconventional monetary policy.

4.6 Extended Period: 2007–18

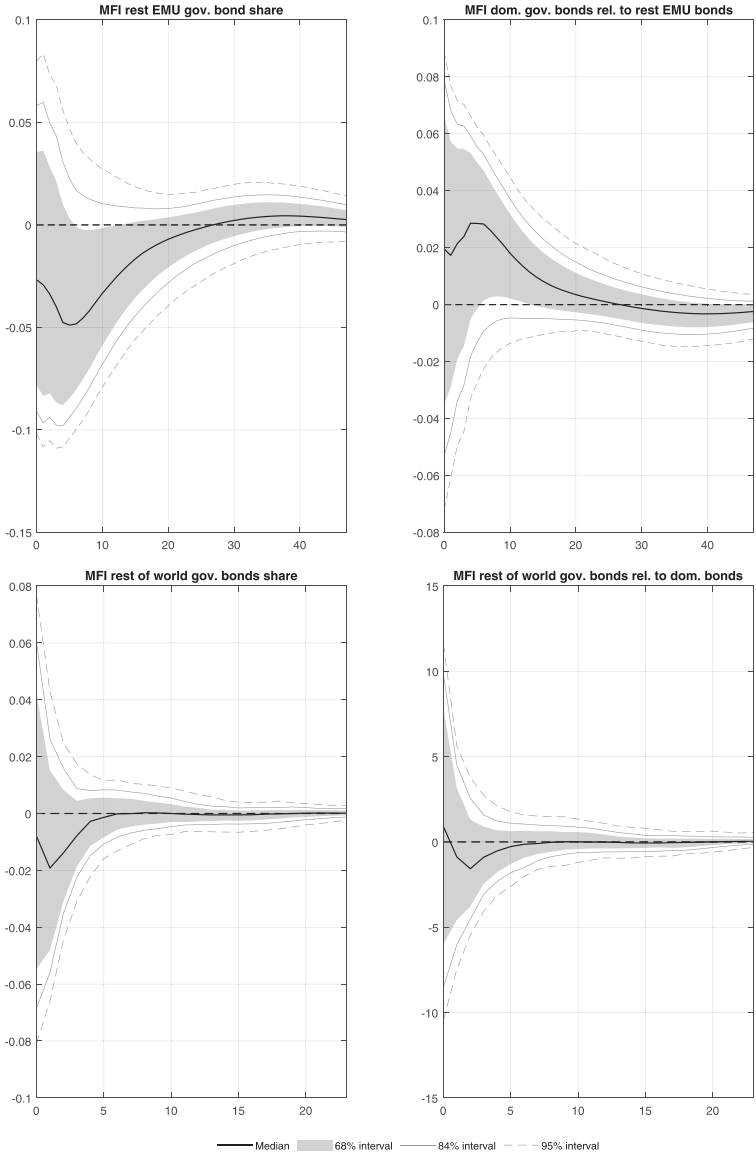
Note that we have excluded the ECB's APP from our sample because the program that started in 2015 was expected (Boeckx, Dossche, and Peersman 2017). The conditions of APP were reported in the press, following the various announcements by the ECB Executive Board members, which summarized the details regarding the conduct of the program (Gambetti and Musso 2017). In particular, the ECB announced the precise volume of the monthly asset purchases, the composition of these purchases regarding the securities issued by euro-area governments, and the maturity of the program.

Figure 8. Reaction of the Crisis Countries' Alternative MFI Ratios to a UMP Shock



Notes: MFIs' rest-of-EMU government bond share reflects the banks' holdings of rest-of-EMU government bonds relative to total assets. MFIs' rest-of-world government bond share reflects the banks' holdings of outside EMU government bonds relative to total assets. The black solid lines are the median impulse responses of the posterior distribution. The shaded areas correspond to the 68 percent posterior credibility bounds. The thin gray lines refer to the 84 percent and the thin gray dashed lines to the 95 percent credible sets, respectively.

Figure 9. Reaction of the Core Countries' Alternative MFI Ratios to a UMP Shock



Notes: MFIs' rest-of-EMU government bond share reflects the banks' holdings of rest-of-EMU government bonds relative to total assets. MFIs' rest-of-world government bond share reflects the banks' holdings of outside EMU government bonds relative to total assets. The black solid lines are the median impulse responses of the posterior distribution. The shaded areas correspond to the 68 percent posterior credibility bounds. The thin gray lines refer to the 84 percent and the thin gray dashed lines to the 95 percent credible sets, respectively.

