Quantitative Easing and the Safe Asset Illusion*

Alexander Bechtel† University of St. Gallen

Jens Eisenschmidt‡ European Central Bank

Angelo Ranaldo§ University of St. Gallen

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†E-mail: alexander.bechtel@unisg.ch.

‡E-mail: jens.eisenschmidt@ecb.int.

§E-mail: angelo.ranaldo@unisg.ch.

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Abstract

We examine the role of quantitative easing (QE) for the market of safe assets. Based on a simple balance sheet framework, we show that QE can impact the allocation of safe assets among different sectors of the economy. We call this phenomenon the safe asset illusion. Analyzing the case of the ECB's Public Sector Purchase Programme (PSPP), we find that for each EUR 1 billion additional government bond purchases, about EUR 750 million million safe assets are transferred from the non-bank to the banking sector. The sectoral shift in the holding structure of safe assets has potentially significant implications for financial stability and the effectiveness of QE. Non-banks are more exposed to credit risk in the banking sector. Banks, on the other hand, reduce their exposure to sovereign credit risk. This mitigates the sovereign-bank nexus.

1 Introduction

Safe assets play an important role for the global financial system. They serve as a store of value, collateral in repurchase and derivatives markets, pricing benchmark, and tool for monetary policy implementation and financial regulation (e.g., International Monetary Fund, 2012; Caballero, Farhi, and Gourinchas, 2017). The global financial crisis of 2007/09 has intensified an ongoing trend of growing demand and supply imbalances in the market for safe assets that has negative consequences for the real economy (e.g., Caballero, Farhi, and Gourinchas, 2008; Caballero and Farhi, 2018).[1]

In this paper, we examine the role of a major post-crisis central bank policy response for the market of safe assets: asset purchases, commonly known as quantitative easing (QE). Despite being arguably the most important monetary policy tool after the crisis, surprisingly little effort has been spent on identifying and measuring the effect of QE on safe assets.

We develop a simple balance sheet framework that enables us to analyze the interactions between the central bank, the non-bank sector, and the banking sector from a safe asset perspective. Based on this framework, we show that QE impacts the composition and distribution of safe assets in the economy. We distinguish between public and private safe assets. The former are provided by public sector entities and are the only truly safe assets. The latter are provided by the private sector and thus inherently less safe than public safe assets. The recent literature

[1]Examples for drivers of the supply and demand for safe assets are regulatory reforms such as Basel III, which increase the demand for safe assets requiring market participants to hold high quality liquid assets and move their derivatives trading to collateralized central clearing. At the same time, rating downgrades have decreased the supply of securities that are perceived to be safe.

on private safe assets suggests that these assets suffer from situations of increased uncertainty and risk, which causes them to lose their safety premium or even become illiquid (e.g., Moreira and Savov, 2017; Kacperczyk, Perignon, and Vuillemey, 2018).

We show that QE triggers a transfer of public safe assets from the non-bank to the banking sector. On the other hand, it leads to the additional creation of private safe assets, predominantly held by the non-bank sector. From the perspective of ultimate safeness, QE policies are thus not safe asset neutral. We call this non-neutrality of QE for safe assets the *safe asset illusion.* The key friction behind the safe asset illusion is the market segmentation originating from the exclusive access of banks to the central bank balance sheet and central bank reserves.

There are two main mechanism driving the non-neutrality of QE for safe assets. First, non-banks cannot directly access the central bank's balance sheet (only indirectly and likely limited through the holding of cash). Specifically, non-banks receive the proceeds from selling government bonds to the central bank in the form of bank deposits. Hence, for the non-bank sector, QE is equivalent to a swap of public safe assets (government bonds) for private safe assets (bank deposits). This increases the exposure of non-banks to credit risk in the banking sector.

The second reason for the non-neutrality of QE is the intermediary function of banks for the non-bank sector. It is usually assumed that QE has little to no effect for the safe asset holdings of the banking sector because banks effectively swap one public safe asset (government bond) for another (reserves). However, this view neglects the role of banks as intermediaries for the non-bank sector. The banking sector does not only receive reserves when selling its own government bonds but also when selling government bonds on behalf of the non-bank sector. Consequently, the safe asset holdings of banks increase due to QE. At the same time, the banking sector needs to issue additional deposits against parts of the newly created reserves. More precisely, it has to credit its non-bank customers an amount of additional deposits that is identical to the reserves coming from the QE transactions of non-banks. This results in an increase in private safe assets that are held by the non-bank sector.

We apply our framework to data from the Public Sector Purchase Programme (PSPP) conducted by the European Central Bank (ECB)[2]. The PSPP has been announced in January 2015 and purchases started in March 2015. Until the end of our sample period in December 2017, the ECB has purchased about EUR 1.9 trillion government bonds. We show that these purchases triggered a transfer of EUR 1.5 trillion public safe assets from the non-banking to the banking sector. At the same time, an identical amount of private safe assets has been created that is held by the non-bank sector. Consequently, for each additional EUR 1 billion government bonds purchased by the central bank under the PSPP, EUR 750 million public safe assets are transferred from the non-banking to the banking sector and an identical amount of private safe assets is created through the banking sector.

The safe asset illusion has important implications for the banking and non-bank sector as well as for the transmission of QE. For the non-bank sector, the safe asset illusion leads to an increasing exposure to the credit risk of banks and a reduction of the overall safeness of asset holdings. Additionally, non-banks have to pay on average a premium of about 10 basis points compared to banks if they want to store their liquidity safely.

For the banking sector, the safe asset illusion has positive and negative im-

[2]To be precise, the PSPP is implemented by the Eurosystem. We use the terms ECB and Eurosystem interchangeably.

plications. On the one hand, the banking sector is forced to hold the additional reserves and deposit them back at the central bank. This might lead to a negative interest rate margin between reserves and deposits, in particular when reserves are remunerated at a negative rate, such as in the euro area since 2014. Additionally, banks need to issue bank deposits to accommodate the reserves arising from asset purchases from its customers. This increases the size of banks' balance sheets, which might lead to increased deposit insurance premia (e.g., FDIC charges) or balance sheet cost (e.g., Basel III leverage ratio). On the other hand, banks decrease their portfolio risk by swapping government bonds for reserves. In particular, we show that the decreased exposure to government bonds mitigates the sovereign-bank risk nexus. In other words, QE extenuates the feedback loop between sovereign and bank credit risk.

Lastly, the safe asset illusion highlights that the riskier the banking sector, the higher the negative impact of QE on the available amount of safeness (in their assets holdings) for the non-bank sector. The policy implication is therefore that the effectiveness of QE depends on the riskiness of the banking sector and suitable measures may need to accompany a decision to undertake QE in order to safeguard the overall effectiveness of government bond purchases. Such measures could be enhanced access to the central bank balance sheet by non-banks or enhanced securities lending facilities.

Our results have important implications for monetary policy and financial stability. We contribute to the debate about whether monetary policy should more directly aim at strengthening financial stability.[3] Stein (2012) shows that banks tend to issue too much short-term debt compared to the socially optimal level. He

[3]See, Greenwood, Hanson, and Stein (2016) for a summary of this debate.

argues that the amount of reserves provided to the banking sector can be used as a tool to mitigate this problem. Greenwood, Hanson, and Stein (2016) follow a similar line of reasoning and advocate a more active use of the Fed's balance sheet to address financial stability concerns. They suggest that an abundance of central bank reserves can drive down financial risk arising from excessive amounts of maturity transformation. Our results suggest that providing the banking sector with additional liquidity through government bond purchases indeed strengthens the financial stability of banks. However, we also show that this comes at the cost of higher risk exposures of non-banks. By exchanging public for private safe assets, non-banks are more exposed to risk in the banking sector.

This paper also contributes more generally to the literature on safe assets, recently surveyed by Gorton (2017) and Golec and Perotti (2017). Prior research shows that safe assets carry a "convenience premium" that increases with a decreasing supply of these assets (Krishnamurthy and Vissing-Jorgensen, 2012). A scarcity of safe assets has lead to global demand and supply imbalances with effects for the financial stability and the real economy (e.g., Caballero, 2006; Caballero, Farhi, and Gourinchas, 2008; Caballero and Krishnamurthy, 2009; Barro, Fernandez-Villaverde, Levintal, and Mollerus, 2017). We show that QE can exacerbate the issue of safe asset scarcity, in particular for non-banks, which rebalance into private safe assets. For the non-banking sector, QE reduces the share of assets considered as truly safe. This share is usually stable over time (Gorton, Lewellen, and Metrick, 2012).

