Available online at www.sciencedirect.com
ScienceDirect
Journal of Policy Modeling xxx (2018) xxx–xxx
Journal of Policy Modeling
www.elsevier.com/locate/jpm

Sovereign bond holdings and monetary policy operations in the euro area

Ivo J.M. Arnold [a,b,*], Beau Soederhuizen [b]

[a] *Erasmus School of Economics, Erasmus University Rotterdam, P.O. Box 1738, 3000DR, Rotterdam, The Netherlands*
[b] *Nyenrode Business Universiteit, Breukelen, Staatweg 25, 3621BG, Breukelen, The Netherlands*

Received 15 December 2017; received in revised form 20 May 2018; accepted 22 May 2018

Abstract

This paper investigates the relationship between sovereign bond holdings of banks and refinancing operations by the ECB for countries in the euro area. We use data collected by Bruegel as well as a new dataset compiled from the annual statements of national central banks to estimate panel regression models. Our findings support the hypothesis that the ECB's refinancing operations have increased resident banks' exposure to domestic sovereign bonds. This is in line with the moral suasion theory advanced in the literature. These results strengthen the case for regulatory changes aimed at reducing the sensitivity of banks to sovereign risk.

JEL classification: F34; F36; G21

Keywords: Monetary policy; Sovereign bonds; Banking system; Euro crisis

1. Introduction

The interconnectedness of sovereign and banking risk is a well-established fact. The euro crisis has exposed a strong mutual dependency between sovereigns and banks in the euro area (EA). At the height of the crisis, governments came to the rescue of banks to safeguard the stability of the financial system, thereby in some cases severely worsening their public finances.

* Corresponding author.
E-mail addresses: arnold@eur.ese.nl (I.J.M. Arnold), b.soederhuizen@nyenrode.nl (B. Soederhuizen).

https://doi.org/10.1016/j.jpolmod.2018.05.004

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

Additionally, the negative effect of banking problems on the real economy has hurt tax revenues and has led to a further weakening of the public finances. Vice versa, deteriorating public finances have increased banking risk in two ways. First, weak public finance may limit a government's ability to bailout systemic banks. Second, banks are vulnerable to sovereign risk because of their exposure to sovereign bonds. Goodhart (1998) has argued that EMU has changed the risk profile of sovereign bonds as EA countries have lost their right to print money to pay off domestic currency debt. Following the introduction of the euro, EA banks' exposure to sovereign bonds, mostly issued by the domestic government, has nonetheless remained large (Merler & Pisani-Ferry, 2012; Arnold, 2012). Since the start of the crisis, policymakers increasingly regard the 'diabolic loop' between banking and sovereign risk as a financial stability risk (ESRB, 2015; Andritzky, Gadatsch, Körner, Schäfer & Schnabel, 2016; Van Riet, 2016). The spillover of sovereign risk to an exposed and intertwined financial sector ultimately provided the justification for the large-scale funding programs to assist distressed EA members. In addition, the ECB's unprecedented monetary policy response to the euro crisis has helped to stabilise EA bond markets and to subdue sovereign risk. Apart from the isolated Greek crisis in 2015, these policy interventions have reduced the immediate market concerns that sovereign risk would spill over into the banking system.

As deflationary risks have subsided and the EA economy has returned to growth, it is expected that the ECB's unconventional monetary policy will be further downsized or even ended in the near future. The foreseeable withdrawal of ECB support to the bond markets opens up the possibility of widening sovereign spreads and higher long-term bond yields for highly indebted EA countries. This could reawaken the dormant diabolic loop between sovereign and banking risk. The end of quantitative easing may thus put the sovereign-bank nexus high on the policy agenda again.

Brunnermeier et al. (2016) list three ingredients to the negative feedback loop between sovereigns and banks: the home bias of banks' sovereign debt portfolios, governments' inability to commit not to bailout distressed banks and free capital mobility. This paper focuses on the first ingredient, and more in particular on the effect of the ECB's refinancing operations on banks' sovereign bond holdings.