Latter changes to the program were communicated.[36] Overall, the use of impulse response analysis might not be appropriate under these conditions because, due to a lack of surprises, the effects of an unexpected shock can hardly be identified.

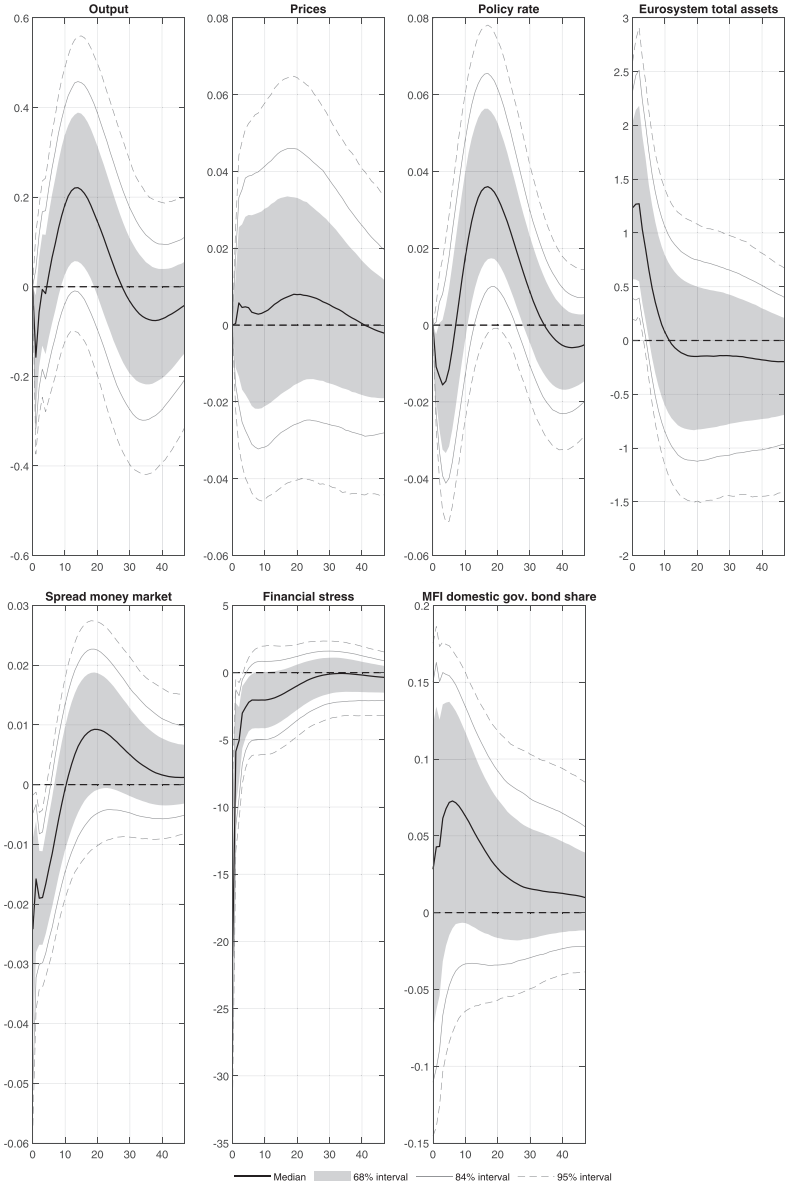
Despite the exception to embedding the episode of the ECB's APP in an impulse response analysis, we proceed by estimating our benchmark model (1) over the period 2007–18 to gain additional insights into the reaction of the MFIs' domestic government bond holdings ratio to an unconventional monetary policy shock. Referring to table 1, we identify the shock by imposing zero and sign restrictions.

For the crisis countries, figure 10 shows the impulse responses of the model variables to a favorable unconventional monetary policy shock. The results are quite similar to those reported for the period 2007–14. Output initially rises after the shock. The boom of the economy is accompanied by an increase in prices. Banks seem to adjust their domestic sovereign debt portfolios. The MFIs' domestic government bond ratio rises, hardly significantly, however, and with a substantial delay.

