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* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

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A comparative analysis of developments in central bank balance sheet composition*

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Abstract

In this paper we analyse developments in the composition of central bank balance sheets for a large set of central banks in a unified framework. Since 2007, central banks in advanced economies have experienced pronounced changes in balance sheet composition as a consequence of unconventional monetary policy measures. In addition, we document a convergence in balance sheet composition from 2007 until 2009, as the initial crisis response was fairly homogeneous across advanced economies, mostly driven by financial stability concerns. However, since 2009 design of balance sheet policies has been more diverse, reflecting diverging policy challenges across regions. By contrast, balance sheets of central banks in emerging market economies have remained broadly unchanged in terms of composition in the period under review.

Keywords: Central bank balance sheet, unconventional monetary policy, dissimilarity analysis.
JEL classification: E40, E42, E50, E58.

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1. Introduction

Since the onset of the global financial crisis, central banks have deployed a wide array of unconventional balance sheet policy measures, in addition to conventional interest rate cuts. With these balance sheet measures central banks aimed to either support financial stability, provide further monetary policy accommodation or limit potential adverse effects from international capital flows. As a consequence, central banks have experienced substantial changes in both the size and composition of their balance sheets (Borio and Disyatat, 2010).

As highlighted by Lautenschläger (2014), monetary policy measures, including balance sheet policies, have been adapted to the institutional conditions, economic specifics and financing structure which characterise an economy. As a consequence, the design in balance sheet policies has differed substantially across central banks. Taking stock of differences in the design of balance sheet policies is crucial for understanding their rationale and assessing their effectiveness, in particular when such policies have led to a significant substitution in terms of central bank assets and liabilities. In this respect, analysing developments in balance sheets across central banks can be an insightful exercise. Unfortunately, comparative analysis of central bank balance sheets often remains limited to a discussion of size metrics, such as developments in total assets or base money. Only a few comparative studies elaborate upon the compositional changes of central bank balance sheets as a consequence of recent unconventional policies. However, such discussions are often reduced to qualitative discussions of recent policy measures. This limits a comprehensive understanding of differences in the design of balance sheet policies across central banks.

The present paper contributes to the literature on central bank balance sheet policies by analysing developments in balance sheet composition across a broad panel of central banks in a unified framework. We introduce a taxonomy of central banks based on the relative distribution of assets and liabilities. This taxonomy allows us to compare the composition of balance sheets across central banks and over time. To our knowledge, this is the first attempt to analyse changes in overall central bank balance sheet configuration across a large cross-country dataset in a unified, quantitative framework. Our panel contains harmonized annual data on central bank balance sheet composition for 14 advanced economies and 20 EMEs from end-2001 until mid-2015. We assess quantitatively to what extent recent balance sheet policies can be considered unconventional relative to both own pre-crisis balance sheet configuration and those of peer central banks. Importantly, our breakdown of the central bank balance sheet follows a counterparty perspective, i.e. we analyse the extent to which central bank assets and liabilities are geared towards different macroeconomic sectors. Hence, our analysis abstracts from changes in the average duration of central bank assets and liabilities that have occurred as a consequence of unconventional monetary policy measures.

The results presented in this paper show that there is substantial heterogeneity in central bank balance sheet composition, in particular among advanced economies. However, from 2007 to 2009, central banks in advanced economies experienced a convergence in balance sheet composition. In this first phase of the crisis, when balance sheet policies were largely motivated by financial stability concerns, central banks simultaneously stepped up lending operations to the private sector (mostly banks). However, since 2009 the observed convergence has been reversed, reflecting diverging policy challenges across economic regions. Whereas some central banks engaged in large-scale purchase programmes of

domestic assets to increase monetary policy accommodation, others started accumulating large foreign exchange reserves to stem currency appreciation. Balance sheets of EME central banks have generally displayed a larger degree of homogeneity over the sample period. Interestingly, since the crisis, advanced economy central banks have become relatively more similar to their EME counterparts in terms of liability composition, largely as a consequence of increasing balance sheets. In this respect, EME central banks may already have valuable experiences in managing central bank liabilities that can also be helpful for advanced economy central banks in managing a large balance sheet. Finally, we show that central banks experiencing the strongest balance sheet expansion did not necessarily also saw the most pronounced change in balance sheet composition.

The remainder of this paper is structured as follows. Section 2 reviews recent literature on central bank balance sheets. Section 3 describes the methodology. Section 4 describes the data. Section 5 presents the results. Section 6 provides suggestions for future research and discusses policy challenges.

2. Literature on central bank balance sheet composition

Interest in the role of central bank balance sheets is typically low during tranquil times and high during financial crises (Caruana, 2012). Therefore, it is not surprising that the literature on central bank balance sheets has surged following the global financial crisis. However, discussions of central bank balance sheet policies are often hampered by inconsistent definitions as well as misunderstanding of differences in central banks' operational frameworks (Borio and Disyatat, 2010; Jobst and Ugolini, 2014). In particular, differences in the design of central bank assets and liabilities are often neglected or only discussed qualitatively.

In what follows we develop an indicator-based framework to systematically analyse the composition central bank balance sheets. The framework used in this paper is based on the framework that has been presented in Pattipeilohy (2013) and Pattipeilohy et al (2013). The former paper analyses historical developments in the balance sheet of De Nederlandsche Bank in the period 1900-1998, whereas the latter analyses balance sheet developments of major advanced economy central banks since the recent crisis. The current paper augments the methodology presented in the earlier papers by summarizing central bank balance sheet composition by four parameters as opposed to three parameters. Before presenting the methodological framework, this section revisits recent relevant literature.

2.1 Pre-crisis view

First, it is relevant to note that current research interest in central bank balance sheets contrasts considerably with the situation before the crisis. Before the crisis it was commonly understood within the central banking community that monetary policy implied controlling short-term interest rates as opposed to steering a concept of central bank reserves to control broad money growth (Bindseil, 2004). Balance sheet policies, ie day-to-day liquidity management to stabilize short-term interest rates, were not or only marginally related to macroeconomic developments.

Indeed, in many macroeconomic models, notably the standard New Keynesian framework as proposed by Eggertson and Woodford (2003), the composition of the central bank balance sheet, and hence open-market operations, is largely irrelevant

for monetary policy purposes. In these models the representative intertemporal optimizing agent will anticipate any change in public sector balance sheets (including the central bank balance sheet) to keep expected consumption unchanged, similar to Barro-Ricardian equivalence. The main channel through which monetary policy may impact output or inflation is by managing expectations on the future path of inflation and short-term interest rates. The composition of the central bank balance sheet is only considered to be relevant to the extent that it signals information on the central bank's reaction function.

2.2 Theoretical relevance

Recent unconventional balance sheet measures by central banks in advanced economies have reopened the theoretical debate on the irrelevance hypothesis of open-market operations. Many theoretical studies have done so by analysing under what conditions central bank balance sheet measures have an impact on private sector balance sheet invoking portfolio rebalancing effects.[1] Examples are Greenwood and Vayanos (2008) and Vayanos and Vila (2009).

While portfolio rebalancing could indeed be an important potential transmission channel of central bank balance sheet policies, the effects on the relative supply of government bonds are only one consequence of such policies. Indeed, as described by Borio and Disyatat (2010), balance sheet policies have often impacted central bank balance sheet configuration – and by definition also the balance sheets of central banks' counterparties – along more than this single dimension. Often, however, these other dimensions are not taken into account in theoretical models analysing unconventional monetary policy.

Cúrdia and Woodford (2011, henceforth CW) is one recent exception to present a comprehensive theoretical framework that does study the effects of innovations in central bank balance sheet composition along multiple dimensions. The authors extend a standard New Keynesian model in which the central bank may pursue balance sheet policies in addition to conventional interest-rate setting. These include both reserve-supply policies, ie steering the level of reserves supplied to the banking sector, and credit policy, ie changing the distribution of central bank private and public sector debt holdings. In terms of the typology of balance sheet policies provided by Borio and Disyatat (2010), the former refers to quantitative easing, whereas the latter refers to credit easing.

With respect to the effects of balance sheet policies, the CW model implies that reserve-supply policies have no benefits by themselves, unless combined with a specific commitment on the future level of the policy rate ('signalling effect').[2] However, it is argued that there could still be potential advantages from central bank credit policies, ie the central bank lending directly to the private sector. In normal times, ie when stochastic financial disturbances are small, it is argued a central bank should follow the 'treasury-only doctrine', meaning the central bank should not actively shift its asset composition.[3] However, in times of severe financial distress, ie when stochastic financial disturbances are large and persistent, the real

[1] Zampolli (2012) gives an overview of the theoretical discussion on portfolio rebalancing effects, linking the current debate to early work of Tobin and Friedman.

[2] The signalling-effect is further elaborated upon by Chen et al (2012) and Cúrdia and Ferrero (2013).

[3] The 'treasuries-only doctrine' should ensure that the central bank avoids taking on financial risks on its balance sheet which could ultimately endanger its independence (see eg Goodfriend, 2011).

cost of private sector financial intermediation may jump, depressing private sector financial intermediation and, as a consequence, output and inflation. Thus, central bank private sector lending, i.e. actively changing the composition of central bank assets, could smooth the impact of adverse financial shocks.

Clearly, however, there are caveats to the CW model to analyse balance sheet policies. Importantly, the model is essentially a closed-economy model, without an external sector and role for the exchange rate. Thus, the model does not analyse potential effects of central bank holdings of foreign assets. As we will explain in section 3, this is rather restrictive to conduct a meaningful comparative analysis across a large set of central banks. As the results presented in section 5 will show, the distribution between domestic and foreign assets is an important identifying parameter for the composition of a central bank's asset holdings for many central banks, in particular for many EME central banks.

2.3 Effectiveness of balance sheet policies

Few empirical papers explicitly assess the effects of changes in central bank balance sheet composition. Instead, many studies have aimed to empirically assess the relevance of portfolio rebalancing effects by analysing the effects of balance sheet policies on term and risk premia (see e.g. Gagnon et al (2011), Joyce et al (2011), Joyce and Tong (2012) and Bauer and Rudebusch (2014)). Other studies that do explicitly incorporate the central bank balance sheet look exclusively at size metrics. For example, Peersman (2011) finds unconventional policies are characterized by an increase in the monetary base or the total size of the Eurosystem's balance sheet, which have similar macroeconomic consequences as standard interest-rate policies. Gambacorta et al (2014) estimate a panel structural VAR for several advanced economies in which they also include total central bank assets as a gauge for unconventional monetary policies. Their approach does not control for heterogeneity in the design of balance sheet policies across different advanced economies. Still, based on individual country results, the authors infer that, despite heterogeneity in design, the impact of unconventional policies has been qualitatively similar across countries. However, there are to our knowledge no papers that formally assess the consequences of differences in design of balance sheet policies in terms of their effectiveness.