While the literature on the sovereign-bank nexus is large, our paper is most closely related to Merler and Pisani-Ferry (2012), Acharya and Steffen (2015) and Drechsler, Drechsel, Marquez-Ibanez and Schnabl, 2016. Merler and Pisani-Ferry (2012) document the vulnerability of banks' portfolios to sovereign risk and the reversal of sovereign bonds holdings by non-residents in EA countries that experienced a deterioration in creditworthiness during the crisis. Acharya and Steffen (2015) argue that in the period 2007–2013, European banks engaged in a carry trade by undertaking long positions in peripheral sovereign bonds, financed by unsecured funding in wholesale markets. They advance three explanations. First, the zero-risk weight for sovereign debt in the Basel framework invites regulatory arbitrage and risk shifting. Second, banks in peripheral countries tend to have a strong home bias in their sovereign bond portfolio. Third, governments may employ moral suasion to stimulate banks to buy domestic sovereign bonds and thereby reduce yields, arguing that this is the patriotic thing to do in times of crisis. Acharya and Steffen (2015) show that moral hazard and moral suasion by governments increase the home bias of peripheral banks. Drechsler et al. (2016) add to the literature by including a role for lender of last resort (LOLR) lending by the ECB. Using a sample that runs from August 2007 to December 2011, they find that weakly capitalized banks have used LOLR lending to buy sovereign debt. Unfortunately, their sample ends just before the ECB decided to allot unprecedented amounts of liquidity, totaling over € 1,000 billion for two rounds, to the EA banking system.

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

Previous empirical work on the sovereign-bank nexus employs either financial market data or data from the stress tests conducted by the European Banking Authority (EBA). The latter source provides insight into sovereign bond holdings for a subset of large EU banks covering ca. 60% of total EU banking assets. The EBA data are available for a limited number of reporting dates only. Acharya and Steffen (2015) and Drechsler et al. (2016) use respectively five and three reporting dates. Our contribution to this literature is to examine the link between banks' sovereign bond exposures and the ECB liquidity operations using a more complete dataset. To this end, we use the data on sovereign bond holdings in Merler and Pisani-Ferry (2012) and the data on the ECB's refinancing operations in Pisani-Ferry and Wolff (2012). Hitherto, these datasets have not been analysed jointly. In addition, we use a new dataset compiled from the annual statements of national central banks participating in the Eurosystem (Soederhuizen & Arnold, 2017). This dataset allows us to analyse a larger number of EA countries, but has an annual frequency. Our estimates of quarterly and annual panel regression models offer strong evidence of a direct link between changes in ECB liquidity provision and changes in sovereign bond holdings by resident banks. This corroborates the view advanced in Acharya and Steffen (2015) that by easing funding pressure the ECB has enabled EA banks to increase their holdings of sovereign bonds. A possible interpretation of this finding is that through its unconventional policies the ECB has provided lender-of-last-resort to EA governments by proxy, with EA banks acting as middlemen.

The ECB's refinancing operations during the crisis thus seem to have exacerbated the systemic problem of the intertwinement of sovereign and banking risk. A policy implication of this research is that the regulatory treatment of sovereign exposures should be tightened, preferably before widening sovereign spreads again raise doubts about the soundness of EA banks. As our findings suggest that during the crisis the ECB has been acting as a lender-last-resort by proxy, a second policy implication is that the euro area is in need of a real lender-of-last-resort for governments that have lost access to the international bond market.

This paper is organised as follows. The next section provides an overview of the literature. Section 3 describes the data and the methodology. Section 4 discusses the empirical results. We finally provide a number of conclusions and policy implications.

2. Literature review

Theoretical contributions to the literature on the sovereign-bank nexus are sparse. Gennaioli, Martin and Rossi (2014) theoretically model the link between government default and financial fragility and conclude that in more developed financial markets the consequences of public defaults are more severe. This strengthens governments' incentive to repay public debt. Bocola (2016) develops a theoretical model in which sovereign defaults hamper financial intermediation in two ways. First, prospected losses on sovereign bonds depress banks' market value and hurt their funding for new bank lending (liquidity channel). Second, banks will perceive claims on the private sector as more risky and thus have a precautionary motive to deleverage (risk channel).