The delayed reaction of banks' domestic government bond holdings to innovations triggered by unconventional monetary policy might be explained by the characteristics of the ECB's APP program, whose introduction marked a break in the conduct of unconventional monetary policy measures. In particular, the size of the monthly securities purchases under the APP exceeded all existing purchases programs that had been implemented before. Thus, banks might have taken more time to adjust their domestic sovereign debt portfolio in response to unconventional monetary policy disturbances over the period 2007–18 compared with 2007–14.

[36]Initially, the ECB announced with the start of the APP a monthly amount of securities purchases of €60 billion in January 2015, which were intended to be carried out until September 2016. However, the ECB decided to expand the monthly amount of securities purchases to €80 billion in March 2016, while in April 2017 the pace of monthly purchases was reduced to €60 billion. Furthermore, the APP was expanded to run until December 2018. Finally, the ECB decided in 2018 to reduce the monthly purchases further to €30 billion and €15 billion, respectively. Overall, the ECB's accumulated purchases of sovereign securities amounted to €2,102,048 billion at the end of 2018.

Figure 10. Euro-Area Crisis Countries Impulse Responses to a UMP Shock



Notes: Impulse responses are calculated from the benchmark model that is estimated over the period 2007–18. See notes of figure 2 for further explanations. The black solid lines are the median impulse responses of the posterior distribution. The shaded areas correspond to the 68 percent posterior credibility bounds. The thin gray lines refer to the 84 percent and the thin gray dashed lines to the 95 percent credible sets, respectively.

5. Conclusion

We estimate panel VAR models for euro-area member countries to explore whether the ECB's unconventional monetary policy conducted between 2007 and 2014 induced banks to increase their domestic government bond holdings, thereby possibly promoting the sovereign-bank nexus. We impose sign restrictions on impulse responses to identify innovations related to nonstandard monetary policy. Our findings can be summarized as follows. Euro-area crisis countries' banks shifted their asset portfolios toward domestic sovereign bond holdings in response to expansionary unconventional monetary policy shocks, thus making their balance sheets more sensitive to fluctuations in sovereign risk. Nonstandard monetary policy disturbances explain around 19 percent on average of the variation in the national banking sectors' share of domestic government bonds. Moreover, banks seemed to manage their sovereign debt portfolios actively. While banks' domestic government bond holdings increased relative to total assets in response to an unanticipated unconventional monetary policy loosening, the share of their holdings of sovereign bonds issued in the rest of EMU declined. Thus, the reaction of banks' sovereign debt portfolios can be characterized by a home bias. In contrast, euro-area core countries' banks did not increase their domestic government bond holdings relative to total assets in response to disturbances related to unconventional monetary policy. However, banks rather restructured their sovereign bond portfolios by lowering their holdings of rest-of-EMU government bonds. Furthermore, estimations using the approach by Jarocinski (2010) showed that banks across crisis countries and across core countries responded in a qualitatively similar way to unconventional monetary policy shocks by adjusting their sovereign debt portfolios. While in Italy, Spain, and Portugal the change in the domestic government bond holdings ratio occurred swiftly, in none of the core countries can a significant response of the domestic government bond holdings ratio be found. Finally, our results suggest that the ECB's SMP contributed to an increase in banks' sovereign debt portfolios. In Portugal, the effect was immediately observable after May 2010, while in Italy and Spain it became apparent after February 2012. Moreover, in Italy the announcement of the OMT program in September 2012 appeared to have contributed to a higher domestic

government bond holdings ratio. Overall, we conclude that euro-area crisis countries' banks enlarged their exposure to domestic sovereign debt in response to expansionary innovations stemming from unconventional monetary policy. While banks' liquidity position improves by such monetary policy measures, they might also contribute to the undesirable side effect of making the banking sector more vulnerable to sovereign distress.

References

Acharya, V., I. Drechsler, and P. Schnabl. 2014. "A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk." *Journal of Finance* 69 (6): 2689–2739.

Acharya, V. V., and S. Steffen. 2015. "The 'Greatest' Carry Trade Ever? Understanding Eurozone Bank Risks." *Journal of Financial Economics* 115 (2): 215–36.