Finally, we contribute to the debate about the effectiveness and possible transmission channels of QE. There is a strong theoretical argument put forward by Woodford (2012) that a mere reshuffling of assets between the public and private sector should have no effect on asset prices and therefore QE is neutral to the economy.[4] Since then, a large body of theoretical and empirical literature has examined the monetary transmission of QE, collecting reasons for the non-neutrality of QE. The two most famous channels are the portfolio rebalancing channel and the idea of forward guidance.[5] We contribute to the fast growing literature on a third channel that has received less attention and relies on the special role of reserves. The channel follows from the replacement of government bonds with reserves during QE. Even though both are public liabilities, they have different properties. In particular, reserves can be held only by banks. Moreover, the central bank can choose the interest rate on reserves, whereas the interest rate on bonds is determined in the market. We show that exchanging government bonds for reserves changes the risk composition of assets in the economy. In particular, it increases the exposure of the the non-bank sector to credit risk in the banking sector. This suggests that the transmission of QE relies on the financial health of the banking sector.

The paper proceeds as follows. In Section 2, we present a balance sheet framework that enables us to assess the effect of QE on the composition of safe assets in the economy. Based on this framework, in Section 3 we examine the impact of the PSPP on the composition of safe assets in the euro area. In Section 4, we discuss various implications of the safe asset illusion for the banking and non-bank sector. Section 5 discusses possible policy responses and concludes.

[4] Woodford's (2012) argument for the irrelevance of QE is mainly based on the so called Wallace neutrality (Wallace, 1981).

[5] See, Andrade, Breckenfelder, De Fiore, Karadi, and Tristani (2016) for a recent summary of the literature on transmission channels of QE.

2 Balance sheet framework

In order to show how QE affects the total amount of safe assets and to examine the implications for different agents of the economy, we develop a simple balance sheet model. Our economy consists of three sectors: the central bank, a banking sector, and a non-bank sector. The distinguishing feature between a bank and non-bank is the access to the central bank's balance sheet. Hence, we define banks as institutions with an account at the central bank. This might include entities without a banking license. In the US, for instance, some government-sponsored enterprises and money market funds have access to facilities of the Fed. Similarly, we define non-banks as institutions that do not have access to the central banks' balance sheet. This includes households, non-financial corporations, insurance companies, money market funds (in the euro area), hedge funds, pension funds, etc. In particular, also foreign banks fall into that category. Hence, the correct label for this sector would be "non-bank sector and foreign banks", which we simply shorten to "non-bank sector for simplicity".

Available assets are government bonds, central bank reserves, and bank deposits. Government bonds are in positive net supply and issued by an exogenous government:[6]

$$G = G_{CB} + G_{BA} + G_{NB}, \tag{1}$$

where G_{CB}, G_{BA}, G_{NB} are the government bond holdings of the central bank,

[6]Note, that in the classical macro literature, the central bank and the government are usually one and the same. In our case, it makes sense to distinguish between the two because—at least in the short run—the central bank's decision to purchase government bonds is unrelated to the government's decision to increase or decrease its debt level.

banking sector, and non-bank sector, respectively. The other assets are in zero net supply, meaning they are a liability of one of the sectors in our economy.

Table 1 presents stylized balance sheets of our sectors. As government bonds are in positive net supply, they are held as asset by all three sectors. The central bank issues reserves, which can only be held by the banking sector. The banking sector issues unsecured deposits that are held by the non-bank sector.

Table 1: Sectoral balance sheets

Table 1 shows the balance sheet of the central bank, the banking sector, and the non-bank sector.

Central Bank		Bank		Non-bank	
GovBond	Reserves	Reserves	Deposits	Deposits	Equity
	Equity	GovBond	Equity	GovBond	

2.1 The central bank

The balance sheet of the central bank is given by

$$P_G G_{CB} = R + E_{CB}, \tag{2}$$

where P_G is the price of government bonds, G_{CB} is the amount of government bonds held by the central bank, R is the amount of outstanding reserves, and E_{CB} is the value of the central bank's equity. There are no cash balances. Following Equation (2), changes in the central bank's equity are determined as follows:

$$\Delta E_{CB} = \Delta P_G G_{CB} + P_G \Delta G_{CB} - \Delta R. \tag{3}$$

The central bank implements QE by purchasing government bonds G_{CB} with newly issued reserves R. Hence, all changes in the central bank's bond holdings have to be matched by changes in reserves, i.e., $P_G \Delta G_{CB} = \Delta R$. Consequently, changes in equity can only arise due to changes in bond prices:

$$\Delta E_{CB} = \Delta P_G G_{CB}. \tag{4}$$

The sensitivity of the central bank's equity w.r.t. bond prices depends on the size of its bond holdings, i.e.,

$$\frac{\partial E_{CB}}{\partial P_G} = G_{CB}. \tag{5}$$

In our analysis, we are particularly interested in the role of our assets as a safe store of value. Therefore, we focus on default instead of price risk. Against this background, we construct the following measure, which we call equity risk ER_{CB} and which follows directly from Equation (4):

$$ER_{CB} = Pr(P_G = 0) G_{CB}, \tag{6}$$

where $Pr(P_G = 0)$ is the probability that the government bond price falls to zero, which is equivalent to a default. Equity risk can change due to a change in default probabilities of government bonds or a change in government bond holdings:

$$\Delta ER_{CB} = \Delta Pr(P_G = 0) G_{CB} + Pr(P_G = 0) \Delta G_{CB}. \tag{7}$$

2.2 The non-bank sector

The consolidated balance sheet of the non-bank sector (including foreign banks) is given by:

$$P_G G_{NB} + P_D D = E_{NB}. \quad (8)$$

Hence, the non-bank sector is financed by equity and holds a portfolio of government bonds G_{NB} and bank deposits D. The price of bank deposits P_D is always one except when banks default, in which case P_D jumps to zero. For simplicity, we assume the level of non-banks' debt, such as bank loans and corporate bonds, to be fixed in the short-run and normalize it to zero. Equation (8) implies that the banking sectors' equity changes according to the following equation:

$$\Delta E_{NB} = \Delta P_G G_{NB} + P_G \Delta G_{NB} + \Delta P_D D + P_D \Delta D. \quad (9)$$

As we assume the non-bank sector's debt levels to be fixed, non-banks can obtain additional deposits only by selling government bonds, i.e., $P_D \Delta D = -P_G \Delta G_{NB}$. Therefore, changes in the equity of the non-bank sector only arise due to changes in prices:

$$\Delta E_{NB} = \Delta P_G G_{NB} + \Delta P_D D. \quad (10)$$

Non-banks' equity is exposed to changes in prices of government bonds and deposits. Hence, its equity risk ER_NB is defined as:

$$ER_{NB} = Pr(P_G = 0)G_{NB} + Pr(P_D = 0)D \tag{11}$$

and can change due to changes in default probabilities of government bonds or the banking sector, as well as changes in government bond or bank deposit holdings:

$$\begin{aligned} \Delta ER_{NB} = \Delta Pr(P_G = 0)G_{NB} + Pr(P_G = 0)\Delta G_{NB} \\ + \Delta Pr(P_D = 0)D + Pr(P_D = 0)\Delta D. \end{aligned} \tag{12}$$

2.3 The banking sector

The consolidated balance sheet of the banking sector is given by

$$R + P_G G_{BA} = P_D D + E_{BA}. \tag{13}$$

Hence, the banking sector is financed by equity and deposits. Changes in the equity of the banking sector can be expressed as follows:

$$\Delta E_{BA} = \Delta R + \Delta P_G G_{BA} + P_G \Delta G_{BA} - \Delta P_D D - P_D \Delta D \tag{14}$$

To keep the model tractable, we make three simplifying assumptions for the banking sector: First, we assume the banking sector cannot acquire additional financing through issuing new equity over the horizon considered in our model. Second, as mentioned earlier, we assume the amount of bank loans to be fixed and normalize it to zero. As a consequence, the level of deposits are exogenous to the banking sector. In other words, banks cannot determine how much deposits they hold because deposits are only affected by a change in government bond holdings of the non-bank sector (recall, $\Delta D = -P_G \Delta G_{NB}$). Third, we refrain from modelling bank default explicitly and instead distinguish between the following two cases:[7]

$$E_{BA} = \begin{cases} R + P_G G_{BA} - P_D D & \text{if} \quad P_D = 1 \\ 0 & \text{if} \quad P_D = 0. \end{cases} \tag{15}$$

We focus on the case in which banks are not in default, i.e., where $\Delta P_D = 0$ and $P_D = 1$. This simplifies Equation (14) to

$$\Delta E_{BA} = \Delta R + \Delta P_G G_{BA} + P_G \Delta G_{BA} - \Delta D \tag{16}$$

The reserve holdings of the banking sector increase either if the sector itself sells government bonds to the central bank or if the non-bank sector does so.[8] Hence, the reserve holdings of banks increase irrespective of which sector sells bonds to the central bank:

$$\Delta R = -P_G(\Delta G_{BA} + \Delta G_{NB}) = -P_G \Delta G_{CB}. \tag{17}$$

Equation (17) shows that the reserve holdings of the banking sector increase one-

[7]Not modelling bank default explicitly means we do not microfound the drivers of $Pr(P_D = 0)$. A possible microfoundation would most likely require a dynamic model. Potential default mechanisms include banks' liquidity and solvency problems. For instance, if depositors withdraw D faster than banks can liquidate G_{BA}, banks might become unable to meet their liabilities. Additionally, if banks' leverage is high and their loan portfolios default, equity can become negative.