The empirical literature on the risk spillovers between banks and sovereigns is large. An early paper by Gerlach, Schulz and Wolff (2010) shows that the size of the banking sector is an important determinant of sovereign risk in the EA. This effect is stronger when bank equity buffers are smaller. Most subsequent work in this area uses price information from financial markets. Ejsing and Lemke (2011) analyse the joint response of bank and sovereign Credit Default Swap (CDS) rates. They find that bank rescues during the crisis induced a decrease of risk spreads for banks at the expense of a marked increase in sovereign risk spreads. They also show that the rescue packages strongly increased the sensitivity of sovereign spreads to the crisis. Alter and Schüler

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

(2012) estimate vector error correction and vector autoregressive models to show that the link between sovereign and bank CDS rates has tightened following bank bailout programs. Similarly, Acharya, Drechsler and Schnabl, 2014 show that following the Irish bank bailout in 2008, the relationship between bank and sovereign CDS rates strengthened. According to Mody and Sandri (2012), the nationalization of Anglo Irish Bank in 2009 increased the link between sovereign spreads and banking risk. Gross and Koky (2013) document the intensity of the sovereign-to-bank spillover at the height of the euro crisis in 2011–2012. Alter and Beyer (2014) also show that the negative sovereign-bank feedback loop intensifies in periods of financial market stress. Arnold (2012) shows that this results from the fact that peripheral banks tend to hold peripheral sovereign bonds. De Bruyckere, Gerhardt, Schepens and Vennet, 2013 identify significant contagion effects between bank and sovereign CDS rates during the crisis, which are stronger between banks and their home country. Bolton and Jeanne (2011) show that banks' exposure to sovereign bonds increases contagion risk.

A number of studies include bank equity prices in their analysis. Using data for banks in 37 countries over the period 1995–2011, Correa, Lee, Sapriza and Suarez, 2014 find a large negative effect of sovereign credit rating downgrades on stock returns for banks that are expected to receive strong government support. This is taken as evidence that stock market investors perceive sovereigns and domestic banks to be strongly interconnected. Betz, Hautsch, Peltonen and Schienle, 2016 estimate time-varying tail risk dependencies and spillovers between European banks and sovereigns using CDS rates and equity prices. Their analysis shows that since the start of the crisis, financial markets have fragmented along national borders and that the interconnectedness between banks and sovereigns has increased. Chan-Lau, Liu and Schmittmann, 2015 find that sovereign risk adds explanatory power to a panel model for equity returns after 2008. Allegret, Raymond and Rharrabti (2017) extend a multifactor model of equity returns with a sovereign risk factor and find a negative effect of the sovereign debt crisis on the equity returns of European banks. As discussed before, Acharya and Steffen (2015) and Drechsler et al. (2016) provide evidence on the home bias of banks' sovereign debt portfolios. In addition, Battistini, Pagano and Simonelli (2014) show that systemic risk increases the home bias in banks' sovereign bond holdings. The present paper adds to the literature on the home bias in banks' sovereign bond holdings by focusing on the role of the ECB's monetary policy operations during the crisis.

3. Data and methodology

As bank-level data on refinancing operations are not publicly available, this paper uses country-level data. For sovereign bond holdings, we use the Bruegel database developed in Merler and Pisani-Ferry (2012), which contains quarterly data for the main EA countries and which starts in December 1997. Using national sources, Merler and Pisani-Ferry (2012) split marketable sovereign debt by holding sector. From their database, we extract sovereign bond holdings by resident banks (*SovBondsResBanks*), sovereign bond holdings by non-residents (*SovBondsNonRes*) and total sovereign bond holdings (*SovBondsTotal*). A second database, the Bruegel database of Eurosystem lending operations developed in Pisani-Ferry and Wolff (2012), reports the amounts borrowed under the ECB's main and longer term refinancing operations. The data have a monthly frequency and start in January 2003. The ECB uses the main refinancing operations (MROs), with maturities of one or two weeks, to guide short-term interest rates, to signal the monetary policy stance and to manage the demand for short-term liquidity. In addition, long-term refinancing operations (LTROs) provide longer-term liquidity, in particular to counterparties with limited access to the interbank market. Typically, LTROs have maturities up to three months, but since the start