Adrian, T., and N. Liang. 2018. "Monetary Policy, Financial Conditions, and Financial Stability." *International Journal of Central Banking* 14 (1, January): 73–131.

Altavilla, C., D. Giannone, and M. Lenza. 2016. "The Financial and Macroeconomic Effects of the OMT Announcements." *International Journal of Central Banking* 12 (3, September): 29–57.

Altavilla, C., M. Pagano, and S. Simonelli. 2017. "Bank Exposures and Sovereign Stress Transmission." *Review of Finance* 21 (6): 2103–39.

Altunbas, Y., L. Gambacorta, and D. Marques-Ibanez. 2014. "Does Monetary Policy Affect Bank Risk?" *International Journal of Central Banking* 10 (1, March): 95–136.

Angeloni, I., E. Faia, and M. Lo Duca. 2015. "Monetary Policy and Risk Taking." *Journal of Economic Dynamics and Control* 52 (March): 285–307.

Arias, J. E., J. F. Rubio-Ramirez, and D. F. Waggoner. 2014. "Inference Based on SVAR Identified with Sign and Zero Restrictions: Theory and Applications." CEPR Discussion Paper No. 9796.

Basel Committee on Banking Supervision. 2017. "The Regulatory Treatment of Sovereign Exposures." Discussion Paper, Bank for International Settlements, December.

Battistini, N., M. Pagano, and S. Simonelli. 2014. "Systemic Risk, Sovereign Yields and Bank Exposures in the Euro Crisis." *Economic Policy* 29 (78): 203–51.

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 (Supplement 1, January): 165–212.

Baumeister, C., and J. D. Hamilton. 2015. "Sign Restrictions, Structural Vector Autoregressions, and Useful Prior Information." *Econometrica* 83 (5): 1963–99.

———. 2018. "Inference in Structural Vector Autoregressions when the Identifying Assumptions Are Not Fully Believed: Re-evaluating the Role of Monetary Policy in Economic Fluctuations." *Journal of Monetary Economics* 100 (December): 48–65.

Boeckx, J., M. Dossche, A. Galesi, B. Hofmann, and G. Peersman. 2019. "Do SVARs with Sign Restrictions Not Identify Unconventional Monetary Policy Shocks?" BIS Working Paper No. 788.

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, February): 297–333.

Breckenfelder, J., F. De Fiore, P. Andrade, P. Karadi, and O. Tristani. 2016. "The ECB's Asset Purchase Programme: An Early Assessment." ECB Working Paper No. 1956.

Brunnermeier, M. K., L. Garicano, P. R. Lane, M. Pagano, R. Reis, T. Santos, D. Thesmar, S. V. Nieuwerburgh, and D. Vayanos. 2016. "The Sovereign-Bank Diabolic Loop and ESBies." *American Economic Review* 106 (5): 508–12.

Brutti, F., and P. Saure. 2015. "Transmission of Sovereign Risk in the Euro Crisis." *Journal of International Economics* 97 (2): 231–48.

Burriel, P., and A. Galesi. 2018. "Uncovering the Heterogeneous Effects of ECB Unconventional Monetary Policies across Euro Area Countries." *European Economic Review* 101 (January): 210–29.

Canova, F. 2007. *Methods for Applied Macroeconomic Research.* Princeton University Press.

Canova, F., and G. de Nicolo. 2002. "Monetary Disturbances Matter for Business Fluctuations in the G-7." *Journal of Monetary Economics* 49 (6): 1131–59.

Carpinelli, L., and M. Crosignani. 2017. "The Effect of Central Bank Liquidity Injections on Bank Credit Supply." FEDS Paper No. 2017-038, Board of Governors of the Federal Reserve System.

Chen, H., V. Curdia, and A. Ferrero. 2012. "The Macroeconomic Effects of Large-scale Asset Purchase Programmes." *Economic Journal* 122 (564): 289–315.

Ciccarelli, M., A. Maddaloni, and J. L. Peydro. 2015. "Trusting the Bankers: A New Look at the Credit Channel of Monetary Policy." *Review of Economic Dynamics* 18 (4): 979–1002.

Colangelo, A., D. Giannone, M. Lenza, H. Pill, and L. Reichlin. 2017. "The National Segmentation of Euro Area Bank Balance Sheets during the Financial Crisis." *Empirical Economics* 53 (1): 247–65.