[8]Recall, that purchasing bonds is the only monetary policy tool available to the central bank. Hence, the central bank can only change the amount of outstanding reserves by purchasing bonds. Additionally, since non-banks cannot hold reserves, they get credited bank deposits when selling bonds and the additional reserves end up on the balance sheet of the banking sector.

to-one with the central bank's asset purchases. Using this together with the fact that $\Delta D = -P_G \Delta G_{NB}$, we can further simplify Equation (16) and express the change in the banking sectors' equity as

$$\Delta E_{BA} = \Delta P_G G_{BA}. \tag{18}$$

This leads us to the following expression of the banking sector's equity risk:

$$ER_{BA} = Pr(P_G = 0) G_{BA} \tag{19}$$

$$\Delta ER_{BA} = \Delta Pr(P_G = 0) G_{BA} + Pr(P_G = 0) \Delta G_{BA} \tag{20}$$

2.4 Equilibrium

The market equilibrium is characterized by a bond price P_G that clears the market for government bonds. More precisely, P_G equilibrates the accumulated demand for bonds from the three sectors with the total exogenous supply of bonds, i.e.,

$$P_G G = P_G (G_{CB} + G_{NB} + G_{BA}), \tag{21}$$

where G is the total amount of government debt. Based on Equation (21), we can formulate the budget constraint for the banking and non-bank sector:

$$P_G (G - G_{CB}) = P_G (G_{NB} + G_{BA}). \tag{22}$$

Since P_D is always 1 in case of no default, P_G also ensures that the demand for bank deposits from the non-bank sector equals the supply from the banking sector.

To see this, recall that the non-bank sector can only adjust its deposit holdings by purchasing or selling government bonds. Finally, P_G also equilibrates banks' demand for reserves and its supply. Reserves are determined as a residual from the central bank's monetary policy, i.e., its purchase program.

In what follows, we do not consider changes in government bond prices and how QE affects these prices. Instead, we take price changes as given and focus on changes in asset holdings of our sectors. For a detailed analysis of the effect of QE on government bond prices in a similar setting, see Christensen and Krogstrup (2018).

2.5 The effect of QE on sectoral holdings of safe assets

Based on our balance sheet framework, we examine the effects of government bond purchases by the central bank on the holdings of public and private safe assets across our different sectors. The safe asset holdings of our sectors are as follows:

$$SA_{CB} = G_{CB} \tag{23}$$

$$SA_{BA} = G_{BA} + R \tag{24}$$

$$SA_{NB} = G_{NB} + D, \tag{25}$$

where all assets are public safe assets, except for bank deposits D, which is a private safe asset.

Table 2 summarizes the impact of QE on the sectoral balance sheets. The central bank purchases government bonds from the banking and non-bank sector in the secondary market against reserves, i.e., $\Delta R = \Delta G_{CB}$. The total amount of outstanding government debt G is unaffected by these purchases, i.e., $\Delta G = 0$.

Table 2: Sectoral balance sheets: Government bond purchases

Table 2 shows the change in sectoral balance sheets when the central bank purchases government bonds from the banking and non-bank sector.

Central Bank		Bank		Non-bank	
ΔG_{CB}	ΔR	ΔR	ΔD	ΔD	
		$-\gamma \Delta G_{CB}$		$-(1-\gamma)\Delta G_{CB}$	

Consequently, the increase in bond holdings at the central bank has to be offset by a decrease in the holdings of the banking and/or non-bank sector. Using the budget constraint Equation (22), we can write

$$\Delta G_{CB} = -(\Delta G_{NB} + \Delta G_{BA}). \tag{26}$$

We assume that a fraction γ of the purchased bonds comes from the banking sector and $1-\gamma$ from the non-bank sector. The variable γ is a reduced-form parameter that reflects the preferences of our sectors to hold government bonds. Consequently, we can rewrite the relation between changes in reserves and government bond purchases as

$$\Delta R = \Delta G_{CB} \tag{27}$$

$$= -\Delta G_{BA} - \Delta G_{NB} \tag{28}$$

$$= \gamma \Delta G_{CB} + (1-\gamma) G_{CB}. \tag{29}$$

This has important implications for the sectoral holdings of private and public safe assets. As shown in Section 2.3, the banking sector receives 100% of the newly created reserves. Hence, the banking sector sells $\gamma \Delta G_{CB}$ government bonds and receives ΔR reserves. The non-bank sector on the other hand sells $(1-\gamma)G_{CB}$ government bonds through the banking sector, which acts as intermediary. The banking sector then grants the non-bank sector $\Delta D = -(1-\gamma)\Delta G$ in deposits. Consequently, the sectoral holdings of public and private safe assets change as follows:

$$\Delta SA_{BA}^{public} = \Delta R - \gamma \Delta G_{CB} \geq 0 \tag{30}$$

$$\Delta SA_{BA}^{private} = 0 \tag{31}$$

$$\Delta SA_{NB}^{public} = (1-\gamma)\Delta G_{CB} \leq 0 \tag{32}$$

$$\Delta SA_{NB}^{private} = \Delta D = -(1-\gamma)\Delta G_{CB} \geq 0 \tag{33}$$

Hence, for positive values of γ, the public safe asset holdings of the banking sector increase and the holdings of the non-bank sector decrease. Additionally, recalling that the increase in non-banks deposit holdings equals the decrease in bond holdings, reveals that the non-bank sector substitutes its public safe assets for private safe assets as a result of QE. Aggregating the changes in public and private safe assets across sectors shows that QE is neutral to the total amount of public safe assets, but leads to a production of additional private safe assets:

$$\Delta SA^{public} = \Delta SA_{BA}^{public} + \Delta SA_{NB}^{public} \tag{34}$$

$$= \Delta R - \gamma \Delta G^{CB} - (1-\gamma)\Delta G^{CB} \tag{35}$$

$$= 0 \tag{36}$$

$$\Delta SA^{private} = \Delta SA_{BA}^{private} + \Delta SA_{NB}^{private} \tag{37}$$

$$= \Delta D. \tag{38}$$

Extension. We extend the model and allow the total level of government debt to change. Therefore, we assume that an exogenous treasury can change the net debt level by purchasing or selling government bonds.[9] Contrary to central bank purchases, these operations change the amount of outstanding government bonds, i.e., $\Delta G \neq 0$. Since governments usually increase their net debt levels, we consider the case in which the the treasury sells bonds, i.e., $\Delta G > 0$. We assume it sells a fraction κ to the banking and $(1-\kappa)$ to the non-bank sector. The sectoral holdings of public and private safe assets change as follows:

$$\Delta SA_{BA}^{public} = \Delta R - \gamma \Delta G_{CB} + \kappa \Delta G \tag{39}$$

$$\Delta SA_{BA}^{private} = 0 \tag{40}$$

$$\Delta SA_{NB}^{public} = -(1-\gamma)\Delta G_{CB} + (1-\kappa)\Delta G \tag{41}$$

$$\Delta SA_{NB}^{private} = \Delta D + \Delta D', \tag{42}$$

where $\Delta D' = -(1-\kappa)\Delta G \leq 0$ is the change in deposits due to non-banks' investments into the newly issued government bonds.

Whenever the treasury sells government bonds, it increases the amount of public

[9]Note, that selling (purchasing) government bonds corresponds to the situation in which the amount of newly issued government bonds exceeds (is smaller than) the amount of maturing ones, such that the net indebtedness of the government increases.

safe assets and decreases the amount of private safe assets:

$$\Delta SA^{public} = \Delta SA^{public}_{BA} + \Delta SA^{public}_{NB} \tag{43}$$

$$= \Delta R - \gamma \Delta G_{CB} + \kappa \Delta G - (1-\gamma)\Delta G_{CB} + (1-\kappa)\Delta G \tag{44}$$

$$= \Delta G \tag{45}$$

$$\Delta SA^{private} = \Delta SA^{private}_{BA} + \Delta SA^{private}_{NB} \tag{46}$$

$$= \Delta D + \Delta D'. \tag{47}$$

The decrease in private safe assets $\Delta D'$ is smaller in absolute values than the increase in public safe assets ΔG as long as some of the newly issued bonds are purchased by the banking sector, i.e., $\kappa > 0$:

$$|\Delta D'| = |(1-\kappa)\Delta G| < |\Delta G| \quad \forall \;\; \kappa > 0 \tag{48}$$

3 Impact of the Public Sector Purchase Programme on euro area safe assets

In this section, we examine the change in public and private safe asset holdings across our sectors due to the ECB's Public Sector Purchase Programme (PSPP).