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

of the crisis their maturity has been extended. From the Pisani-Ferry and Wolff (2012) database, we retrieve monthly series for the sum of MROs and LTROs. We convert these to a quarterly frequency using the last monthly observation as quarterly observation. The resulting series is denoted *CBLiq*. Combining the two Bruegel databases yields a quarterly unbalanced dataset for seven EA countries: Germany, France, Spain, Italy, Ireland, Portugal and Greece. In addition to these sources, we use the annual database of the balance sheets of the national central banks in the Eurosystem complied by Soederhuizen and Arnold (2017). While the annual frequency reduces the number of observations, this source allows us to include data for Belgium, Finland and The Netherlands. The annual dataset also allows us to construct a variable measuring net liquidity provision by the ECB (*CBLiqNet*), which is defined as *CBLiq* minus central bank liabilities to EA credit institutions. With this adjustment we take into account that in some EA member states, the ECB's refinancing operations have led some banks to deposit large amounts of liquidity at the Eurosystem. For our annual estimates, we convert the quarterly data on sovereign bond holdings to an annual frequency using the last quarterly observation. We finally include interest rates from *Datastream*. As the sovereign debt crisis has led to a strong divergence of bond yields across the EA, banks may have managed their sovereign exposures out of yield considerations. To measure changes in sovereign bond holdings due to possible risk shifting, we include 10-year sovereign bond yields (denoted *Yield*) as an additional variable. As we are interested in how *additional* liquidity provision spills over into sovereign bond holdings, below we will use absolute changes of all variables.

We investigate the relationship between sovereign bond holdings by resident banks and central bank liquidity by estimating the following panel model:

$$d(SovBondsResBanks)_{i,t} = b_i + b_1\, d(CBLiq)_{i,t} + b_2\, d(SovBondsTotal)_{i,t} + b_3\, d(Yield)_{\mathrm{i,t}} + \varepsilon_{\mathrm{i,t}}, \quad (1)$$

where $d(SovBondsResBanks)_{i,t}$ denotes the absolute change in sovereign bond holdings by resident banks in country i at time t, $d(CBLiq)_{i,t}$ denotes the absolute change in central bank liquidity provision to banks in country i at time t, $d(SovBondsTotal)_{i,t}$ denotes the absolute change in total sovereign bond holdings in country i at time t and $d(Yield)_{i,t}$ is the absolute change in the 10-year bond yield in country i at time t. Country-specific fixed effects are denoted by b_i and $\varepsilon_{i,t}$ denotes the error term. Our interest is in coefficient b_1, which measures how changes in central bank liquidity translate into sovereign bond holdings. According to the moral suasion hypothesis, b_1 should be positive and significantly different from zero. Below, a number of different specifications based on Equation (1) will be estimated. We will present estimates for the complete sample period, as well as estimates covering the period since the start of the Global Financial Crisis. We will also show the effect of excluding the control variables $d(Yield)_{i,t}$ and $d(SovBondsTotal)_{i,t}$. In addition, the annual estimates include $d(CBLiqNet)_{i,t}$.

As a supporting analysis, we estimate a panel model for the change in sovereign bonds held by non-residents. The underlying idea is that central bank liquidity may have been especially advantageous for countries that have lost the confidence of international investors. If this is correct, it would show up in a negative relationship between *SovBondsNonRes* and *CBLiq*. Equation (2) is as follows:

$$d(SovBondsNonRes)_{i,t} = b_i + b_1\, d(CBLiq)_{i,t} + b_2\, d(SovBondsTotal)_{i,t} + b_3\, d(Yield)_{i,t} + \varepsilon_{i,t}, \quad (2)$$

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

Table 1
Sovereign bonds holdings by resident banks; panel regressions with quarterly data

Dependent variable: *d(SovBondsResBanks)*						
Panel A: 2003:Q2-2016:Q2						
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	0.884	(0.670)	−0.509	(0.639)	-0.509	(0.640)
d(CBLiq)	0.121	(0.031)***	0.144	(0.028)***	0.144	(0.029)***
d(SovBondsTotal)			0.158	(0.020)***	0.158	(0.020)***
d(Yield)					-0.009	(0.462)
Adjusted R-squared	0.061		0.214		0.211	
N	316		316		316	
Panel B: 2008:Q3-2016:Q2						
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	2.068	(0.940)**	0.429	(0.906)	0.429	(0.908)
d(CBLiq)	0.115	(0.036)***	0.139	(0.033)***	0.139	(0.034)***
d(SovBondsTotal)			0.151	(0.025)***	0.151	(0.025)***
d(Yield)					0.002	(0.536)
Adjusted R-squared	0.067		0.209		0.205	
N	209		209		209	

Note: significance levels are indicated as follows: 0.10 (*), 0.05 (**), 0.01 (***).

where $d(SovBondsNonRes)_{i,t}$ denotes the absolute change in sovereign bond holdings by non-residents in country i at time t and all other variables are as previously defined. Equations (1) and (2) are estimated using pooled least squares and include country fixed effects.