2.4 Central bank governance and finances

Another strand of literature relevant to the current paper discusses the central bank balance sheet from a corporate governance and financial risk management perspective. For example, BIS (2009) presents a comprehensive overview of issues in the corporate governance of central banks, which includes a study of the balance sheet from a sources and uses of funds approach. In a related analysis, Archer and Moser-Boehm (2013) investigate the optimal level of financial resources for central banks.[4] This literature considers the composition of the central bank balance sheet to be the result of both economic policy choices, which could refer to monetary, exchange-rate or financial stability policies, and structural factors. We will elaborate

[4] There is a related strand of literature that focusses explicitly on the role of central bank capitalisation, see eg Stella (1997 and 2008) and Buiter (2008).

further on how both policy and structural factors influence the central bank balance sheet in subsection 3.2.

3. Methodology

3.1 Stylised central bank balance sheet

As discussed above, comparative analysis of central bank balance sheet policies is often limited to a discussion of size measures. Many studies analyse the evolution of the total balance sheet size or base money. However, such size-indicators do not take into account that the design of balance sheet policies differed substantially across central banks, reflecting differences in the rationale for undertaking such policies. Therefore, in order to enhance understanding of balance sheet policies, this paper focuses explicitly on developments in the composition of central bank balance sheets, ie the overall relative distribution of assets and liabilities.

Simplified central bank balance sheet — Table 1

Assets		Liabilities	
Foreign exchange reserves	FX	Banknotes in circulation	Bn
Domestic private sector debt	L	Liabilities to banking sector	Rs
Domestic public sector debt	G	Liabilities to government	Rg

Our analytical framework departs from a simplified central bank balance sheet as shown in Table 1, reminiscent to what is used by Ho (2008), Filardo and Yetman (2012) and Cook and Yetman (2012) in their surveys on central banks' balance sheets in Asia. Central bank assets can be subdivided in holdings of foreign exchange reserves (FX) and domestic assets. The foreign exchange reserves encompass assets denominated in foreign currency, assets issued by foreign counterparties or both and will also include central bank holdings of precious commodities (eg gold). Domestic assets consist of domestic public sector debt (G) and domestic private sector debt (L), with the latter usually referring to loans to or debt securities issued by banks and other financial intermediaries (the former may take the form of collateralized lending or repurchase agreements).

With respect to central bank liabilities, typically the distinction is made between base money, ie banknotes in circulation (Bn) and reserve balances from commercial banks, and non-monetary liabilities. While theoretically appealing, the definition of what is included in base money in addition to banknotes differs considerably across central banks, making it a less suitable concept to study differences in balance sheet composition for larger cross-sectional datasets. For example, most central banks that issue debt certificates do so to sterilize the effects of asset purchases on the formal definition of base money. However, Bank of Indonesia considers its debt instruments as secondary reserves and does include them in the formal definition of base money.[5] A similar problem occurs when considering how to classify term deposits issued by central banks. Despite the fact that substitutability between central bank current accounts and term deposits can be quite high, the former are

[5] http://www.bi.go.id/NR/rdonlyres/60BD54F8-7596-496D-A34E-32A7737EA5CB/22934/Metadata_Uang_Primer_English_9.docx

usually included in base money, while the latter are not. Borio and Disyatat (2010) argue that the effectiveness of balance sheet measures is not so much affected by whether they rely on base money per se, due to high substitutability with other central bank liabilities. This suggests that what is included in base money in practice is largely a matter of semantics with different outcomes across times and regions.

To sidestep the practical inconveniences associated with the conventional theoretical differentiation between monetary and non-monetary liabilities we take a different approach and classify non-banknote central bank liabilities by counterparty; ie liabilities to banks (Rs, which also includes term deposits and debt certificates) and liabilities to the government (Rg). In this respect our approach is very similar to that of Archer and Moser-Boehm (2013) who also take a counterparty approach to classify central bank liabilities. Note that, even though we take a counterparty approach on central bank liabilities in the current paper, the distinction between monetary- and non-monetary liabilities may gain in relevance in future monetary policy frameworks.[6]

3.2 Balance sheet indicators

The aim of this paper is to analyse the overall composition of central bank balance sheets, ie the relative distribution of central bank assets and liabilities. To do so, we compute a set of four balance sheet indicators – two for the asset side and two for the liability side - that jointly summarize central bank balance sheet configuration.

On the asset side we consider the relative distribution between domestic and foreign assets, by computing (G+L)/FX using the definitions in Table 1. In addition, we document whether a central bank's domestic asset portfolio is geared more heavily towards domestic government debt or domestic private sector debt by computing G/L. Similar indicators can be constructed for the composition of central bank liabilities. First, we will analyse developments in the relative distribution between total non-banknote liabilities and banknotes in circulation, or (Rg+Rs)/Bn. In addition, we consider whether a central bank's deposit liabilities are geared more towards the banking sector or the domestic government, by computing Rg/Rs.

The application of the set of balance sheet indicators as described above is useful, as it allows us to summarize information on balance sheet composition using only a limited number of parameters. This will be helpful in formulating a taxonomy of central banks based on balance sheet configuration (subsection 3.3). Moreover, using balance sheet ratios, we will be able to quantitatively assess relative changes in balance sheet composition through time, as well as relative differences between central banks (subsection 3.4).

The four indicators are constructed in such a way that *ex ante* they are independent and uncorrelated. In other words, in principle, an unconstrained central bank can decide on the size of any of the four indicators irrespective of the impact on the other three. In geometrical terms, an unconstrained central bank will be able to position itself anywhere in the four-dimensional [G/L – (G+L)/FX – Rg/Rs – (Rg+Rs)/Bn]-plane. This may be illustrated by an example (inspired by Pattipeilohy, 2013, p14). Consider the situation in which the central bank would want to increase

[6] See eg Blinder (2010), who notes that the Federal Reserve may consider issuing term deposits or certificates of deposit that are not counted as 'official reserves', ie base money. Gagnon and Sack (2014) suggest a post-crisis operating framework for the Federal Reserve in which it would offer overnight reverse repurchase agreements as its main policy instrument.

its public debt holdings by buying governments bonds from the banking sector. *Ceteris paribus*, all four indicators will be affected by this transaction, as G enters in both asset-side indicators, while Rs enters in both liability-side indicators. However, should the central bank be willing to increase only G/L it may neutralize (or sterilize) the impact on the other indicators by simultaneously cutting back lending to banks by the same amount as government bond purchases. This will increase the original positive effect on G/L, while it will restore the increase in the other indicators. So by simultaneously increasing G and decreasing L, an unconstrained central bank can choose any value for G/L while keeping all indicators equal.

However, in practice a central bank will not be fully unconstrained. Therefore, it may not be able (or willing) to decide on the size of every single balance sheet indicator autonomously. Instead, it will consider many developments as exogenous shocks and adjust its balance sheet endogenously. As noted in subsection 2.4, typically a distinction is made between structural and policy-related factors that may affect central bank balance sheet composition (BIS, 2009). As part of the former we consider behavioural, operational and institutional factors. These factors are often denoted as autonomous liquidity factors, see eg Ho (2008) or ECB (2011).

An example of behavioural factors impacting the central bank balance sheet refers to the supply of banknotes. Typically, a central bank takes demand for banknotes as given and ensures it is fully accommodated. This means that the supply of banknotes is not a monetary policy instrument on which autonomous decisions would be made. Therefore, assuming no other constraints, a central bank may only be able to steer the indicator (Rg+Rs)/Bn by steering the size of the numerator, ie the amount of deposits held by the government and by banks.

From an operational perspective the role of the central bank in the context of payment systems is an important factor affecting its balance sheet. Banks' deposits at the central bank play a crucial role in settling large value interbank payments on a day-by-day basis (CPSS, 2003), which means interbank payments can lead to large intraday fluctuations within the central bank balance sheet. Moreover, the design of payment and settlement systems also affects central bank balance sheet composition. As noted in BIS (2009), operating a real-time gross settlement system would typically require more intraday liquidity than a system of end-of-day netting. Jobst and Ugolini (2014) argue that there is a reciprocal interdependency between the structure of money markets and monetary policy design. Thus, the functioning of money markets – and thus the level of Rs – depends on central bank operating frameworks, while, at the same time, central banks may adjust their instruments to the structure of the money market to ensure the efficacy of its policies.

Furthermore, in many countries the government holds its main account with the central bank (BIS, 2009). In this case, the composition of central bank liabilities will depend on incoming and outgoing payments from the government. In the case of the Eurosystem, it is found that general government deposits at the level of the national central banks are relatively volatile in some member states, leading to high forecast errors in the context of its liquidity analysis.[7] By contrast, at the Bank of Canada (the BoC) government deposits are not dealt with as autonomous liquidity factors. Instead, the BoC actively manages the level of government deposits to steer banks' liquidity position vis-à-vis the central bank (Engert et al, 2008).

[7] See http://www.ecb.europa.eu/mopo/liq/html/treas.en.html.

The exchange rate regime applicable represents an important institutional determinant for central bank balance sheet composition. Take for example the well-known impossible trinity in international macroeconomics, which implies that in a regime of fixed exchange rates with free capital flows independent monetary policy is no longer feasible (Obstfeld and Taylor, 1998). Instead, domestic monetary policy becomes endogenous to the monetary policy of the (implicit) anchor currency within the exchange rate arrangement, both in terms of (conventional) interest rate setting and in terms of balance sheet policies. With respect to the latter, the central bank may have to intervene in foreign exchange markets at specific predetermined levels of the exchange rate, rendering the balance sheet endogenous to capital flows. Large reserve accumulation by many EMEs has largely been driven by these considerations (Obstfeld et al, 2010). An example among advanced economies is the Swiss National Bank that set a unilateral cap for the exchange rate of the Swiss franc versus the euro from September 2011 until January 2015 and communicated its preparedness to defend the cap by buying foreign exchange in unlimited amounts.

In addition to the above mentioned structural factors, decisions related to monetary policy or financial stability interventions will also impact the central bank balance sheet (BIS, 2009). For example, on the asset side, monetary policy operations may involve the purchase of either domestic or foreign currency assets or entering into repo agreements with banks. In terms of liabilities the central bank can manage commercial banks' reserve positions by setting reserve requirements or by issuing longer-term liabilities including term deposits or central bank bills. Specific policy decisions can also render the central bank balance sheet endogenous to external factors.[8] For example, the ECB's policy of fixed rate full allotment in its refinancing operations implies that the supply of reserves is endogenous to banks' demand for (excess) liquidity. Financial stability interventions typically refer to short-term emergency lending facilities for private sector counterparties, even though financial stability concerns may also alter central bank balance sheet composition more persistently, as observed during the recent financial crisis.