3.1 Data

We use data from the ECB's Monetary and Financial Institutions (MFI) balance sheet items (BSI) dataset collected by the Eurosystem with a view to support the performance of the tasks of the ECB. The BSI statistics contain information about euro area MFI's balance sheets at a monthly frequency. MFI's are defined as credit institution in accordance to European Union law as well as institutions whose business is to receive deposits in order to grant credits or make investments in securities.[10] This definition includes central banks, credit institutions, other deposit taking institutions, and money market funds. We exclude central banks from the data. More than 86% of the remaining institutions are credit institutions, i.e., classical banks. In the remaining 14% of institutions, there might be entities without access to the central bank's balance sheet. Consequently, we might slightly overestimate the size of the banking sector in our analysis. Since the absolute majority of MFI's are classical banks, we will keep on using the term "banks" for simplicity.

Important for our purposes is the information on banks' holdings of euro area government bonds. The BSI statistics distinguish between domestic and other euro area government bonds. Furthermore, we enrich the BSI dataset with information on the total amount of outstanding euro area government bonds as well as PSPP government bond purchases. Our sample starts in December 2014 and ends in December 2017. All data is freely available through the ECB's Statistical Data Warehouse.

3.2 Public Sector Purchase Programme

The PSPP was formally announced in January 2015 and further implementation details were communicated in March 2015, which marks also the start date of the large scale asset purchase programme of the euro area. The policy rationale of the

[10] See, the manual on MFI balance sheet statistics, available at `https://www.ecb.europa.eu/pub/pdf/other/manualmfibalancesheetstatistics201204en.pdf`.

PSPP was to provide additional monetary policy accommodation in a situation in which policy rates could not be cut (much) further (the deposit facility rate had reached a level of -0.20 percent and the main refinancing rate stood at 0 percent).

The initial monthly envelope of PSPP purchases was EUR 60 billion, which was increased in March 2016 to EUR 80 billion and then decreased again to EUR 60 billion in December 2017. Between March 2015 and December 2017, the Eurosystem has purchased EUR 1.9 trillion of euro area government bonds, agency bonds and euro area supras (e.g., EIB bonds). The purchase volumes were split according to the capital key. In other words, each national central bank of the Eurosystem purchased the share of the monthly PSPP envelope that corresponds to its capital share, exclusively focusing on the govenment bonds of their own country.

As of 31 December 2017, out of the total PSPP purchase volume, the Eurosystem had acquired EUR 463 billion in German, EUR 383 billion in French, EUR 329 billion in Italian, EUR 232 billion in Spanish and EUR 105 billion in Dutch government bonds, corresponding to 26.5%, 20.0%, 17.0%, 23.3%, 25.6% of all outstanding bonds of these countries.

3.3 Empirical analysis

The system of equations (30) $-$ (33) describes the change in private and public safe asset holdings across our sectors due to QE. We can directly measure ΔR, which is equivalent to the total amount of government bond purchases by the Eurosystem G_{CB}. We also observe the change in net government debt levels ΔG. Unfortunately, we do not observe the parameter γ, i.e., we do not know which fraction of the government bonds are purchased from the banking and non-bank sector. Consequently, Equation (30) and (32) are not identified.

However, we do observe the total change in government bond holdings of the banking and non-bank sector, i.e., the accumulated change due to the PSPP and new net government debt issuance. Consequently, we can measure $(-\gamma\Delta G_{CB} + \kappa\Delta G)$ and $(-(1-\gamma)\Delta G^{CB} + (1-\kappa)\Delta G)$ using the changes in the sectors' holdings of euro area government bonds between December 2014 and December 2017. This enables us to identify Equations (39) to (42) from the extended version of our model. The first column in Table 3 summarizes our estimates of the individual components of this system of equations.[11]

Table 3: Variable estimates

Table 3 shows the estimates for the individual components of the system of equations (39) to (42).

Variable	Joint estimate	$\kappa = 0.24$
ΔR	$1,931$bn	$1,931$bn
$-\gamma\Delta G_{CB}$	-370bn	-474bn
$+\kappa\Delta G$		104bn
$-(1-\gamma)\Delta G_{CB}$	$-1,126$bn	$-1,457$bn
$+(1-\kappa)\Delta G$		331bn

We find that the public safe asset holdings of the banking sector increase by EUR 1,561 billion. This number is driven by two opposing factors. First, the banking sector receives EUR $1,931$ billion in reserves coming from government bond purchases of the central bank. Recall, that the banking sector always receives additional reserves when any of the sectors sell assets to the central bank. Second,

[11] In detail, our computations look as follows: We know $\Delta R = 1,931$ from PSPP data, we know $-\gamma\Delta G_{CB} + \kappa\Delta G = -370$ from MFI data, and we know $\Delta G = 435$ from data on changes in outstanding euro area sovereign debt. Taking all these values, we can solve Equation (44) for the change in government bond holdings of the non-bank sector $-(1-\gamma)\Delta G_{CB} + (1-\kappa)\Delta G = 1,126$.

the banking sector reduces its government bond holdings by EUR 370 billion. This reduction is composed of asset sales to the central bank ($\gamma\Delta G_{CB}$) as well as purchases of newly issued government bonds ($\kappa\Delta G$). Without further assumptions, we cannot disentangle these two components.

Panel (a) of Figure 1 illustrates the origin of the increase in safe asset holdings of the banking sector. It plots the government bond and excess liquidity holdings of banks. Changes in excess liquidity clearly outweigh changes in government bond holdings. As mentioned above, the strong increase in excess liquidity goes back to the role of banks as intermediary for non-banks and the fact that banks receive additional reserves whenever non-banks sell bonds to the central bank.

$$\Delta SA_{BA}^{public} = \Delta R - \gamma\Delta G_{CB} + \kappa\Delta G = 1,931\text{bn} - 370\text{bn} = 1,561\text{bn} \tag{49}$$

$$\Delta SA_{BA}^{private} = 0\text{bn} \tag{50}$$

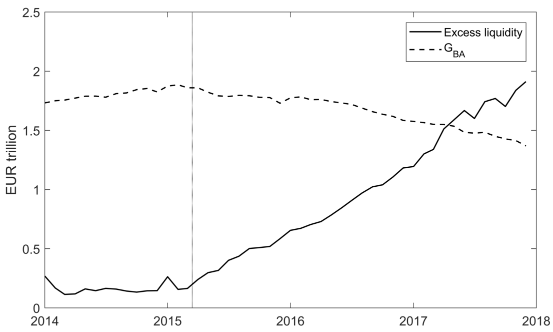
$$\Delta SA_{NB}^{public} = -(1-\gamma)\Delta G_{CB} + (1-\kappa)\Delta G = -1,126\text{bn} \tag{51}$$

$$\Delta SA_{NB}^{private} = \Delta D - \Delta D' = 1,126\text{bn}. \tag{52}$$

The non-bank sector reduces its government bond portfolio by EUR -1,126 billion and thereby swaps EUR -1,126 billion in public safe assets for the same amount of private safe assets. Similar to banks, the change in bond holdings originates from selling assets to the central bank ($(1-\gamma)\Delta G_{CB}$) as well as purchases of newly issued government bonds ($(1-\kappa)\Delta G$), which we cannot disentangle without further assumptions. Since non-banks receive bank deposits for selling government bonds and pay with bank deposits when acquiring newly issued bonds from the government, it applies that the change in government bond holdings equals the change in deposits, i.e., $(1-\gamma)\Delta G_{CB} = \Delta D$ and $(1-\kappa)\Delta G = \Delta D'$. This can also

Figure 1: Bank and non-bank portfolio

Panel (a) of Figure 1 plots the excess liquidity and government bond holdings of the banking sector. Panel (b) plots the deposit and government bond holdings of the non-bank sector. The dotted vertical line marks the start of the PSPP purchases in March 2015.



(a) Banking sector

(b) Non-bank sector

be seen in Panel (b) of Figure 1, which plots the government bond and deposit holdings of the non-bank sector. Both move in opposite directions at a similar pace and magnitude.