4. Empirical results

Below, we first discuss the estimation results for our quarterly data, both for Equations (1) and (2). Next, we present findings for our annual dataset. Table 1 reports estimates of six specifications of Equation (1), which differ with regard to the sample period and the inclusion of $d(SovBondsTotal)_{i,t}$ and $d(Yield)_{i,t}$. Across all specifications, b_1, the coefficient measuring how changes in central bank liquidity feed through to sovereign bonds held by resident banks, is positive and significantly different at a 1% level. The value of b_1 is also stable across specifications, ranging from 0.10 and 0.15. This implies that a € 1 mln increase in liquidity translates into an increase in sovereign bonds held by resident banks of between € 0.10 mln and € 0.15 mln. The inclusion of $d(SovBondsTotal)_{i,t}$ substantially raises the explanatory power of the model, from ca. 0.06 to around 0.2, but has no strong effect on b_1. The final two columns in Table 1 show that $d(SovBondsResBanks)_{i,t}$ is not significantly related to $d(Yield)_{i,t}$, which suggests that risk shifting has not been the main driver of increased sovereign exposure. A comparison between panels A and B furthermore shows that limiting the sample to the post-Lehman period does not change the results.

Table 2 provides the quarterly estimates for Equation (2), relating non-resident sovereign bond holdings to liquidity provision. Across all specifications, b_1 is negative and significant at a 1% level, mirror-imaging the positive relationship between $d(SovBondsResBanks)_{i,t}$ and $d(CBLiq)_{i,t}$. Countries that faced a decrease in non-resident sovereign bond holdings also needed to resort to ECB liquidity. The coefficient b_1 ranges between −0.20 and −0.32. As in Table 1, the inclusion of

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

Table 2
Sovereign bonds holdings by non-residents; panel regressions with quarterly data.

Dependent variable: *d(SovBondsNonRes)*						
Panel A: 2003:Q2-2016:Q2						
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	5.361	(1.341)***	−0.410	(0.755)	−0.411	(0.756)
d(CBLiq)	−0.312	(0.062)***	−0.219	(0.034)***	−0.219	(0.034)***
d(SovBondsTotal)			0.656	(0.024)***	0.656	(0.024)***
d(Yield)					−0.035	(0.546)
Adjusted R-squared	0.120		0.743		0.742	
N	316		316		316	
Panel B: 2008:Q3-2016:Q2						
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	4.904	(1.927)**	−2.528	(0.979)**	−2.534	(0.982)**
d(CBLiq)	−0.316	(0.074)***	−0.208	(0.036)***	−0.207	(0.036)***
d(SovBondsTotal)			0.685	(0.027)***	0.684	(0.027)***
d(Yield)					−0.122	(0.578)
Adjusted R-squared	0.126		0.794		0.793	
N	209		209		209	

Note: significance levels are indicated as follows: 0.10 (*), 0.05 (**), 0.01 (***).

$d(SovBondsTotal)_{i,t}$ raises the explanatory power of the model. It also reduces b_1 from ca. −0.3 to −0.2. Changes in bond yields are negatively, but insignificantly related to $d(SovBondsNonRes)_{i,t}$. As in Table 1, limiting the sample to the post-Lehman period has no effect on the results.

When moving from quarterly to annual data (and thus from seven to ten EA countries) a few observations are noteworthy. First, the main conclusions from the quarterly estimates still hold: there is positive and significant relationship between $d(SovBondsResBanks)_{i,t}$ and $d(CBLiq)_{i,t}$ and a negative relationship between $d(SovBondsNonRes)_{i,t}$ and $d(CBLiq)_{i,t}$. Second, for Equation (1), the *net* measure of central bank liquidity, $d(CBLiqNet)_{i,t}$, has a somewhat stronger relationship with $d(SovBondsResBanks)_{i,t}$, as evidenced by the larger and more significant value of b_1 in Table 3. However, this is not true for the relationship with $d(SovBondsNonRes)_{i,t}$ in Table 4. Third, the relationship between $d(SovBondsTotal)_{i,t}$ and $d(SovBondsResBanks)_{i,t}$, while strong in the quarterly estimates, is absent in the annual data. Finally, as in the quarterly estimates, the differences between the sample periods are small and our yield variable is always insignificant.