From the above it should be clear that overall central bank balance sheet configuration is not something that monetary policy makers decide upon on a day-by-day basis. However, it is in the end a policy decision which balance sheet items the central bank is willing to adjust endogenously and which items it wants to steer actively in the conduct of monetary policy. The outcome may differ across different central banks and is likely to be time-variant. It may depend, among other factors, on monetary policy regime, the central bank's mandate, structure of the financial system and financial market conditions. In the remainder of this paper, we will let the data speak. We analyse recent developments in central bank balance sheets and try to expose common characteristics therein. Abovementioned considerations should be kept in mind, however, as they imply that observed changes in balance sheets may not necessarily be induced by an explicit policy decision.

3.3 An indicator-based taxonomy

The set of indicators described above can be used to classify central banks by the composition of central bank assets and liabilities. The rules underlying our classification scheme are summarised in Table 2. Depending on asset composition a central bank may be classified as *foreign exchange holder*, *treasuries holder* or

[8] This is closely linked to institutional determinants mentioned in the previous paragraph.

private sector lender. In addition, based on the composition of central bank liabilities a central bank may be classified as *note issuer*, *government's banker* or *bankers' banker*. It should be noted that these definitions are for illustrative purposes only and will be determined by actual observations of balance sheet composition. Moreover, the classification scheme should be interpreted with some caution. The classification rules assume discrete thresholds to differentiate between types. In fact, all balance sheet indicators can take on a continuum of values, implying central banks will exhibit characteristics of a specific type to a higher or lesser degree.

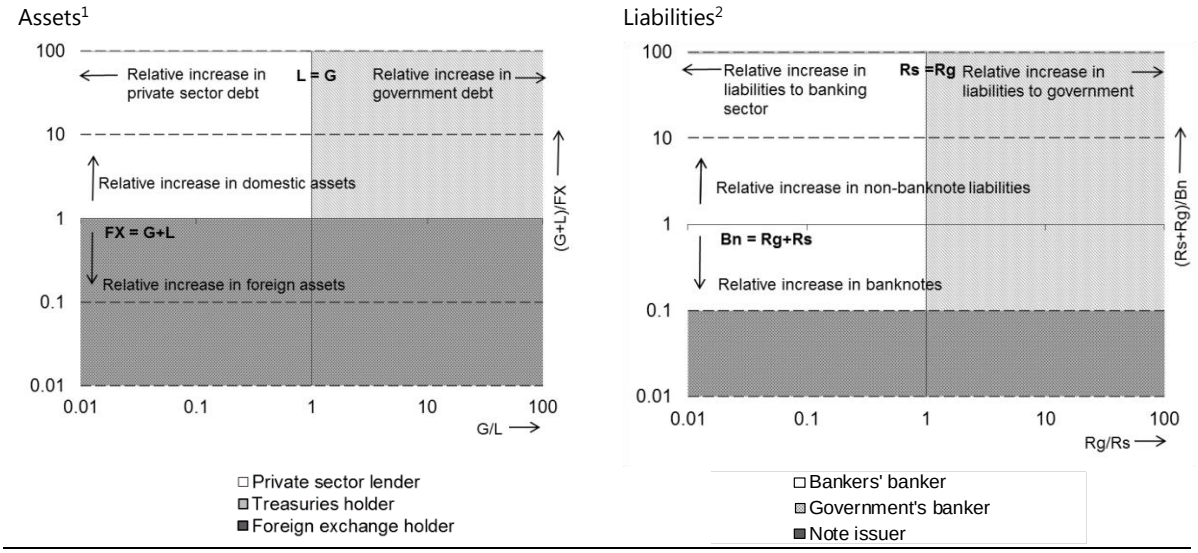
A taxonomy of central bank balance sheets

Overview of classification scheme — Table 2

Category	Classification rule	Explanation
Assets:		
Foreign exchange holder	FX > (G+L)	More than half of central bank assets are foreign exchange reserves
Treasuries holder	(G+L) > FX and G > L	More than half of central bank assets are domestic assets. Of domestic assets more than half has domestic government as counterparty/issuer
Private sector lender	(G+L) > FX and L > G	More than half of central bank assets are domestic assets. Of domestic assets more than half has domestic private sector as counterparty/issuer
Liabilities:		
Note issuer	Bn > 10(Rg+Rs)	Total deposits at central bank are less than 10% of banknotes in circulation
Government's banker	Bn < 10(Rg+Rs) and Rg > Rs	Total deposits at central bank are more than 10% of banknotes in circulation. Of total deposits, more than half is associated with domestic government.
Bankers' banker	Bn < 10(Rg+Rs) and Rs > Rg	Total deposits at central bank are more than 10% of banknotes in circulation. Of total deposits, more than half is associated with domestic banking sector.

The rules underlying our classification scheme can be transposed graphically to Figure 1. The left-hand panel in Figure 1 shows the two dimensions along the asset-side indicators, while the right-hand panel shows the two dimensions along the liability-side indicators. In the left-hand panel a shift along the horizontal axis refers to a change in the distribution between government debt holdings and private sector debt holdings (G/L). By contrast, a shift along the vertical axis refers to a change in the distribution between total domestic assets and foreign assets (G+L/FX). In the right-hand panel a shift along the horizontal axis implies a change in the distribution between liabilities to the government and liabilities to the banking sector (Rg/Rs), whereas a shift along the vertical axis refers to a change in the distribution between non-banknote liabilities and banknotes in circulation (Rg+Rs)/Bn). The scales in Figure 1 are denoted in logarithms, as to ensure that a change in any variable by a factor x will lead to a shift in the graphs with a similar (Euclidian log) distance, irrespective of the starting value of the respective indicator. This will be useful when we compute quantitative measures for changes in balance sheet composition and cross-sectional dissimilarity. The box on pages 11 and 12 describes conceptually how a policy of quantitative easing would impact central bank balance sheet configuration within the context of Figure 1.

Taxonomy of central bank balance sheets Figure 1



Note: Logarithmic scales.

[1]L = domestic private sector debt; G = domestic public sector debt; FX = Net foreign exchange reserves. [2]Rs = bank reserves; Rg = government deposits; Bn = banknotes in circulation.

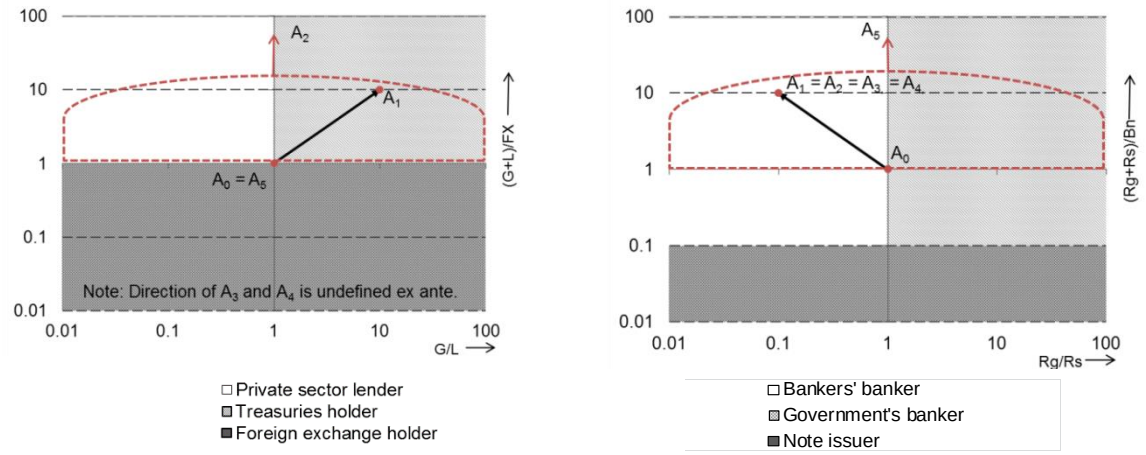
Box: Quantitative easing and central bank balance sheet composition

Within the context of Figure 1 we are able to track how balance sheet policies impact central bank balance sheet composition. For illustrative purposes, this box analyses the impact of quantitative easing. Different definitions have been put forward in the literature on what such a policy could encompass. Borio and Disyatat (2010) discuss four: (1) a targeted increase in bank reserves by the purchase of government bonds (Ugai, 2006); (2) the purchase of either public or private sector bonds by using high-powered money (or bank reserves) (Benford et al, 2009); (3) a reduction in long-term interest rates through an increase in bank reserves (Spiegel, 2001); or (4) any increase in bank reserves irrespective of whether it is explicitly targeted or not (Auerbach and Gale, 2009; Krugman, 2009). Lenza et al (2010) present yet another definition that views quantitative easing as (5) any expansion of the central bank balance sheet which does not alter the composition of central bank assets. This contrasts with qualitative or credit easing that does alter the central bank asset composition, while leaving the size of the balance sheet unchanged. Definition (5) also matches best the definitions for reserve-supply policy and credit policy in the CW-model discussed in section 2.4.

Clearly, different interpretations of quantitative easing would imply different consequences for the central bank balance sheet. This is illustrated in Figure 2 in which a central bank with a starting balance sheet configuration denoted by A_0 would move to balance sheet configuration A_i by engaging in quantitative easing according to definition i. The right-hand panel shows that with respect to the impact on central bank liabilities definitions (1) to (4) are consistent as they all refer to an increase of bank reserves (*ceteris paribus* a northwestern shift in the liability-plane). However, in terms of the impact on central bank assets the different definitions would have differing implications. For instance, definition (1) explicitly refers to the purchase of government bonds, which would imply a northeastern shift in the asset-plane. However, according to definition (2) either public or private sector debt may be bought under quantitative easing, which would imply a northern shift but would leave unclear *ex ante* whether a move along the horizontal axis would also take place (region A_2 defined by the red dashed area). Definitions (3) and (4) both leave unclear what should be the counterpart to the increase in bank reserves, leaving the direction of A_3 and A_4 in the asset-plane *ex ante* undefined. Finally, definition (5) by Lenza et al (2010) implies a different effect on both asset- and liability-side compared to the other definitions. On the asset-side, definition (5) implies unchanged composition of assets ($A_0 = A_5$). Assuming banknotes in circulation are fixed, on the liability side an increase in total balance sheet size can be accommodated by any combination of an increase in bank reserves and government deposits; a northern shift in the liability-plane, leaving unclear *ex ante* what movement would occur along the horizontal axis (region A_5 defined by the red dashed area).