Crosignani, M., M. Faria-e-Castro, and L. Fonseca. 2017. "The (Unintended?) Consequences of the Largest Liquidity Injection Ever." FEDS Paper No. 2017-011, Board of Governors of the Federal Reserve System.

Curdia, V., and M. Woodford. 2011. "The Central Bank Balance Sheet as an Instrument of Monetary Policy." *Journal of Monetary Economics* 58 (1): 54–79.

Delis, M. D., I. Hasan, and N. Mylonidis. 2017. "The Risk-Taking Channel of Monetary Policy in the U.S.: Evidence from Corporate Loan Data." *Journal of Money, Credit and Banking* 49 (1): 187–213.

Dell'Ariccia, G., C. Ferreira, N. Jenkinson, L. Laeven, A. Martin, C. Minoiu, and A. Popov. 2018. "Managing the Sovereign-Bank Nexus." ECB Working Paper No. 2177.

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

Dell'Ariccia, G., P. Rabanal, and D. Sandri. 2018. "Unconventional Monetary Policies in the Euro Area, Japan, and the United Kingdom." *Journal of Economic Perspectives* 32 (4): 147–72.

Dieppe, A., B. van Roye, and R. Legrand. 2016. "The BEAR Toolbox." ECB Working Paper No. 1934.

Drechsler, I., T. Drechsel, D. Marques-Ibanez, and P. Schnabl. 2016. "Who Borrows from the Lender of Last Resort?" *Journal of Finance* 71 (5): 1933–74.

Elbourne, A., and K. Ji. 2019. "Do Zero and Sign Restricted SVARs identify Unconventional Monetary Policy Shocks in the Euro Area?" CPB Discussion Paper No. 391.

European Central Bank. 2011. "The ECB's Non-standard Measures — Impact and Phasing-out." *Monthly Bulletin* (July): 55–69.

———. 2013. "Assessing the Retail Bank Interest Rate Pass-through in the Euro Area at Times of Financial Fragmentation." *Monthly Bulletin* (August): 75–91.

———. 2015. "The Role of the Central Bank Balance Sheet in Monetary Policy." *Economic Bulletin* 4 (June): 61–77.

Falagiarda, M. 2014. "Evaluating Quantitative Easing: A DSGE Approach." *International Journal of Monetary Economics and Finance* 7 (4): 302–27.

Farhi, E., and J. Tirole. 2018. "Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops." *Review of Economic Studies* 85 (3): 1781–1823.

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.

Gambetti, L., and A. Musso. 2017. "The Macroeconomic Impact of the ECB's Expanded Asset Purchase Programme (APP)." ECB Working Paper No. 2075.

Gennaioli, N., A. Martin, and S. Rossi. 2018. "Banks, Government Bonds, and Default: What do the Data Say?" *Journal of Monetary Economics* 98 (October): 98–113.

Gertler, M., and P. Karadi. 2011. "A Model of Unconventional Monetary Policy." *Journal of Monetary Economics* 58 (1): 17–34.

Hesse, H., B. Hofmann, and J. M. Weber. 2018. "The Macroeconomic Effects of Asset Purchases Revisited." *Journal of Macroeconomics* 58 (December): 115–38.

Hoerova, M., C. Mendicino, K. Nikolov, G. Schepens, and S. Van den Heuvel. 2018. "Benefits and Costs of Liquidity Regulation." ECB Working Paper No. 2169.

Hofmann, B., G. Peersman, and R. Straub. 2012. "Time Variation in U.S. Wage Dynamics." *Journal of Monetary Economics* 59 (8): 769–83.

Hohberger, S., R. Priftis, and L. Vogel. 2019. "The Macroeconomic Effects of Quantitative Easing in the Euro Area: Evidence from an Estimated DSGE Model." *Journal of Economic Dynamics and Control* 108 (November): Article 103756.

Hristov, N., O. Hülsewig, T. Wollmershäuser, and T. Siemsen. 2019. "Restoring Euro Area Monetary Transmission: Which Role for Government Bond Rates?" *Empirical Economics* 57 (3): 991–1021.

International Monetary Fund. 2018. *Global Financial Stability Report: A Decade after the Global Financial Crisis: Are We Safer?* New York: International Monetary Fund.