5. Conclusions

The sovereign debt crisis has brought to the fore severe flaws in the design of EMU. Prominent among these is the failure to recognise EA sovereigns as a potential risk factor. Prior to the crisis, academics have argued that EMU has increased the likelihood that a sovereign debt crisis threatens the solvency of domestic banks (see a.o. Grilli, Masciandaro & Tabellini, 1991 and Arnold & Lemmen, 2001). The diabolic loop between sovereign and banking risk could have been mitigated if prior to the crisis adjustments would have been made to the relevant banking regulation. The large exposure directive, which states that banks should not lend more than 25% of their capital to a single private borrower, should have been extended to sovereign bonds. In addition, the standard zero-risk weightings for sovereign bonds in the capital requirements regulation should have been changed to take into account the higher risk profile of sovereign debt.

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

Table 3
Sovereign bonds holdings by resident banks; panel regressions with annual data.

Dependent variable: *d(SovBondsResBanks)*								
Panel A: 2000–2015								
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	1.792	(1.522)	2.147	(1.506)	2.136	(1.518)	2.045	(1.528)
d(CBLiq)	0.089	(0.040)**						
d(CBLiqNet)			0.100	(0.036)***	0.100	(0.037)***	0.103	(0.037)***
d(SovBondsTotal)					0.001	(0.010)	0.000	(0.010)
d(Yield)							-0.439	(0.706)
Adj. R-squared	0.105		0.123		0.117		0.113	
N	144		144		144		144	
Panel B: 2008–2015								
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	6.998	(2.127)***	7.367	(2.102)***	7.364	(2.121)***	7.286	(2.141)***
d(CBLiq)	0.083	(0.044)*						
d(CBLiqNet)			0.095	(0.039)**	0.094	(0.040)**	0.097	(0.041)**
d(SovBondsTotal)					0.000	(0.010)	0.000	(0.011)
d(Yield)							−0.336	(0.749)
Adj. R-squared	0.206		0.230		0.218		0.209	
N	80		80		80		80	

Note: significance levels are indicated as follows: 0.10 (*), 0.05 (**), 0.01 (***).

Table 4
Sovereign bonds holdings by non-residents; panel regressions with annual data.

Dependent variable: *d(SovBondsNonRes)*

Panel A: 2000–2015								
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	17.527	(3.396)***	16.554	(3.671)***	14.773	(3.266)***	14.508	(3.281)***
d(CBLiq)	−0.429	(0.089)***						
d(CBLiqNet)			−0.076	(0.087)	−0.186	(0.079)**	−0.175	(0.080)**
d(SovBondsTotal)					0.133	(0.022)***	0.132	(0.022)***
d(Yield)							−1.277	(1.515)
Adj. R-squared	0.216		0.083		0.282		0.280	
N	144		144		144		144	

Panel B: 2008–2015								
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	15.024	(5.821)**	15.017	(6.418)**	13.364	(5.671)**	13.110	(5.720)**
d(CBLiq)	−0.463	(0.121)***						
d(CBLiqNet)			−0.071	(0.120)	−0.162	(0.108)	−0.152	(0.110)
d(SovBondsTotal)					0.132	(0.029)***	0.131	(0.029)***
d(Yield)							−1.089	(2.000)
Adj. R-squared	0.208		0.043		0.256		0.248	
N	80		80		80		80	

Note: significance levels are indicated as follows: 0.10 (*), 0.05 (**), 0.01 (***).

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

Whereas policymakers refrained from making the regulatory adjustments prior to the crisis, monetary policy interventions during the crisis may have worked to exacerbate the sovereign-bank nexus. This paper adds to the growing evidence that during the crisis ECB's refinancing operations have increased banks' exposure to domestic sovereign bonds. In contrast to previous studies, we estimate a direct link between sovereign bond holdings of resident banks and central bank liquidity provision using time series data. We estimate panel models using both quarterly and annual data. Across all specifications, we find a positive and significant relationship between changes in central bank liquidity uptake and changes in sovereign bond holdings by resident banks. This is in line with the moral suasion theory advanced in the literature. We find no evidence that the divergence in EA bond yields during the crisis has contributed to changes in sovereign bond holdings. This suggests that risk shifting has not been the main driver of sovereign exposure. Finally, we find that central bank liquidity is negatively and significantly related to the amount of sovereign bonds held by non-residents, suggesting that central bank liquidity flowed to countries from which foreign investors withdrew. Since the start of the crisis, concerns about the sovereign-banking nexus have been noted within the central banking community (Handelsblatt, 2015). It is therefore ironic that the ECB's refinancing operations seem to have exacerbated the problem.