Quantitative easing and central bank balance sheet composition Figure 2

Assets[1] Liabilities[2]



Definitions for quantitative easing (following Borio and Disyatat (2010) and Lenza et al (2010)):

A_0: Starting balance sheet configuration.

A_1: Ugai (2006): Targeted increase in bank reserves by buying government bonds.

A_2: Benford et al (2009): The purchase of either public or private sector bonds by using high-powered money.

A_3: Spiegel (2001): A reduction in long-term interest rates through an increase in bank reserves.

A_4: Auerbach and Gale (2009)/Krugman (2009): Any increase in bank reserves irrespective of whether it is targeted or not.

A_5: Lenza et al (2010): Any expansion in of the central bank balance sheet which does not alter the composition of the asset side of the balance sheet.

Note: Logarithmic scales. All scenarios under assumption of *ceteris paribus*.

[1] L = domestic private sector debt; G = domestic public sector debt; FX = Net foreign exchange reserves. [2] Rs = bank reserves; Rg = government deposits; Bn = banknotes in circulation.

The exposition above underlines the importance of clear definitions when analysing different policies by central banks. Similar concepts may actually have quite different consequences in terms of central bank balance sheet composition, as well as their market impact. However, in the current paper we will not restrict ourselves to a single definition for quantitative easing. Instead we follow definitions by respective central banks in discussing recent policy innovations. This implies that, for example, quantitative easing in the UK may have a different impact on central bank balance sheet composition than quantitative easing in the US. In fact, we will show how different rounds of quantitative easing in the US have impacted central bank balance sheet configuration differently.

3.4 Dissimilarity analysis

The use of a set of balance sheet indicators allows us to compute quantitative measures for (dis)similarity in balance sheet composition. In fact, the combined distance between two balance sheet configurations from both panels of Figure 1 can be used for this purpose. In mathematical terms, we can calculate the logarithmic Euclidian distance between two coordinates in the [G/L – (G+L)/FX – Rg/Rs – (Rg+Rs)/Bn]-plane, ie the length of a vector between two states, as a quantitative measure for (dis)similarity (through time or cross-section). In this paper we will consider two fairly simple and intuitive measures of this type.

First, we will analyse changes in balance sheet composition through time, by calculating the length of the vector between balance sheet configurations in 2006 and mid-2015 for the central banks included in our sample. The distance between a central bank's mid-2015 balance sheet configuration and the one observed in 2006 can be interpreted as a measure of 'activeness' in terms of balance sheet policies

undertaken by a central bank. In other words, the central banks that have covered the largest distance between 2006 and mid-2015 have seen the most pronounced change in balance sheet composition. It should be noted that 'activeness' is approximated here by measuring absolute change in balance sheet composition. Hence, this measure does not tell us anything about the direction of the change in balance sheet composition, nor whether this should be interpreted as an easing or tightening of monetary policy.[9] We will elaborate further on this in subsection 5.3.

Second, we analyse aggregate cross-country dissimilarity, ie to what extent does a set of central banks in our dataset display a degree of similarity or dissimilarity in terms of balance sheet composition. We will calculate an aggregate dissimilarity measure by taking the average of all elements in the dissimilarity matrix D_t, with element $a_{ij,t}$ referring to the bilateral distance in the [G/L – (G+L)/FX – Rg/Rs – (Rg+Rs)/Bn]-plane between country i and country j at time t. By computing this measure for each year in the sample we can analyse whether central bank balance sheet composition is converging or diverging over time.

3.5 Caveats

There are some caveats to the application of our methodology. First, for the purpose of increasing comparability, the framework depends on a highly simplified central bank balance sheet. Needless to say, simplifying assumptions entail a loss of information on balance sheet composition, which could imply important identifying characteristics are lost. Actual changes in balance sheet composition could therefore be more pronounced than suggested in this analysis. For example, we do not discuss the maturity of central bank assets, which can differ quite substantially across different central banks and through time. Indeed, one element of the ECB's non-standard measures was an extension of the maturity of its bank lending operations from a maximum of three months in 2007 to a maximum of three years by end-2010 (Coeuré, 2013). In a similar fashion, in 2011 the Federal Reserve has also aimed to increase the average maturity of its Treasury bond holdings by selling short-term bonds and buying longer-term bonds for a similar amount (commonly referred to as 'Operation Twist'; Meaning and Zhu, 2012). These changes in average duration of central bank asset holdings will not be accounted for in this paper and could have effects that are empirically non-trivial (Chadha et al, 2013).

Problems related to oversimplification may also arise with respect to central banks' liability composition, eg by combining all non-monetary liabilities not related to domestic government as liabilities to the banking sector. We have argued that this treatment was warranted for the purpose of our paper as substitutability between these different types of liabilities tends to be high (as noted by Borio and Disyatat, 2010). Nevertheless, by doing so, we may understate actual dissimilarity in central bank liabilities. This may be the case in particular for EME central banks, for which Filardo and Yetman (2012) document a high degree of heterogeneity in these types of central bank liabilities. Moreover, we do not control for differences in the average maturity of central bank liabilities. These seem to have become more relevant for central banks with large balance sheets that aim to sterilize the effects of large asset holdings on base money by issuing longer-term liabilities.

[9] Lombardi and Zhu (2014) present a strategy how to assess the stance of monetary policy in the US in context of the zero-lower bound and balance sheet policies.

Unfortunately, not all countries in our sample report all relevant data in the IFS database. This means we have to complement the IFS data with information from national sources for New Zealand, Norway, Switzerland, the United Kingdom and the euro area. Note that for the euro area we will analyse the consolidated balance sheet of the Eurosystem, net of intra-Eurosystem positions. We do not include information on the balance sheets of individual national central banks within the Eurosystem as these central banks are jointly responsible for the implementation of the ECB's single monetary policy.[10] Similar to Gambacorta et al (2014) we exclude assets and liabilities related to the government pension fund for the Norwegian central bank to focus on the part of the balance sheet relevant for monetary policy purposes. For an overview of the construction of the data that could not be gathered along the lines of Table 2 the reader is directed to the appendix.

Furthermore, the counterparty perspective as utilized in this paper may not necessarily represent the most appropriate way to study the central bank balance sheet from a macroeconomic perspective. For example, it could be argued that outright purchases of government bonds are economically very similar to lending operations to banks, as the latter are typically collateralized by government bonds and could in principle be rolled-over over the full maturity of the underlying bond. Expanding on this argument, one could argue that differences and changes in central bank collateral frameworks should also be taken into account when analysing central bank balance sheets and balance sheet policies. Indeed, as noted by Cheun et al (2009), differences in collateral frameworks between central banks were relatively large before the crisis and many changes have occurred since.[11] Moreover, making the distinction between public and private sector debt may not always be as clear cut. For example, the Federal Reserve's purchases of MBS by issued agencies under government conservatorship could be considered very similar to purchases of treasuries, at least from a financial risk perspective.[12]

The caveats discussed above are non-trivial and they imply that our methodology may disregard relevant characteristics of recent balance sheet policies. Unfortunately, these caveats are difficult to circumvent, in particular when the aim is to conduct a comparative analysis across a large cross-section of central banks. The reason is largely related to a lack of harmonised data on central bank balance sheets. Central banks' own reporting practices differ substantially and are largely dependent on monetary policy frameworks and country-specific guidelines. Therefore, these national data sources are less suited for cross-country analyses. Instead, we will rely on data from the IMF International Financial Statistics that are less granular, but can easily be transposed to our methodology (section 4). Despite the limitations discussed, our application uncovers interesting insights on central bank balance sheets, beyond what can be learnt from looking only at size-metrics.

[10] Note that it would also not be clear how to classify intra-Eurosystem assets and liabilities, which have increased dramatically in recent years, see eg Cecchetti et al (2012).

[11] See also BIS (2013) and ECB (2013) for comparative studies of central bank collateral frameworks.

[12] Thanks are due to Morten Bech (Bank of International Settlements) for pointing this out.

4. Data

We have constructed a unique dataset including annual data on balance sheet composition from 2001 until 2015 for 34 central banks. We use end-of-year data, except for the observation for 2015 which refers to June 2015 due to data availability. The panel includes 14 central banks from advanced economies and 20 from EMEs. The distinction between advanced and emerging market economies is based on current IMF definitions.[13] To apply the methodology described in the previous section we use data from different resources. Most countries report standardized data on the central bank's balance sheet in the central bank survey of the IMF's International Financial Statistics that is easily transposed to Table 1 (see Table 2).

Data construction for countries reporting in standardized IFS representation Table 2

Assets		Liabilities	
FX	Claims on non-residents	Bn	Currency in circulation
L	Claims on other depository corporations	Rs	Liabilities to other depository corporations
	Claims on other financial corporations		Liabilities to other sectors
	Claims on private sector		Liabilities to other depository corporations not included in monetary base
	Claims on other sectors		Deposits and securities other than shares excluded from monetary base
G	Claims on central government	Rg	Liabilities to central government
	Claims on state and local government		
	Claims on public non-financial corporations		

Note: Countries included in our sample that report in the standardized format are Algeria, Argentina, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Czech Republic, Denmark, Hungary, Iceland, India, Indonesia, Japan, Korea, Malaysia, Mexico, Philippines, Poland, Romania, Russia, South Africa, Sweden, Thailand, Turkey and United States.

It is important to note that not all central banks included in our sample have non-zero positions for all asset and liability classes identified in Tables 1 and 2. Therefore, the balance sheet indicators we calculate may take on a value of zero or $+\infty$. Because these values are not defined in the logarithmic Euclidian plane that is the workhorse for our analysis, we may run into difficulties in terms of interpretation. When applying the graphical representation, we can be pragmatic and minimize values at 0.01 (including zero observations) and maximize values at 100 (including $+\infty$ observations), without this having any impact on the classification outcomes, while keeping the graphs tractable. Clearly, however, this approach does not work when we compute quantitative measures for dissimilarity as the calculated distances would underestimate actual change or dissimilarity. Unfortunately, there is no clear alternative to overcome this problem, except for dropping the countries with any zero or $+\infty$ observations from the computations. Excluded observations will be explicitly mentioned when presenting the results.

[13] The advanced economies are Australia, Canada, Czech Republic, Denmark, Iceland, Japan, Korea, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States. The EMEs included are Algeria, Argentina, Brazil, Bulgaria, Chile, China, Colombia, Croatia, Hungary, India, Indonesia, Malaysia, Mexico, Philippines, Poland, Romania, Russia, South Africa, Thailand, and Turkey.