Interestingly, the change in government bond holdings of the banking and non-bank sector are almost identical when measured as fraction of their total bond holdings. The reduction of EUR 370 billion in government bond holdings of the banking sector corresponds to a decrease of 20.3%. In case of the non-bank sector, the reduction of EUR 1,126 billion is equivalent to a decrease of 19.8%. The total amount of public safe assets increases due to the additional government debt and the amount of private safe assets increases due to the newly created bank deposits:

$$\Delta SA^{public} = \Delta G \qquad = \; 435\text{bn} \tag{53}$$

$$\Delta SA^{private} = \Delta D - \Delta D' \qquad = \; 1,126\text{bn} \tag{54}$$

In order to estimate the direct effect of the PSPP on the safe asset holdings across our sectors, we need to control for the increase in net government debt levels. To this end, we make the assumption that the banking and non-bank sector purchase new government bonds according to the fraction of their government bond holdings in December 2014 (pre-QE). This seems reasonable, given the fact that the relative changes in government bond holdings of the banking and non-bank sector are almost identical (20.3% vs. 19.9%), as mentioned above. The fraction of outstanding government bonds held by banks in December 2014 was 24%. Thus, we assume the banking sector to purchase 24% of the newly issued government bonds ($\kappa = 0.24$). The updated estimates of our variables are shown in the second column of Table 3. We are left with the following change in the amount of safe assets:[12]

$$\Delta SA_{BA}^{public}|_{\Delta G=0} = \Delta R - \gamma \Delta G_{CB} = 1,931\text{bn} - 474\text{bn} = 1,457\text{bn} \quad (55)$$

$$\Delta SA_{BA}^{private}|_{\Delta G=0} = 0\text{bn} \quad (56)$$

$$\Delta SA_{NB}^{public}|_{\Delta G=0} = -(1-\gamma)\Delta G_{CB} = -1,457\text{bn} \quad (57)$$

$$\Delta SA_{NB}^{private}|_{\Delta G=0} = \Delta D = 1,457\text{bn}. \quad (58)$$

Hence, the banking sector profits from EUR 1,457 billion in additional public safe assets in the form of central bank reserves. These safe assets come from the non-bank sector, which sells EUR 1,457 billion worth of government bonds to the central bank, receiving the same amount of bank deposits in return (private safe asset). Controlling for changes in net government debt levels also reveals that QE

[12] We simply plug in $\kappa = 0.24$ and then take all terms involving this variable out of the system of equations.

is neutral to the total amount of public safe assets and has a positive effect on the amount of private safe assets:

$$\Delta SA^{public} = \Delta R - \gamma\Delta G_{CB} - (1-\gamma)\Delta G_{CB} \quad = \ 0\text{bn} \tag{59}$$

$$\Delta SA^{private} = \Delta D \quad = \ 1,457\text{bn.} \tag{60}$$

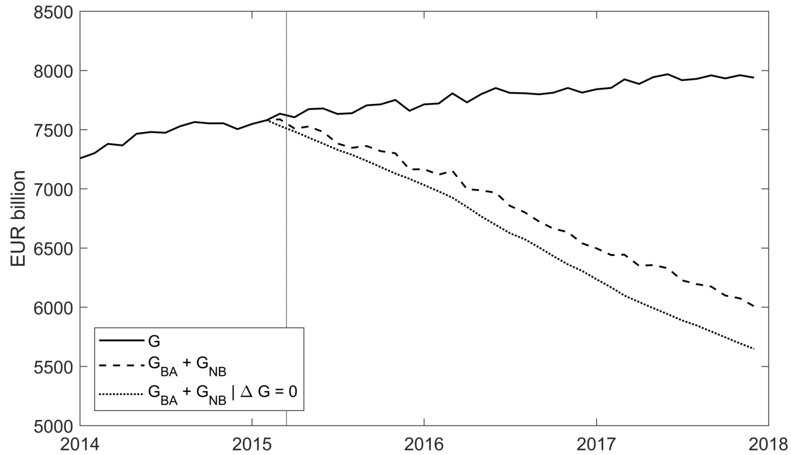
Figure 2 plots the total outstanding euro area government bonds as well as the accumulated government bond holdings of the banking and non-bank sector. Before the start of the government bond purchases in March 2015, the outstanding government bonds were exclusively held by the banking and non-bank sector. Subsequently, the Eurosystem started acquiring a growing share of outstanding bonds, at a pace much faster than the issuance of new government debt. The increasing wedge between the solid and dashed line mirrors the growing government bond portfolio of the central bank. The dotted line represents the counterfactual bond holdings of the banking and non-bank sector if new net debt issuance had been zero.

3.4 Robustness check and limitations

We derive changes in non-banks' deposit holdings from changes in their government bond holdings. Thereby, we implicitly assume the non-bank sector to hold all proceeds from QE in the form of bank deposits. Instead of holding on to deposits, however, non-banks might also rebalance into other securities. This could affect their safe asset holdings as well as risk exposure. In this section, we examine to what extent deriving changes in deposit holdings from changes in bond holdings might affect our results and the quintessence of our findings.

Figure 2: Government bond holdings

Figure 2 plots the total outstanding euro area government bonds (solid line) as well as the accumulated government bond holdings of the banking and non-bank sector when controlling (dotted line) and not controlling for new net debt issuance (dashed line). The dotted vertical line marks the start of the PSPP purchases in March 2015.



It is important to note that we do not assume each individual non-bank to keep its proceeds from QE in the form of deposits. Instead, we only assume the non-bank sector as a whole to do so. This is an important difference because changes in deposits of individual non-banks are not the same as changes in aggregate non-bank deposits. To see this, assume one non-bank purchases a corporate bond from another and pays with deposits. This affects the deposit holdings of these two entities, but it leaves the aggregate deposit holdings of the non-bank sector unchanged. On aggregate, deposit holdings of the non-bank sector are only affected through trades with the banking sector. Hence, variation in aggregate deposits is much smaller than variation in individual deposits.

Based on our methodology, which derives changes in deposits from changes in government bonds, we find that the non-bank sector increases its deposit holdings by EUR 1,126 billion between December 2014 and December 2017.[13] The actual changes in deposit holdings reported in the BSI data are EUR 837 billion. Consequently, it seems as if non-banks have reinvested parts of their proceeds from QE into substitute assets from the banking sector.

These reinvestments can have a positive or negative effect on the safe asset holdings and risk exposure of the non-bank sector. Non-banks might either rebalance back into public safe assets, i.e., government bonds, or they might purchase riskier assets, such as corporate bonds or asset backed securities. Depending on which of these two effects dominates, we might over- or underestimate the impact of QE on safe asset holdings and the risk exposure of the non-bank sector.

Let us first take a look at rebalancing back into public safe assets. Our methodology already captures any reinvesting into euro area government bonds. In other words, we control for the situation in which non-banks sell government bonds to the central bank and use the proceeds to purchase substitute government bonds from the euro area.[14] Consequently, the only public safe asset we currently ignore are foreign government bonds. Based on the ECB's Securities Holdings Statistcs, Koijen, Koulischer, Nguyen, and Yogo (2017) show that the non-bank sector increases its foreign government bond holdings by EUR 20 billion quarterly between Q2 2015 and Q4 2015. Extrapolating this to Q4 2017 yields an increase in foreign bond holdings of EUR 220 billion. However, note that the safe asset function of foreign bonds might be impaired by the exposure to exchange rate, liquidity, and

[13]Note, that we use the changes in deposits without controlling for new net debt issuance in order to compare the number with data from the BSI statistics.

[14]Recall, that we only look at net changes of government bond holdings and do not distinguish between (1) a non-bank that sells EUR 100 billion euro area government bonds to the central bank and reinvests EUR 50 billion into other euro area government bonds and (2) a non-bank that simply sells EUR 50 billion euro area government bonds to the central bank.

credit risk, such that most likely only US Treasuries serve as a true alternative to euro area public safe assets.[15] Consequently, the volume of rebalancing into foreign public safe assets is too small to have any material impact on the bottom line of our results.

Instead of foreign government bonds, the non-bank sector might also reinvest its proceeds from QE into riskier assets such as corporate bonds, asset-backed securities, or equity. In this case, our assumption that non-banks hold their proceeds from QE in the form of bank deposits is conservative because it underestimates the risk exposure of non-banks' portfolios. Consequently, the changes in the non-bank sector's equity risk, which we compute in the next section, are lower bound estimates.

4 Implications of the safe asset illusion

In this section, we examine some important implications of the safe asset illusion for the banking and non-bank sector.

4.1 Equity risk

In this section, we examine how banks' and non-banks' equity risk has changed since the introduction of the PSPP. We have derived the equity risk of our sectors

[15]This view is supported by a growing literature on the role of US Treasuries as a global safe asset (e.g., He, Krishnamurthy, and Milbradt, 2016).

in our model as

$$ER_{BA} = Pr(P_G = 0)G_{BA}$$
$$ER_{NB} = Pr(P_G = 0)G_{NB} + Pr(P_D = 0)D.$$

Recall, that variation in equity risk can originate from changes in default probabilities as well as portfolio holdings:

$$\Delta ER_{BA} = \Delta Pr(P_G = 0)G_{BA} + Pr(P_G = 0)\Delta G_{BA}$$
$$\Delta ER_{NB} = \Delta Pr(P_G = 0)G_{NB} + Pr(P_G = 0)\Delta G_{NB}$$
$$+ \Delta Pr(P_D = 0)D + Pr(P_D = 0)\Delta D.$$

In order to identify the effect of QE on equity risk, we have to identify the effect of QE on each of these components. While we have done this for the changes in portfolio holdings ΔG_{NB}, ΔD, and ΔG_{BA}, it lies beyond the scope of this paper to identify the effect of QE on default risk $\Delta Pr(P_G = 0)$ and $\Delta Pr(P_D = 0)$. Instead, we examine the two extreme cases where QE has no effect on default probabilities and where QE is the only driver of default probabilities.