The policy implications of this paper are two-fold. First, the current paper strengthens the case for re-regulation of banks' sovereign bond exposures. Prior to the crisis, Arnold and Lemmen (2001) have argued in favour of a better diversification of banks' sovereign bond holdings. More recently the ESRB (2015) has proposed to introduce non-zero risk weights and diversification requirements for sovereign exposures. As an alternative solution, Brunnermeier et al. (2016) have proposed to break the diabolic loop by limiting banks' sovereign bonds holdings to the senior tranches of a well-diversified portfolio. These holdings are labeled European Safe Bonds (ESBies). Due to the 'double protection' of diversification and seniority, ESBies would be relatively insensitive to sovereign risk and thus remove a major source of banking instability. Reforms along these lines are long overdue. Limiting and diversifying sovereign bond holdings of banks would bring banking regulation in line with article 102 of the Maastricht Treaty – which prohibits privileged access for the public sector to financial institutions – and increases their ability to withstand disruptions in the market for sovereign debt. Increased diversification of the credit exposures of banks to the public sector would thus promote the stability of the euro-area financial system. Unfortunately, the urgency of reform of the regulatory treatment of sovereign exposures is not sufficiently recognised by the European Commission (2017). In its roadmap for the completion of EMU, reform in the area is included only as a possible step in the period 2020–2025. Applying non-zero risk weightings and diversification rules will be painful. EA governments will dislike the notion that their bonds carry default risk and the possible upward effect of such reform on government bond yields. EA banks may dread the effect on equity ratios. In the face of strong opposition from both governments and banks, an isolated reform of the regulatory treatment of sovereign exposures is therefore unlikely to succeed.

This brings us to the second policy implication. Our findings provide further support for the notion that by providing ample liquidity the ECB has enabled EA banks to increase their holdings of sovereign bonds and to contribute to the stabilization of the bond markets. The ECB's refinancing operations can thus be interpreted as an instrument to provide lender-of-last-resort to EA governments by proxy. While this could be justified as a necessary policy intervention during a crisis for which the EA was ill-prepared, it cannot be a structural solution to the institutional weaknesses of the EA. Both the future normalization of monetary policy and the desirable reform of the regulatory treatment of sovereign exposures lay bare the need for a stronger fiscal union. Such a union should include a proper lender-of-last-resort for governments that have lost access

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

to the capital markets. Without it, governments will not surrender their privileged access to their banks. A stronger fiscal union thus is a sine qua non for tackling the systemic problem of the intertwinement of sovereign and banking risk.

References

Acharya, V. V., & Steffen, S. (2015). The greatest carry trade ever? Understanding eurozone bank risks. *Journal of Financial Economics*, *115*(2), 2015–2236.

Acharya, V. V., Drechsler, I., & Schnabl, P. (2014). A pyrrhic victory? Bank bailouts and sovereign credit risk. *Journal of Finance*, *69*(6), 2689–2739.

Allegret, J. P., Raymond, H., & Rharrabti, H. (2017). The impact of the European sovereign debt crisis on banks stocks. Some evidence of shift contagion in Europe. *Journal of Banking & Finance*, *74*(January), 24–37.

Alter, A., & Beyer, A. (2014). The dynamics of spillover effects during the European sovereign debt turmoil. *Journal of Banking & Finance*, *42*(May), 134–153.

Alter, A., & Schüler, Y. S. (2012). Credit spread interdependencies of European states and banks during the financial crisis. *Journal of Banking & Finance*, *36*(12), 3444–3468.

Andritzky, J., Gadatsch, N., Körner, T., Schäfer, A., & Schnabel, I. (2016). Removing privileges for banks' sovereign exposures – a proposal. *European Economy*, *2016*(1), 139–152.

Arnold, I. J. M. (2012). Sovereign debt exposures and banking risks in the current EU financial crisis. *Journal of Policy Modeling*, *34*(6), 906–920.

Arnold, I. J. M., & Lemmen, J. J. G. (2001). The vulnerability of banks to government default risk in the EMU. *International Finance*, *4*(1), 101–125.