5. Results

In this section, we present a comparative analysis, applying the methodology described in section 3. First, we present a time-series analysis of recent developments in balance sheet composition for the Federal Reserve, the Bank of England and the Eurosystem (subsection 5.1). For pinpointing the timing of policy measures we rely heavily on Fawley and Neely (2013). Next, we analyse cross-sectional differences in balance sheet composition for the full sample both before and after the crisis (subsection 5.2). In addition, we quantify which central banks have experienced the most pronounced change in balance sheet composition since end-2006 (subsection 5.3). We conclude with a discussion of developments in aggregate dissimilarity in central bank balance sheet configuration (subsection 5.4).

5.1 Time-series analysis of central bank balance sheet composition

The top panels in Figure 3 show developments in the Federal Reserve's balance sheet since 2001. In 2001 the Federal Reserve starts out as a *treasuries holder* in terms of asset composition and a *note issuer* in terms of liability composition. This reflects the fact that the asset-side of its balance sheet is dominated by its system open market portfolio of government bonds, while the liability-side consisted mostly of banknotes in circulation. The graph shows that the composition of the Fed's balance sheet composition was fairly stable from 2001 until 2006.

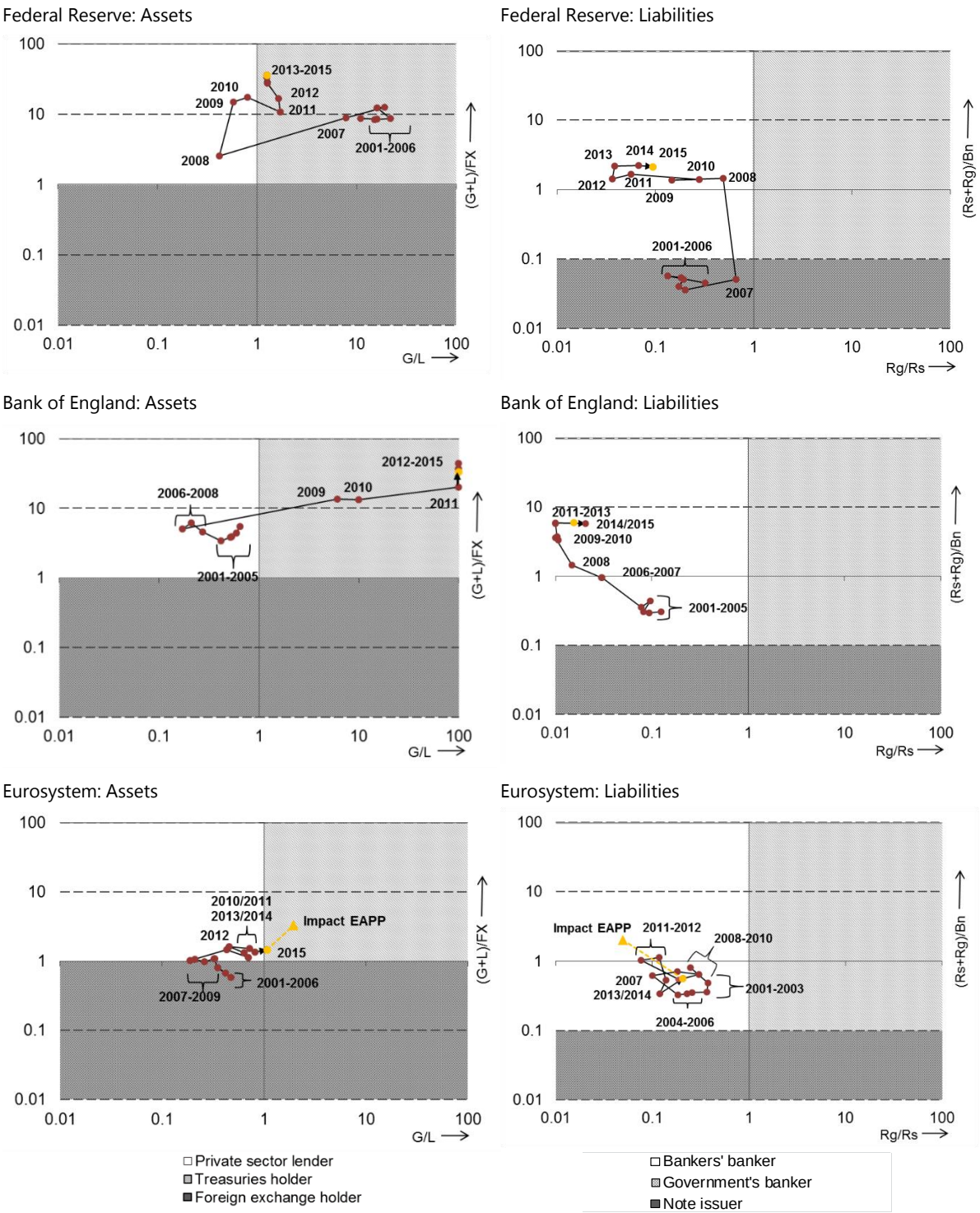
As the financial crisis unfolded from 2007 onwards, some significant changes in balance sheet composition occurred. In terms of asset composition the Fed switched to being a *private sector lender* from 2008 until 2010. At first, this reflected an increase in lending operations to banks, as the Fed deployed a Term Auction Facility to counter liquidity pressures in the interbank market by end-2007 (see for example Taylor and Williams, 2009). As of late 2008, the Fed introduced a purchasing programme for mortgage backed securities to support mortgage lending in an effort to stimulate the economy (QE1), contributing to the observed shift in asset composition.[14] In conjunction with the observed changes in asset composition, bank reserves increased exponentially relative to banknotes, implying a reclassification to *bankers' banker* in terms of liability structure.

The next major change in the Fed's balance sheet can be observed in 2011, as it started a large-scale purchasing programme for treasuries (QE2). In terms of asset composition this development led to a reclassification back to a *treasuries holder*. Moreover, bank reserves increased further, even though the relative increase was much less pronounced than what was observed during earlier stages of the crisis, as the increase occurred from a higher base. The third round of quantitative easing (QE3) was announced in September 2012 and involved large scale purchasing of both MBS and treasuries. As the distribution of MBS and treasury purchases under QE3 is relatively similar to the distribution of domestic asset holdings by end-2011, the impact of QE3 on asset composition has been relatively muted, compared to earlier rounds of quantitative easing. The same holds for the impact of QE3 on the

[14] In the panel displaying the Fed's composition of assets a southward shift can also be observed during 2008. This reflects the Federal Reserve's claims on other central banks related to drawings on US dollar swap lines, instituted to counter strains in foreign exchange markets in late 2008 (Ho and Michaud, 2008; Allen and Moessner, 2010). The utilization of these foreign exchange swap lines decreased from 2009 onwards as can be observed from the northward shift in the graph.

distribution of liabilities, as the relative increase in bank reserves over 2012/13 occurred from a much higher base level compared to that in 2007/08. As of 2013 the balance sheet configuration of the Fed has remained relatively unchanged.

Developments in balance sheet composition of major central banks — Figure 3



Note: Logarithmic scales. Values smaller than 0.01 and larger than 100 have been set at 0.01 and 100 respectively. Observation for – mid-2015 marked in gold. For the Eurosystem the projected impact of the EAPP is marked by a triangle. This assumes a monthly amounts of purchases of EUR 60 billion until March 2016 and EUR 80 billion until March 2017 of which 80% concerns the purchase of government bonds and 20% asset-backed securities, covered bonds and corporate bonds. These purchases are financed exclusively by an increase in bank reserves. All other balance sheet items are assumed unchanged from their mid-2015 level.

Source: IMF International Financial Statistics, national sources and author's own calculations.

In contrast to the Fed, the Bank of England already had relatively large private sector debt holdings before the crisis (Figure 3, centre row panels). Moreover, the proportion of private sector debt holdings was already increasing well before the crisis hit. Specifically, a noticeable shift can be observed in 2006. This shift refers to a Bank of England initiated reform in the UK money market to reduce money market rate volatility (Bank of England, 2005). The reform introduced a system of voluntary reserves that were remunerated at the Bank rate, whereas before 2006 bank reserves were unremunerated. The level of remunerated reserves UK banks were willing to hold voluntarily was much higher than the level of unremunerated reserves under the previous arrangement, which explains the observed north-western shift in terms of liability composition. The higher levels of desired reserves also implied that the dependence of UK banks on central bank refinancing increased, which further expanded the Bank of England's role as a *private sector lender*. Since the financial crisis, several additional significant changes in the Bank of England's balance sheet configuration can be observed. First, the Bank of England has steadfast increased the level of reserves supplied to commercial banks, as is clear from the continued north-western shift in the right-hand panel. In 2008 the increase in reserves did not yet coincide with a significant change in asset composition, as the Bank of England relied mainly on instruments it already had at its disposal following the 2006 money market reform (see also Appendix Figure A2). However, the asset composition of the Bank of England did change dramatically from 2009 onwards, as it engaged in large-scale purchases of gilts in the context of its quantitative easing programme. These large-scale gilt purchases implied a reclassification of the Bank of England to a *treasuries holder*. The north-eastern shift is exacerbated by the fact that commercial banks gradually started repaying almost all regularly outstanding liquidity providing operations, as they were flooded with reserves by the Bank of England's continued gilt purchases. As of late-2011 the Bank of England's assets consist almost exclusively of domestic government bonds.

The two bottom panels in Figure 3 show developments in the balance sheet configuration of the Eurosystem. The Eurosystem is the only one of the three central banks considered in this subsection being an *FX-holder* before the crisis, ie having more foreign than domestic asset holdings. As noted by Nagel (2012), this reflects to a large extent relics from before the launch of monetary union, when many of the national central banks had managed the exchange rate and, in that capacity, had accumulated large amounts of foreign exchange reserves. In terms of liability composition, the Eurosystem already operated as a *bankers' banker* before the crisis, similar to the Bank of England. Nagel (2012) notes that in this respect the Eurosystem pre-crisis balance sheet may be considered having been less 'lean' or 'streamlined' than the balance sheet of the Fed.[15]

Turning to developments in the Eurosystem's balance sheet since 2007 it is noteworthy that the density of the observations in the graphs is much higher than what we have observed for the Fed and the Bank of England. In other words, the relative changes in the Eurosystem´s balance sheet have been less pronounced as has been the case for the Fed and the Bank of England, at least following the methodology applied in this paper.