Jarocinski, M. 2010. "Responses to Monetary Policy Shocks in the East and the West of Europe: A Comparison." *Journal of Applied Econometrics* 25 (5): 833–68.

Jasova, M., C. Mendicino, and D. Supera. 2018. "Rollover Risk and Bank Lending Behavior: Evidence from Unconventional Central Bank Liquidity." 2018 Meeting Papers No. 500, Society for Economic Dynamics.

Jimenez, G., S. Ongena, J.-L. Peydro, 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.

Kapetanios, G., H. Mumtaz, I. Stevens, and K. Theodoridis. 2012. "Assessing the Economy-Wide Effects of Quantitative Easing." *Economic Journal* 122 (564): 316–47.

Koijen, R. S. J., F. Koulischer, B. Nguyen, and M. Yogo. 2017. "Euro-Area Quantitative Easing and Portfolio Rebalancing." *American Economic Review* 107 (5): 621–27.

Krippner, L. 2013. "Measuring the Stance of Monetary Policy in Zero Lower Bound Environments." *Economics Letters* 118 (1): 135–38.

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* 42 (2, Fall): 215–87.

Le, V. P. M., D. Meenagh, and P. Minford. 2016. "Monetarism Rides Again? US Monetary Policy in a World of Quantitative Easing." *Journal of International Financial Markets, Institutions and Money* 44 (September): 85–102.

Lewis, V., and M. Roth. 2019. "The Financial Market Effects of the ECB's Asset Purchase Programs." *Journal of Financial Stability* 43 (August): 40–52.

Maddaloni, A., and J.-L. Peydro. 2011. "Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-Area and the U.S. Lending Standards." *Review of Financial Studies* 24 (6): 2121–65.

Neuenkirch, M., and M. Nöckel. 2018. "The Risk-Taking Channel of Monetary Policy Transmission in the Euro Area." *Journal of Banking and Finance* 93 (August): 71–91.

Ongena, S., A. Popov, and N. Van Horen. 2019. "The Invisible Hand of the Government: Moral Suasion during the European Sovereign Debt Crisis." *American Economic Journal: Macroeconomics* 11 (4): 346–79.

Peersman, G. 2005. "What Caused the Early Millennium Slowdown? Evidence Based on Vector Autoregressions." *Journal of Applied Econometrics* 20 (2): 185–207.

Peydro, J. L., A. Polo, and E. Sette. 2017. "Monetary Policy at Work: Security and Credit Application Registers Evidence." CEPR Discussion Paper No. 12011.

Quint, D., and P. Rabanal. 2017. "Should Unconventional Monetary Policies Become Conventional?" IMF Working Paper No. 17/85.

Richter, B., M. Schularick, and P. Wachtel. 2017. "When to Lean Against the Wind." CEPR Discussion Paper No. 12188.

Rubio-Ramirez, J. F., D. F. Waggoner, and T. Zha. 2010. "Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference." *Review of Economic Studies* 77 (2): 665–96.

Sa, F., P. Towbin, and T. Wieladek. 2014. "Capital Inflows, Financial Structure and Housing Booms." *Journal of the European Economic Association* 12 (2): 522–46.

Schenkelberg, H., and S. Watzka. 2013. "Real Effects of Quantitative Easing at the Zero Lower Bound: Structural VAR-based Evidence from Japan." *Journal of International Money and Finance* 33 (March): 327–57.

Scholl, A., and H. Uhlig. 2008. "New Evidence on the Puzzles: Results from Agnostic Identification on Monetary Policy and Exchange Rates." *Journal of International Economics* 76 (1): 1–13.

Uhlig, H. 2005. "What are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure." *Journal of Monetary Economics* 52 (2): 381–419.

———. 2014. "Sovereign Default Risk and Banks in a Monetary Union." *German Economic Review* 15 (1): 23–41.

Walther, A. 2016. "Jointly Optimal Regulation of Bank Capital and Liquidity." *Journal of Money, Credit and Banking* 48 (2-3): 415–48.

Weale, M., and T. Wieladek. 2016. "What are the Macroeconomic Effects of Asset Purchases?" *Journal of Monetary Economics* 79 (May): 81–93.

Wu, J. C., and F. D. Xia. 2016. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound." *Journal of Money, Credit and Banking* 48 (2-3): 253–91.