Battistini, N., Pagano, M., & Simonelli, S. (2014). Systemic risk, sovereign yields and bank exposures in the euro crisis. *Economic Policy*, *29*(78), 203–251.

Betz, F., Hautsch, N., Peltonen, T. A., & Schienle, M. (2016). Systemic risk spillovers in the European banking and sovereign network. *Journal of Financial Stability*, *25*(August), 206–224.

Bocola, L. (2016). The pass-through of sovereign risk. *Journal of Political Economy*, *124*(4), 879–926.

Bolton, P., & Jeanne, O. (2011). Sovereign default risk and bank fragility in financially integrated economies. *IMF Economic Review*, *59*(2), 162–194.

Brunnermeier, M. K., Garicano, L., Lane, P. R., Pagano, M., Reis, R., Santos, T., et al. (2016). The sovereign-bank diabolic loop and ESBies. *American Economic Review*, *106*(5), 508–512.

Chan-Lau, J. A., Liu, E. X., & Schmittmann, J. M. (2015). Equity returns in the banking sector in the wake of the great recession and the European sovereign debt crisis. *Journal of Financial Stability*, *16*, 164–172.

Correa, R., Lee, K.-H., Sapriza, H., & Suarez, G. A. (2014). Sovereign credit risk, banks' government support, and bank stock returns around the world. *Journal of Money, Credit and Banking*, *46*, 93–121.

De Bruyckere, V., Gerhardt, M., Schepens, G., & Vennet, R. V. (2013). Bank/sovereign risk spillovers in the European debt crisis. *Journal of Banking & Finance*, *37*(12), 4793–4809.

Drechsler, I., Drechsel, T., Marquez-Ibanez, D., & Schnabl, P. (2016). Who borrows from the lender of last resort? *Journal of Finance*, *71*(5), 1933–1974.

Ejsing, J., & Lemke, W. (2011). The Janus-headed salvation: Sovereign and bank credit risk premia during 2008–2009. *Economics Letters*, *110*(1), 28–31.

ESRB. (2015). *ESRB report on the regulatory treatment of sovereign exposures*. European Systemic Risk Board. March 2015.

European Commission. (2017). *Further steps towards completing Europe's Economic and Monetary Union: A roadmap*. Brussels: European Commission. December 6, 2017.

Gennaioli, N., Martin, A., & Rossie, S. (2014). Sovereign default, domestic banks, and financial institutions. *Journal of Finance*, *69*, 819–866.

Gerlach, S., Schulz, A., & Wolff, G. B. (2010). *Banking and sovereign risk in the Euro Area*. Deutsche Bundesbank. Discussion Paper Series 1: Economic Studies No 09/2010.

Grilli, V., Masciandaro, D., & Tabellini, G. (1991). Political and monetary Institutions and public financial policies in the industrial countries. *Economic Policy*, *6*(2), 341–392.

Goodhart, C. A. E. (1998). Two concepts of money: Implications for the analysis of optimum currency areas. *European Journal of Political Economy*, *14*, 407–432.

Gross, M., & Koky, C. (2013). *Measuring contagion potential among sovereigns and banks using a mixed-cross-section GVAR*. ECB Working Paper, No. 1570.

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004

Handelsblatt. (2015). *ECB's Nouy: Government debt is not risk-free*. March 31, 2015.
Merler, S., & Pisani-Ferry, J. (2012). *Who's afraid of sovereign bonds. Bruegel Policy Contribution 2012\02*.
Mody, A., & Sandri, D. (2012). The eurozone crisis: How banks and sovereigns came to be joined at the hip. *Economic Policy*, *27*(70), 199–230.
Pisani-Ferry, J., & Wolff, G. (2012). *Propping up Europe? Bruegel Policy Contribution 2012\07*.
Van Riet, A. (2016). *Addressing the safety trilemma: A safe sovereign asset for the Eurozone*. mimeo.
Soederhuizen, B., & Arnold, I. J. M. (2017). *A disaggregated balance sheet of the eurosystem*. mimeo, Nyenrode Business Universiteit.

Please cite this article in press as: Arnold, I. J. M., & Soederhuizen, B. Sovereign bond holdings and monetary policy operations in the euro area. *Journal of Policy Modeling* (2018), https://doi.org/10.1016/j.jpolmod.2018.05.004