First, we assume QE to have no effect on default probabilities such that $\Delta Pr(P_G = 0) = \Delta Pr(P_D = 0) = 0$. Note, that this simplifies changes in equity risk to

$$\Delta ER_{BA} = Pr(P_G = 0)\Delta G_{BA} \tag{61}$$
$$\Delta ER_{NB} = Pr(P_G = 0)\Delta G_{NB} + Pr(P_D = 0)\Delta D. \tag{62}$$

We approximate the default probabilities of euro area governments and banking sectors $Pr(P_G = 0)$ and $Pr(P_D = 0)$ by constructing two indices of CDS spreads. We plot these indices in Figure 3. The index for the default probability of government bonds is based on nine euro area governments and the one for the banking sectors on a total of 36 banks from these nine countries.[16] We compute the indices as weighted average CDS spread of these countries and banking sectors. CDS spreads are retrieved from Bloomberg. The weights for the sovereign CDS index are based on the amount of outstanding debt of the respective country relative to the total size of the debt in all nine countries, available through the ECB's Statistical Data Warehouse. The weights for the bank CDS spread are based on the MFI deposits of the respective banking sector relative to the total MFI deposits of all nine banking sectors from BSI data. The CDS spread of the banking sector is on average 41 points or 65% higher than the index of sovereign CDS spreads, reflecting the additional credit risk of banks compared to euro area governments.

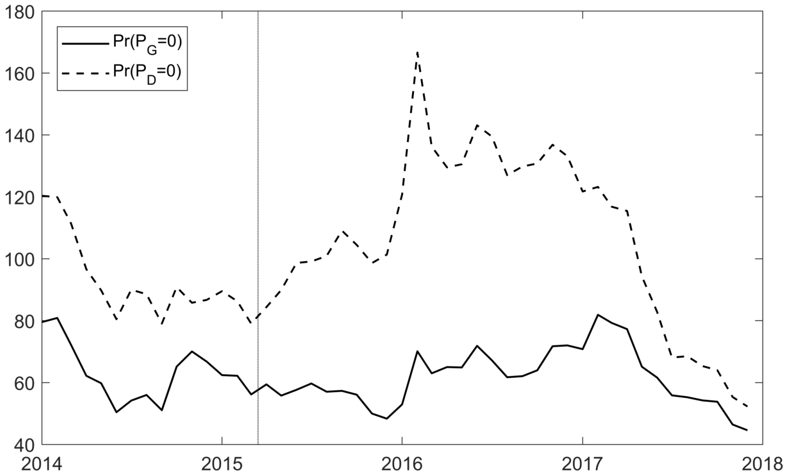
We use the average CDS spreads of both indices in 2014 to approximate the default probabilities $Pr(P_G = 0)$ and $Pr(P_D = 0)$ in Equation (61) and (62). In particular, we compute relative default probabilities by dividing the average of both indices in 2014 by the average of the sovereign CDS index in 2014. This normalizes $Pr(P_G = 0)$ to 1 and gives us 1.48 for $Pr(P_D = 0)$, which indicates that the banking sector's credit risk exceeds the sovereign credit risk by 48%. We find that the equity risk of the banking sector decreases by EUR 456 billion or 25% between December 2014 and December 2017. At the same time, the equity risk of the non-bank sector increases by EUR 786 billion or 4%.[17] These results reflect

[16] The indices capture the following countries: Austria, Belgium, Germany, Spain, Finland, France, Italy, Netherlands, and Portugal.

[17] Note, that we implicitly assume recovery rates to be constant or change equally between

Figure 3: Sovereign and banking sector CDS index

Figure 3 plots two CDS spread indices. One for the government and one for the banking sector. We compute the indices as weighted average CDS spread of nine euro area countries and 36 banks from these countries. The weights for the sovereign CDS index are based on the amount of outstanding debt of the respective country relative to the total size of the debt in all nine countries. The weights for the bank CDS spread are based on the MFI deposits of the respective banking sector relative to the total MFI deposits of all nine banking sectors. The dotted vertical line marks the start of the PSPP purchases in March 2015.



that banks rebalance from government bonds into risk-free reserves and non-banks rebalance from government bonds into riskier bank deposits.

Next, we assume QE to be the only driver of default probabilities. In other words, we use realized changes in CDS spreads from Figure 3 as proxy for the default probabilities. Figure 4 plots the equity risk for both sectors under this assumption. It shows that the equity risk of both sectors first remains stable or slightly increases, before it strongly decreases in 2017 due to a strong decrease in default probabilities as shown in Figure 3. Between December 2014 and December 2017, the equity risk of the banking sector is reduced by EUR 911 billion or 50% and the one of the non-bank sector by EUR $5,627$ billion or 29%.

Panel (b) of Figure 4 also reveals that the total equity risk of the non-bank sector is mainly driven by its exposure to the more volatile banking sector. Rebalancing into deposits exacerbates this situation and might have adverse consequences in case of a banking crisis, creating a feedback loop between the banking and non-bank sector similar to a sovereign-bank risk nexus.

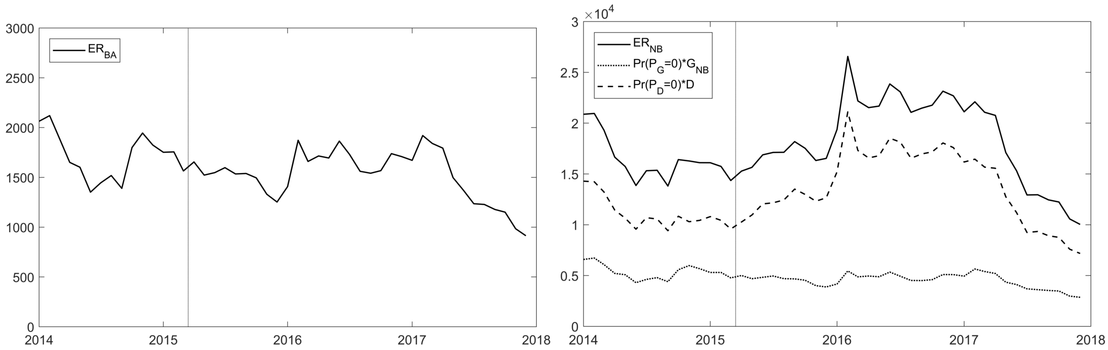
4.2 Safe storage premium

We have shown that the non-bank sector swaps big amounts of public for private safe assets during QE and hence increases its portfolio risk. One way to mitigate this risk would be to store the liquidity safely instead of holding it in the form of bank deposits. Contrary to the banking sector, however, non-banks cannot store their liquidity risk-free at the central bank. Instead, they have to rely on secured deposits. In this section, we examine the additional cost this causes to non-banks. The most important safe storage facility for non-banks are secured

government and bank fixed income assets.

Figure 4: Equity risk

Panel (a) of Figure 4 plots the equity risk of the banking sector. Panel (b) plots the equity risk of the non-banking sector as well as its two components, namely the risk coming from government bond holdings (dotted line) and from bank deposits (dashed line). Both equity risks are constructed using realized changes in default probabilities. The dotted vertical line marks the start of the PSPP purchases in March 2015.



(a) Banking sector

(b) Non-bank sector

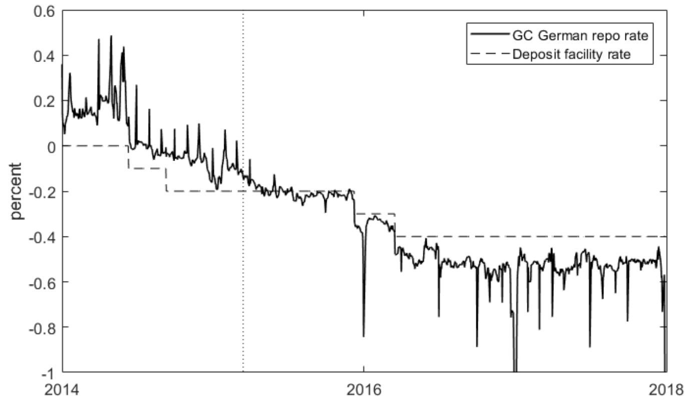
deposits, in particular overnight repurchase agreements (repos) backed by high quality collateral. A repo is conceptually identical to a secured loan. Hence, the cash-rich agent lends or deposits its funds at a cash-seeking agent at a predefined rate and maturity against collateral.