Still, several developments can be observed in terms of asset composition. First, in 2007/08 the Eurosystem increased its supply of liquidity to banks. By end-2007

[15] According to Nagel (2012), a central bank balance sheet can be considered lean "*if banknotes in circulation make up the majority of the balance sheet total, provided that the minimum reserve requirement is correspondingly low*".

this concerned liquidity operations with a very short maturity to accommodate potential end-of-year liquidity tensions.[16] Following the collapse of Lehman Brothers in late-2008, the increase in liquidity provision was maintained, as the allotment procedure in refinancing operations was changed to fully allotting all bids against a fixed rate.[17] Second, from 2009 until 2011 the Eurosystem increased its holdings of domestic government bonds, which is displayed in the bottom left-hand panel as a gradual eastward shift. At this stage, the Eurosystem's purchases of government bonds remained rather limited, thus leading to a much smaller shift in asset composition than observed for the Bank of England. At the same time, the Eurosystem again stepped up its lending operations to banks. The introduction of two very long term refinancing operations in in late-2010/early-2011 translates to another westward shift in terms of asset composition.

Finally, in early-2015, the ECB announced to engage in large-scale purchases of government bonds to support a sustained adjustment in the path of inflation in line with its definition of price stability. The purchases of government bonds are part of the Expanded Asset Purchase Programme (EAPP) which also includes the purchase of euro denominated asset-backed securities, covered bonds and, as of the second quarter of 2016, corporate bonds. Currently, the ECB has announced that the EAPP will purchase EUR 80 billion of bonds per month until March 2017 and in any case until the Governing Council of the ECB sees a sustained adjustment in the path of inflation that is consistent with its definition of price stability. As a consequence of EAPP-purchases being skewed towards government bonds (about 80% of total purchases), the Eurosystem has become a *treasuries holder* as of mid-2015. The gold triangle in the graph shows that completion of the EAPP (under modalities currently announced and *ceteris paribus*) will imply a substantial shift in balance sheet configuration relative to the pre-crisis situation.

In terms of changes in liability composition, the right-hand panel shows that until 2012 the Eurosystem experienced a gradual further increase in bank reserves relative to banknotes as bank demand for central bank liquidity increased during the sovereign debt crisis. In 2013, as acute tensions dissipated, banks in the euro area gradually started early repayment of the long-term refinancing operations which were allotted in 2010/11. This has implied an eastward shift in terms of asset composition and a southward shift in terms of liability composition. In terms of our methodology, the Eurosystem's relative liability structure by mid-2015 was little different from the one observed end-2007. Similar to what we have seen in terms of asset composition, completion of the EAPP (gold triangle) would imply a significant shift in liability composition, beyond what has been observed in previous years.

When we compare developments in balance sheet composition across the three central banks some interesting features stand out. A first noticeable difference refers to the very different starting positions in terms of balance sheets of the three central banks. This reflects to a large extent differences in operational frameworks, in spite of the short term money market rate being the operational target for all three central banks (see eg Borio, 2001). Second, the amplitude and direction of the change in balance sheet composition differed remarkably across central banks from 2009 onwards. Whereas the Federal Reserve and the Bank of England experienced very significant changes in balance sheet composition, they moved in the exact opposite direction. By contrast, the relative shift in asset composition by the

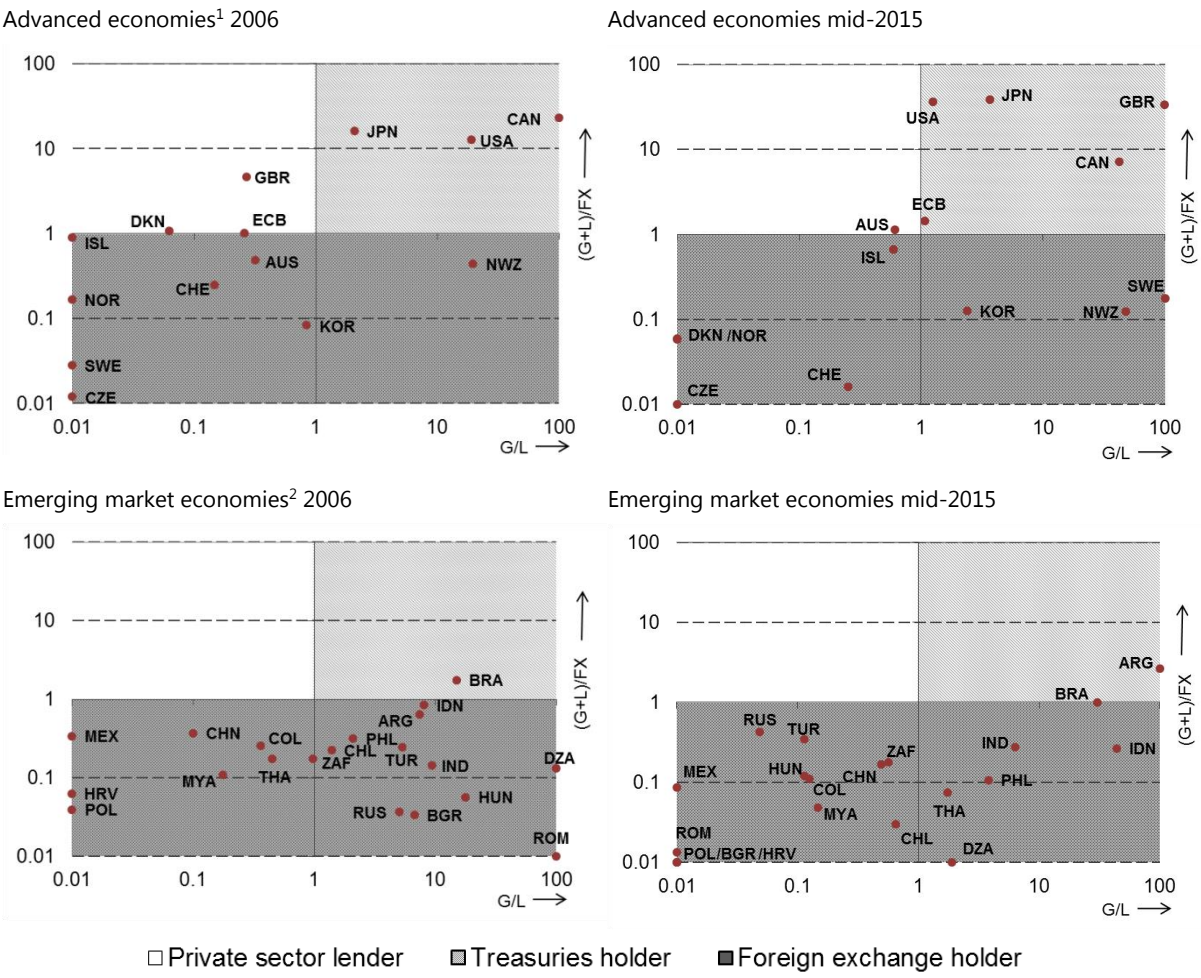
[16] See Abbassi and Linzert (2011), Cassola and Durré (2011) and Lenza et al (2012.

[17] Conditional on providing sufficient eligible collateral.

Eurosystem was much less pronounced, even though this will change in following years as the EAPP will be implemented. Remarkably, in spite of the differences in asset composition, in terms of central bank liabilities all central banks moved in the same direction, actually converging in terms of similarity.

Composition of central bank assets

Figure 4



Note: Logarithmic scales. Horizontal axis refers to ratio domestic public sector debt to domestic private sector debt. Vertical axis refers to ratio domestic debt to foreign exchange reserves. Values smaller than 0.01 and larger than 100 have been set at 0.01 and 100 respectively.

[1] AUS = Australia; CAN = Canada; CHE = Switzerland; CZE = Czech Republic; DNK = Denmark; ECB = euro area; GBR = United Kingdom; ISL = Iceland; JPN = Japan; KOR = Korea; NOR = Norway; NWZ = New Zealand; SWE = Sweden; USA = United States. [2] ARG = Argentina; BGR = Bulgaria; BRA = Brazil; CHL = Chile, CHN = China; COL = Colombia; DZA = Algeria; HRV = Croatia; HUN = Hungary; IDN = Indonesia; IND = India; MEX = Mexico; MYS = Malaysia; PHL = Philippines; POL = Poland; ROM = Romania; RUS = Russia; THA = Thailand; TUR = Turkey; ZAF = South Africa.

Source: IMF International Financial Statistics, national sources and author's own calculations.

5.2 Cross-sectional comparison of central bank balance sheets

Figure 4 presents a snap-shot of central bank asset composition for 14 central banks in advanced economies and 20 central banks in EMEs by end-2006 and mid-2015. A first result that stands out from the graphs is that differences in central bank asset holdings are substantial. In general, dissimilarity in asset composition appears much larger between advanced economies than between EMEs. In terms of our