Figure 5 plots the rate on the ECB's deposit facility together with the overnight rate on general collateral (GC) German repos. In an overnight GC German repo, the non-bank deposits cash overnight in return for a German government bond. The transaction is reversed the next day. Both the deposit facility rate and GC German repo rate have moved to negative territory already in 2014. Additionally, the repo rate has dropped below the deposit facility rate shortly after the start of the PSPP and stayed there ever since.[18] Hence, since at least mid-2015 non-banks

[18]We have chosen repos backed by German collateral because these assets are arguably the safest way to store overnight liquidity for non-banks and hence they are most similar to the

Figure 5: The safe storage premium

Figure 5 plots the rate on the ECB's deposit facility rate together with the overnight rate on general collateral (GC) German repurchase agreements (repos). The dotted vertical line marks the start of the PSPP purchases in March 2015.



have to pay a premium to store their overnight liquidity safely. Between March 2015 and December 2017, the premium has averaged 10 basis points. Consequently, the banking sector safes about EUR 1-2 billion per year in safe storage cost compared to the non-bank sector.[19]

4.3 The inevitability of reserves and deposits

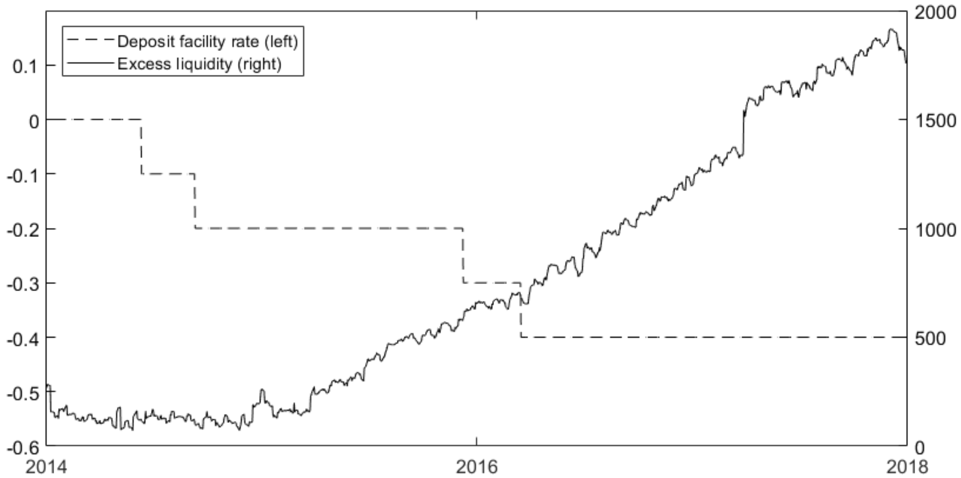
QE creates a source of exogenous variation in reserves and deposits for the banking sector. First, the banking sector as a whole is obliged to hold the additional reserves created by the central bank during QE. Second, it is forced to issue bank deposits against parts of the reserves. Both obligations have important consequences for banks' profitability and funding or balance sheet cost.

ECB's deposit facility. Rates for repos backed by other core euro area sovereigns such as the Netherlands or France also trade below the deposit facility rate.

[19]The exact cost depends on the size of the total excess liquidity held by the banking sector.

Figure 6: Deposit facility rate and aggregate excess liquidity

Figure 6 plots the ECB's rate on reserves—the deposit facility rate—and the total amount of excess liquidity in the Eurosystem.



Our model shows that the aggregate level of reserves is determined by the central bank and hence exogenous to the banking sector. In other words, banks cannot decide to hold more or less reserves on aggregate. For this reason, the central bank can extend its balance sheet and create a regime of permanent excess liquidity as done in the US and euro area after the Global Financial Crisis. Figure 6 presents these developments for the euro area. It plots the interest rate the ECB pays on excess liquidity, called deposit facility rate, together with the total amount of excess liquidity in the Eurosystem.[20]

The policy mix of the ECB is composed of conventional decreases in interest rates as well as increasing levels of reserves due to QE. The combination of the

[20]Excess liquidity is defined as deposits at the deposit facility net of the recourse to the marginal lending facility, plus current account holdings in excess of those contributing to the minimum reserve requirements.

two forces banks to accept a negative return on a growing part of their assets. At the end of 2017, banks in the euro area held a total of EUR 1,758 billion in excess liquidity with increasing tendency because the PSPP was still ongoing. Given the level of the deposit facility rate of −40 basis points and assuming that banks pay zero interest rates on their deposits, this amounts to a negative interest rate margin that costs banks EUR 7 billion p.a. Additionally, further increasing the amount of excess liquidity or decreasing the deposit facility rate exacerbates this situation. In particular, at the excess liquidity levels of end-2017, decreasing the deposit facility rate by 10 basis points increases the negative return for the banking sector by another EUR 1.8 billion.

Additionally, we have shown that banks have to issue bank deposits against reserves whenever the non-bank sector sells government bonds to the central bank. In other words, as soon as bank customers sell government bonds, they get credited additional deposits while the bank holds the additional reserves (recall, $\Delta D = -P_G \Delta G_{NB}$). This exogenously changes the funding structure and balance sheet size of banks, which might increase deposit insurance premia (e.g., FDIC charges) and balance sheet cost (Basel III leverage ratio).

In sum, the banking sector has to hold the additional reserves created through QE and is forced to at least partially issue deposits against them. Both obligations have negative externalities in the sense that they squeeze banks' profit margins and create additional balance sheet cost.

4.4 The sovereign-bank risk nexus

The interconnectedness of bank and sovereign credit risk, known as "sovereign-bank nexus", has proofed to be an important source of systemic risk, aggravating vulnerabilities and leading to adverse feedback loops. The government bond portfolio of the banking sector is one major channel through which banks and sovereigns are intertwined (e.g., Acharya, Drechsler, and Schnabl, 2014; Fratzscher and Rieth, 2015). We have shown that the banking sector decreases its government bonds holdings as a result of QE. Hence, it stands to reason that QE has mitigating effects on the sovereign-bank nexus.

The main challenge when testing this hypothesis is to identify the direct channel between sovereign and bank credit risk. Hence, we have to control for other (unobserved) factors that contemporaneously impact sovereign and bank credit risks, such as regulation or changes in macroeconomic risk. For instance, changes in expectations about economic growth or employment might lead to changes in sovereign credit risk and at the same time have direct effects on banks' loan and mortgage portfolios. This could lead to a comovement between sovereign and credit risk without there being a direct link between the two.

We address this challenge employing three sets of control variables similar to Acharya, Drechsler, and Schnabl (2014). First, we capture changes in variables that have market-wide effects on the financial sector by including day fixed effects. Hence, we control for all macro variables and changes in regulation that contemporaneously affect bank and sovereign credit risk.

Second, we control for the exposure of each country's banking sector to foreign credit risk. To this end, we create a foreign exposure measure, which captures changes in banks' credit risk due to changes in sovereign credit risk of foreign countries. We compute this measure as the weighted average of foreign countries' CDS prices. The weights are based on the size of the foreign exposure relative to the total size of a country's banking sector. Foreign exposures are available in the consolidated banking statistics of the Bank for International Settlements.[21] The total sizes of euro area sovereign banking sectors are retrieved from the ECB's MFI balance sheet items via the Statistical Data Warehouse.[22]

Third, we control for heterogeneity in banks' exposure to changes in macroeconomic variables and regulation. To this end, we include bank fixed effects as well as an aggregate measure for volatility (VDAX) and credit risk (iTraxx Europe). In case of the VDAX and the iTraxx Europe, we allow for bank-specific coefficients by interacting the indices with our bank fixed effects. The VDAX is based on the German stock market index DAX and is analogous to the VIX. It captures changes in expectations about aggregate volatility, which are pivotal for the pricing of credit risk. The iTraxx Europe is a CDS market index and consists of 125 highly liquid European entities with investment grade credit ratings as published by Markit. It captures variation in CDS prices that might be caused by shocks specific to the CDS market or changes in market-wide credit risk and liquidity.

We estimate the following regression:

$$\begin{aligned}\Delta\log(\text{Bank CDS}_{ijt}) = {} & \alpha_i + \delta_t + \beta\Delta\log(\text{Sovereign CDS}_{jt}) + \\ & \gamma\Delta\log(\text{Foreign Exposure CDS}_{ijt}) + \rho_i \Delta X_{ijt} + \varepsilon_{ijt},\end{aligned}$$

where $\Delta\log(\text{Bank CDS}_{ijt})$ is the daily change in logged CDS prices of bank i

[21]See, https://www.bis.org/statistics/consstats.htm.

[22]See, https://sdw.ecb.europa.eu/browse.do?node=9691312.

located in country j, $\Delta\log(\text{Sovereign CDS}_{jt})$ is the daily change in logged CDS prices of sovereign j, $\Delta\log(\text{Foreign Exposure CDS}_{ijt})$ is the daily change of the foreign exposure measure, and ΔX_{ijt} captures daily changes of aggregate volatility (VDAX) and the CDS market index (iTraxx Europe), whereby we allow for bank-specific coefficients ρ_i. Finally, α_i are bank fixed effects and δ_t are time fixed effects.

Table 4 presents the results. We investigate the link between sovereign and bank credit risk separately before and after the start of the PSPP government bond purchases in March 2015. Columns (1) and (2) cover the pre-PSPP period from 1 January 2014 to 8 March 2015 and Columns (3) and (4) the post-PSPP period from 9 March 2015 to 31 December 2017. For each period, we present the results with and without bank fixed effects and bank-specific coefficients on the CDS market and volatility index.

In the pre-PSPP period, we find a positive and statistically as well as economically significant relation between sovereign and bank credit risk. A 10% increase in the sovereign CDS price leads to 1.2% increase in the bank CDS price. This result is robust to including bank-specific controls and suggests there was a feedback loop between bank and sovereign credit risk before the introduction of the PSPP. The size of the effect is similar to the findings of Acharya, Drechsler, and Schnabl (2014) for European banks and sovereigns in the years after the global financial crisis.

In the post-PSPP period, the coefficient is still positive and statistically different from zero, but it has decreased by about 70%. A 10% increase in sovereign CDS prices only leads to $0.3 - 0.4\%$ increase in bank CDS prices. These results are in line with the view that the PSPP mitigates the feedback loop between sovereign and bank credit risk by lowering the government bond holdings of the banking

Table 4: Change in Bank and Sovereign Credit Risk

Table 4 shows the effect of sovereign credit risk on bank credit risk before and after the introduction of the Public Sector Purchase Programme (PSPP). The sample with daily frequency covers 58 banks with publicly traded credit default swaps (CDS) from 11 different euro area countries. Columns (1) and (2) cover the pre-QE period (1 January 2014 to 8 March 2015) and columns (3) and (4) cover the post-QE period (8 March 2015 to 31 December 2017). ΔLog(Bank CDS) is the daily change in the natural logarithm of bank CDS. ΔLog(Sovereign CDS) is the daily change in the sovereign CDS of the country in which the bank is headquartered. ΔLog(Foreign Exposure CDS) is the change in the sovereign CDS of other countries weighted by cross-country exposure. All columns include day fixed effects. Columns (2) and (4) additionally include bank fixed effects as well as interactions of bank fixed effects with the change in the CDS market index and the change in the volatility index. t-statistics are in parentheses and the stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Δ Log(Bank CDS)			
	Pre-QE		Post-QE	
	(1)	(2)	(3)	(4)
Δlog(Sovereign CDS)	0.118***	0.0798***	0.0359***	0.0271***
	(4.80)	(3.67)	(3.25)	(3.36)
Δlog(Foreign Exposure CDS)	0.0468	0.0304	-0.00116	-0.00856
	(1.66)	(1.45)	(-0.06)	(-0.45)
Time FE	Y	Y	Y	Y
Bank FE	N	Y	N	Y
Bank-level betas	N	Y	N	Y
Observations	17,516	17,516	42,702	42,702
Banks	58	58	58	58
R^2	0.152	0.194	0.156	0.209
Adjusted R^2	0.137	0.172	0.142	0.192

t statistics in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

sector.

Note, that also the coefficient on the foreign exposure measure decreases. It ranges between 0.03 and 0.05 in the pre-PSPP period and is on the cusp of being significant. In the post-PSPP period it is zero for all practical purposes. This suggests that the exposure to foreign credit risk, which emerged as a factor in the pricing of bank credit risk after the financial crisis (see, Acharya, Drechsler, and Schnabl, 2014), ceases to exist after the introduction of the PSPP. Hence, QE might not only mitigate the relation between sovereign and bank credit risk, but also between foreign sovereign and domestic bank credit risk. Recall, that we control for the joint variation of macroeconomic variables and for bank-specific exposure to aggregate volatility and the CDS market. Consequently, it is unlikely that these results are driven by market-wide shocks.

To provide additional evidence for the effect of the PSPP on the relation between sovereign and bank credit risk, we sort our sample of banks into two groups according to their changes in government bond holdings. Banks that reduce their portfolio of domestic government bonds most are labelled *Top* and the ones with the smallest reductions in domestic bond holdings are labelled *Bottom*. Due to data limitations, our sample of banks is reduced to 36, still coming from 11 different euro are countries. In line with our balance sheet model, we expect the relation between sovereign and bank credit risk to decrease more for banks that reduce their government bond holdings more.

Table 5 presents the results. We only present results including the full set of control variables. First, we examine the period before the start of government bond purchases. Columns (1) and (2) find similar coefficients for top as well as bottom banks in the pre-PSPP period. Additionally, these coefficients are similar to the coefficients from the total sample of banks presented in Table 4. This indicates that the exposure of banks to sovereign credit risk does not differ systematically between these two groups before the start of the PSPP.

Next, we analyze sovereign-bank feedback for top and bottom banks after the start of the PSPP. Columns (3) and (4) find that the relation between sovereign and bank credit risk weakens for both groups but particularly for banks that strongly reduce their government bond holdings. The coefficient for bottom banks falls by about 60% but remains positive and statistically significant. The point estimate of the coefficient for top banks falls by almost 90% and is statistically not different from zero anymore. Consequently, we find that a stronger reduction in government bond holdings coincides with a stronger mitigation of the sovereign-bank risk nexus.

5 Conclusion

We develop a simple balance sheet model that enables us to analyze the effect of QE on the composition of safe assets in the economy. We show that QE is not neutral to the allocation of safe assets across the banking and non-bank sector. In particular, our model suggests that banks increase their public safe asset holdings due to QE, while non-banks swap public for private safe assets. We call this the safe asset illusion.

Bringing our model to data from the ECB's Public Sector Purchase Programme, we find that about EUR 1.5 trillion in public safe assets are transferred from the non-banking to the banking sector. The non-bank sector receives an identical amount of private safe assets in return.

The change in the composition of safe assets due to QE has several important

Table 5: Change in Bank and Sovereign Credit Risk (top and bottom sellers of government bonds)

Table 5 shows the effect of sovereign credit risk on bank credit risk before and after the introduction of the Public Sector Purchase Programme (PSPP). The sample with daily frequency covers 36 banks with publicly traded credit default swaps (CDS) from 11 different euro area countries. We sort the banks according to their changes in government bond holdings and split the sample into the top and bottom 50%, where *Top* captures those banks that reduced their government bond holdings most. Columns (1) and (2) cover the pre-QE period (1 January 2014 to 8 March 2015) and columns (3) and (4) cover the post-QE period (9 March 2015 to 31 December 2017). ΔLog(Bank CDS) is the daily change in the natural logarithm of bank CDS. ΔLog(Sovereign CDS) is the daily change in the sovereign CDS of the country in which the bank is headquartered. ΔLog(Foreign Exposure CDS) is the change in the sovereign CDS of other countries weighted by cross-country exposure. All columns include day fixed effects. Columns (2) and (4) additionally include bank fixed effects as well as interactions of bank fixed effects with the change in the CDS market index and the change in the volatility index. t-statistics are in parentheses and the stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Δ Log(Bank CDS)			
	Pre-QE		Post-QE	
	Top (1)	Bottom (2)	Top (3)	Bottom (4)
Δlog(Sovereign CDS)	0.107***	0.0910**	0.0125	0.0341**
	(3.39)	(2.38)	(0.64)	(2.68)
Δlog(Foreign Exposure CDS)	0.0171	0.0164	-0.00174	-0.0335
	(0.38)	(0.75)	(-0.06)	(-1.35)
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
Bank-level betas	Y	Y	Y	Y
Observations	5,436	5,436	13,320	13,320
Banks	36	36	36	36
R^2	0.230	0.245	0.364	0.218
Adjusted R^2	0.176	0.192	0.324	0.168

t statistics in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

implications. First, the non-bank sector is exposed to additional risk because private safe assets do not have a similar level of safety as public safe assets. In particular, non-banks are more exposed to credit risk in the banking sector, which might lead to a negative feedback loop during banking crises. Second, non-banks are not only exposed to more risk, but it is also more costly for them to circumvent this risk and store liquidity safely. This safe storage premium arises because non-banks have no access to the risk-free deposit facility at the central bank. Third, even though it is less expensive for banks to store liquidity safely, it still comes at a cost, in particular when deposit facility rates at the central bank are negative such as in the Eurosystem. We show that banks cannot circumvent these cost because on aggregate the banking sector is forced to hold the reserves create by the central bank during QE. Lastly, we show that QE mitigates the sovereign-bank risk nexus and thereby potentially increases financial stability.

The main friction behind the safe asset illusion is the market segmentation originating from granting only the banking sector access to the central bank's balance sheet. This gives rise to two possible policy responses that can mitigate the adverse effects of QE on safe assets: First, central banks could extend the access to their balance sheets to a wider range of institutions. This would allow (parts of) the non-bank sector to profit from the same advantage as banks in safely and (relatively) cheaply storing liquidity. Second, the central banks could intensify their efforts to give back safe assets to the market via their securities lending programs. This would increase the effective supply of collateral in the repo market and therefore decrease the cost of safely storing liquidity for those institutions without access to the central bank.

The Fed has already implemented—at least to a certain extent—both of these policy recommendations. First, it grants a wider range of institutions access to its balance sheet than the ECB. Second, it channels assets back into the market via its overnight reverse repurchase facility. We leave it to future research to apply our framework to the US case in order to estimate the effects of QE on the reallocation of safe assets in the US economy.

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