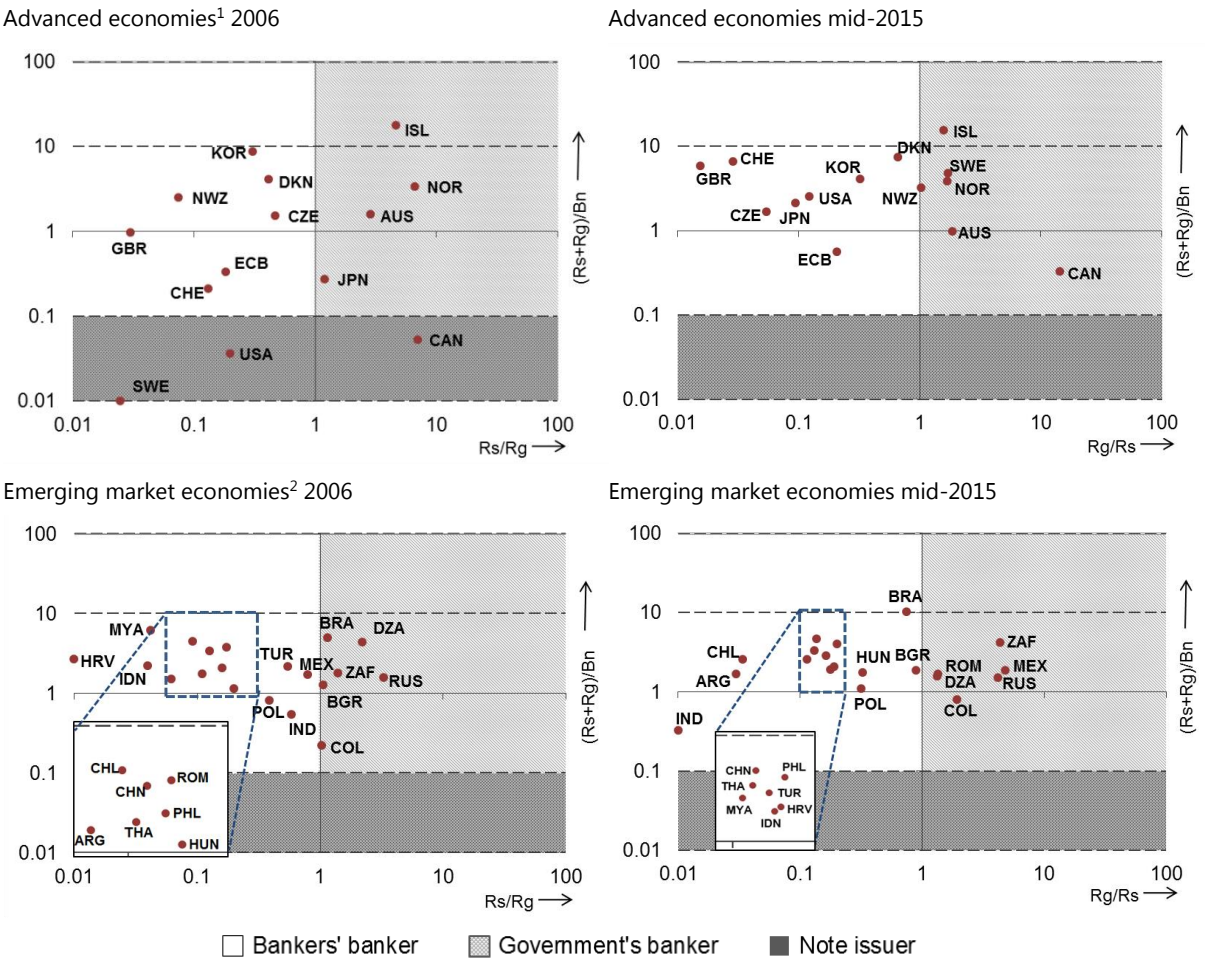
taxonomy almost all emerging market central banks are classified as *foreign exchange holders*). By contrast, almost half of the advanced economy central banks have domestic asset holdings equal to or larger than foreign asset holdings and are thus either *private sector lender* or *treasuries holder*. The graph shows that this concerns in particular the major advanced economy central banks. Many central banks in smaller advanced economies have large foreign exchange holdings, similar to most EME central banks. Many of these small advanced economy central banks have increase their relative foreign exchange exposures. Specifically, this concerns the central banks in Denmark, New Zealand, Norway and Switzerland. In Denmark and Switzerland this has coincided with active foreign exchange interventions to stem currency appreciation vis-à-vis the euro.

Figure 4 also shows that many central banks have no or negligible holdings of domestic government debt, with them being displayed at the far-left side in the panels. This is the case for the Norwegian, Czech, Croatian, Polish and Mexican central banks both in 2006 and 2015, and the central banks from Denmark, Romania and Bulgaria in 2015. Iceland's central bank had negligible government debt holdings in 2006, but has increased the exposure on its sovereign since. In terms of domestic asset holdings, the Swedish central bank moved from no domestic government bonds in 2006 to holding exclusively government bonds in its domestic asset portfolio in 2015. It should be noted, though, that total domestic asset holdings relative to foreign asset holdings by the Swedish central bank have been very modest both relative to foreign exchange reserves in 2006 and 2015. Finally, from the bottom panels in Figure 4 it can be observed that most EME central banks have shifted in a south-western direction. These central banks have increased foreign asset holdings and/or domestic private sector debt relative to domestic government debt holdings. This may have been a consequence of foreign exchange interventions to counter currency appreciation and capital inflows as a consequence highly accommodative monetary policy in many advanced economies. However, the observation does not hold for the central banks in Argentina, India and Indonesia that have either maintained, or increased their relative holdings of domestic government bonds versus other asset categories.

Figure 5 turns to the results for the composition of central bank liabilities in 2006 and 2015. In terms of liability structure we observe a higher degree of clustering between central banks than in terms of asset composition. In other words, in the context of our framework, central banks are more homogeneous in terms of liability composition then they are in terms of asset composition. Before the crisis, EME central banks generally had higher levels of bank and government deposits relative to banknotes than advanced economy central banks. However, since the crisis differences in liability structure between advanced economy and EME central banks have narrowed. Most central banks are classified as *bankers' banker*, having higher liabilities vis-à-vis the domestic private sector as opposed to liabilities vis-à-vis the domestic public sector. Seven central banks in our sample are classified as *government's banker* in both 2006 and 2015; those in Australia, Iceland, Norway, Algeria, Colombia, Russia and South Africa. Interestingly, these countries exhibit as a common characteristic that they are (large) commodity exporters. Whether any causality may be inferred from this observation lies beyond the scope of this paper.

Composition of central bank liabilities

Figure 5



Note: Logarithmic scales. Horizontal axis refers to ratio government deposits to bank reserves. Vertical axis refers to ratio reserves (bank and government) to banktnotes. Values smaller than 0.01 and larger than 100 have been set at 0.01 and 100 respectively.

[1] AUS = Australia; CAN = Canada; CHE = Switzerland; CZE = Czech Republic; DNK = Denmark; ECB = euro area; GBR = United Kingdom; ISL = Iceland; JPN = Japan; KOR = Korea; NOR = Norway; NWZ = New Zealand; SWE = Sweden; USA = United States.
[2] ARG = Argentina; BGR = Bulgaria; BRA = Brazil; CHL = Chile, CHN = China; COL = Colombia; DZA = Algeria; HRV = Croatia; HUN = Hungary; IDN = Indonesia; IND = India; MEX = Mexico; MYS = Malaysia; PHL = Philippines; POL = Poland; ROM = Romania; RUS = Russia; THA = Thailand; TUR = Turkey; ZAF = South Africa.

Source: IMF International Financial Statistics, national sources and author's own calculations.

Table 3 provides a summary overview of the central banks that have switched type from 2006 to 2015 in terms of our typology. To sum up, in total 14 central banks switched type in the period under review, ie around 40% of the total sample. Five central banks switched type only in terms of asset composition, while nine central banks did so in terms of the composition of their liabilities. With respect to the latter group most type-switching central banks saw a relative increase in government deposits, leading to a reclassification to a *government's banker*. The remainder experienced an increase in bank reserves, switching to a *bankers' banker*. There were no central banks in our sample that switched type both in terms of asset and liability composition in the period under review.

Type switching central banks

Table 3

Central bank	Type in 2006		Type in 2015	
Assets:				
Argentina	***FX-holder***	Bankers' banker	***Treasuries holder***	Bankers' banker
Australia	***FX-holder***	Government's bankers	***Private sector lender***	Government's bankers
Euro area	***FX-holder***	Bankers' banker	***Treasuries holder***	Bankers' banker
Denmark	***Private sector lender***	Bankers' banker	***FX-holder***	Bankers' banker
United Kingdom	***Private sector lender***	Bankers' banker	***Treasuries holder***	Bankers' banker
Liabilities:				
Brazil	Treasuries holder	***Government's banker***	Treasuries holder	***Bankers' banker***
Bulgaria	FX-holder	***Government's banker***	FX-holder	***Bankers' banker***
Canada	FX-holder	***Note issuer***	FX-holder	***Government's banker***
Japan	Treasuries holder	***Government's banker***	Treasuries holder	***Bankers' banker***
Mexico	FX-holder	***Bankers' banker***	FX-holder	***Government's banker***
New Zealand	FX-holder	***Bankers' banker***	FX-holder	***Government's banker***
Romania	FX-holder	***Bankers' banker***	FX-holder	***Government's banker***
Sweden	FX-holder	***Note issuer***	FX-holder	***Government's banker***
United States	Treasuries holder	***Note issuer***	Treasuries holder	***Bankers' banker***

Note: Changes marked in ***bold italics***.

5.3 Measuring changes in balance sheet composition

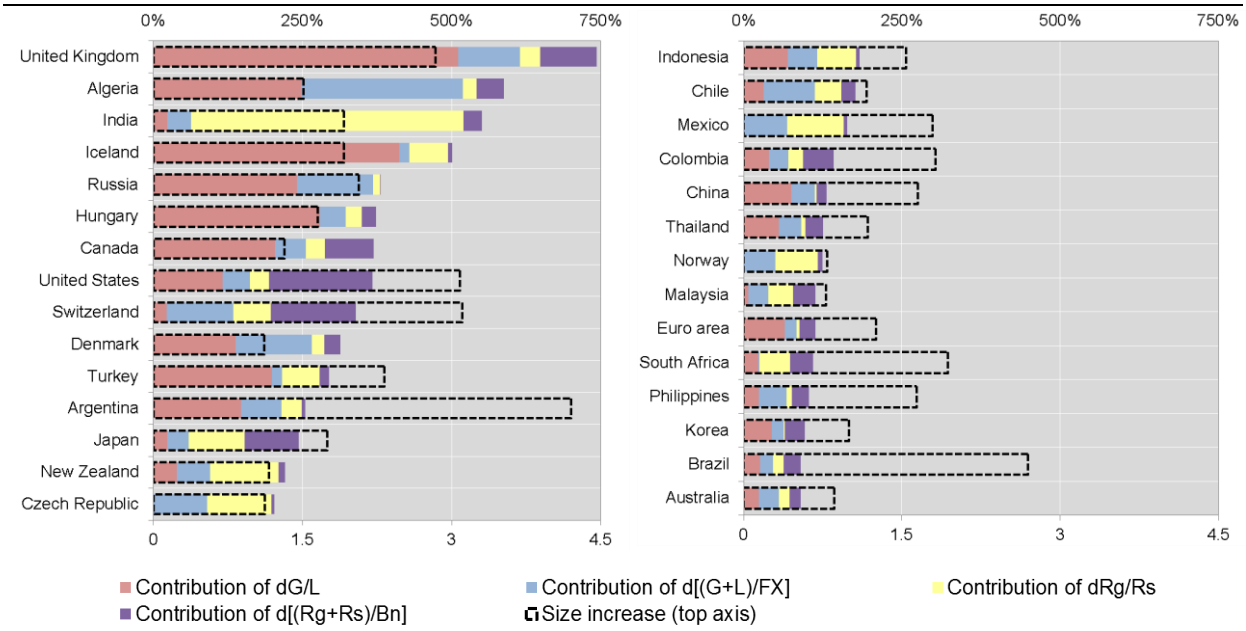
As described in section 3.4, the combined (Euclidian log) distance between two observations in the four-dimensional [G/L – (G+L)/FX – Rg/Rs – Rt/Bn]-plane gives a quantitative measure for the change in the composition of the central bank balance sheet. In Figure 6 we have plotted the change in balance sheet composition from end-2006 (pre-crisis) to mid-2015 (post-crisis) for the central banks in our dataset. In this exercise we have excluded central banks with zero and $+\infty$ values on any of the balance sheet indicators, as the distance between two states will be undefined in those cases. The combined length of the coloured bars gives the total absolute distance between end-2006 and mid-2015 balance sheet configuration. The different coloured segments show how much of the change in balance sheet composition was caused by a change in the respective indicator.

As noted before, because we are measuring absolute distance, no inferences can be made about the direction of the change in balance sheet composition based on this measure. For example, a large contribution of G/L (ie a large red bar) may reflect either a large increase of G relative to L or vice versa. This also means that we cannot make any inferences on changes in the level of monetary policy accommodation provided by different central banks based on the information in

Figure 6. In other words, a change in balance sheet composition does not necessarily reflect a loosening or tightening of monetary policy. Instead, Figure 6 displays which central banks have moved furthest away from their pre-crisis balance sheet configuration, ie which central banks have experienced the most pronounced change in balance sheet composition since 2006. For reference, Figure 6 also includes the change in balance sheet size (striped bars, top axis). Note that in Figures 4 and 5 we minimized/maximized all coordinates at 0.01 and 100 to keep the graphs tractable. Here we calculate the distance between the unconstrained coordinates. As we measure relative changes in Euclidian logarithmic space, changes from a relatively small base level will be inflated relative to their significance in nominal terms. We will take this into account when discussing the results.

Changes in balance sheet composition 2006-2015

Panel comparison for compositional changes in central bank balance sheets — Figure 6



Note: Length of the vector in [G/L – (G+L)/FX – Rg/Rs – (Rg+Rs)/Bn]-plane between end-2006 and end-2013 balance sheet configuration, including contribution per indicator. For reference that ratio of total central bank assets in 2013 relative to 2006 is also included (dotted line, top axis). Bularia, Croatia, Poland Romania and Sweden not included.

Source: IMF International Financial Statistics, national sources and author's own calculations.

Figure 6 shows that the Bank of England has seen the most pronounced change in balance sheet composition from end-2006 until mid-2015, while at the same time experiencing one of the strongest increases in the size of its balance sheet. The change in balance sheet composition was primarily caused by a change in the G/L-indicator (red bar), as a consequence of the large increase in government bond holdings by the Bank of England (causing it to be reclassified from a *private sector lender* in 2006 to a *treasuries holder* in 2013 as described in subsection 5.1). The graph shows that for most central banks that experienced a relatively large change in balance sheet composition did so by altering the composition of their domestic asset allocation (red bar). Different from the Bank of England, for many central banks, including those in Algeria, Russia, Hungary, Canada and the US this was caused not by a relative increase in government debt holdings, but rather by a relative increase in lending to the private sector. Among the central banks that experienced the most pronounced change in balance sheet composition the

Reserve Bank of India stands out, in that it saw a big shift in the composition of its non-banknote liabilities (yellow bar). This reflects a significant drop in government deposits held at the central bank in the period under review.

Interestingly, the graph shows that large changes in balance sheet composition did not always coincide with dramatic increases in the size of the balance sheet. The central banks of Algeria, India, Iceland, Russia, Hungary and Canada are ranked next in terms of having experienced the largest change in balance sheet composition, but rank in the middle of the sample in terms of change in balance sheet size. For some central banks this is caused by the base effects described above. For example, the Icelandic central bank had negligible government debt holdings in 2006, so any increase in this balance sheet item would lead to a relatively large shift in the composition of its domestic asset portfolio (red bar). The reverse is true for the central bank of Canada that had negligible outstanding lending operations to the domestic banking sector in 2006.

At the same time, central banks seeing the strongest increase in balance sheet size did not always also see significant changes to balance sheet composition. Specifically, the central banks in Argentina and Brazil are the ones that experienced the largest increase in balance sheet size, but rank respectively twelfth and second lowest in terms of changes in balance sheet composition. In other words, these central banks manage to expand their balance sheet, without altering significantly the relative distribution of central bank assets and liabilities.

At glance, the association between large changes in balance sheet size and composition seems somewhat stronger for advanced economy central banks than for those in EMEs. For example, the Swiss National Bank and the Federal Reserve did also experience both pronounced changes in balance sheet size and composition. As shown in Figure 6, in these two cases this was caused mostly by an increase in (bank) reserves relative to government deposits and banknotes (combination of both purple and yellow bars). As discussed in subsection 5.1, for the Federal Reserve this development coincided with an increase in private sector asset holdings during the crisis (decrease in G/L, red bar). In the case of the Swiss National Bank, it coincided with an accumulation of foreign exchange reserves (decrease in (G+L)/FX, blue bar). The same also applies to the Danish central bank, even though in the case of Denmark the accumulation of foreign exchange reserves did not coincide with a similar increase in total balance sheet size (implying the shedding of other domestic assets). Many other central banks that accumulated large amounts of foreign exchange reserves in the period under review already started out with relatively high holdings of foreign exchange in 2006. Thus, the impact of further acquisitions of foreign assets on balance sheet composition has been relatively muted. This holds for many EME central banks included in the right-hand panel of Figure 6.

It is beyond the scope of this paper to assess why certain central banks have experienced a more significant change in balance sheet composition than others and how this relates to other central bank actions (eg changes in balance sheet size and policy rates). However, section 6.1 provides some suggestions for future research following up on the results presented in Figure 6.

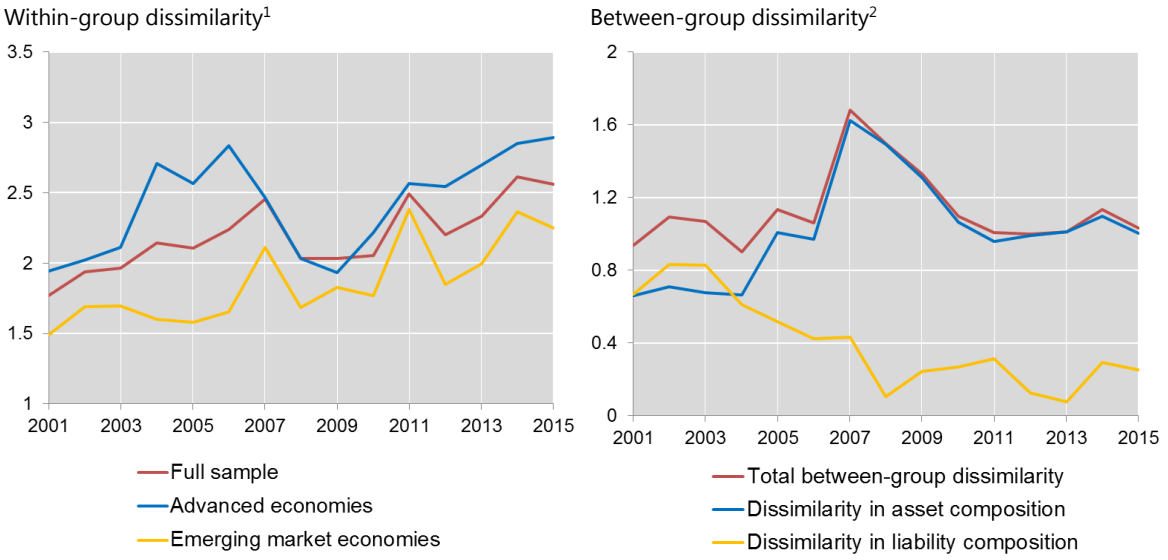
5.4 Measuring dissimilarity in balance sheet composition

In section 5.2 we concluded from our taxonomy that dissimilarity in central banks' balance sheet configuration is larger between advanced economies than between EMEs. As described in section 3.4 we can analyse this issue using a more quantitative approach by calculating aggregate dissimilarity measures.

The left-hand panel in Figure 7 displays developments in the annual average of cross-country pairwise bilateral distances. Aggregate dissimilarity by this measure has been calculated over the full sample, and for the advanced economy and EME subsamples. Indeed, the graph confirms that aggregate dissimilarity in central bank balance sheet composition is higher for central banks in advanced economies (blue line) than it is for central banks in EMEs (yellow line). With respect to advanced economy central banks we can distinguish three episodes. First, in the years leading up to the crisis, dissimilarity in balance sheet composition increased. However, during the global financial crisis in 2007-2009 this trend reversed and central banks in advanced economies became more homogeneous in terms of balance sheet composition. This reflects a high degree of similarity in the initial policy response to the global financial crisis across advanced economy central banks. As noted in sections 5.1 and 5.2, this response was generally characterized by an increase in the supply of reserves to the banking sector by increasing central bank lending to commercial banks. However, from 2009 onwards, Figure 7 shows a rebound in heterogeneity in balance sheet composition as many advanced economy central banks pursued again differing policies after the initial crisis response. Some, in particular major advanced economy, central banks engaged in large-scale purchases of domestic assets to add further monetary policy accommodation. By contrast, other advanced economy central banks, mostly in smaller open economies, experienced an increase in foreign exchange asset holdings. In contrast to advanced economies, heterogeneity in balance sheet composition between EME central banks has slightly trended upward in the period under review, but remains below the levels observed for advanced economies.

Aggregate dissimilarity in central bank balance sheet composition

Figure 7



[1] The graph shows the bilateral distance between countries in the [G/L – (G+L)/FX – Rg/Rs – (Rg+Rs)Bn]-plane averaged across countries over the full sample (red line) and subsample groupings (blue and yellow lines). [2] The graph refers to the distance between the average advanced economy and emerging market economy central bank balance sheet. End-of-year data, except for 2015 (June).

Source: Author's own calculations.

The right-hand panel in Figure 7 displays the evolution in dissimilarity between the average advanced economy and EME central bank balance sheet. In this graph, between-group dissimilarity refers to the distance between the average advanced and emerging market economy central bank balance sheets. The graph displays

both total dissimilarity (red line), ie jointly over asset and liability composition, as well as dissimilarity over either asset or liability composition (blue line and yellow line, respectively). The graph confirms that dissimilarity between advanced economy and emerging economy central banks increased in particular in the first phase of the crisis. As discussed in subsection 5.2, in 2007 many advanced economy central banks increased their holdings of domestic (private sector) asset holdings, whereas EME central banks continued to increase their foreign exchange holdings. From 2008 onwards, between-group dissimilarity decreased again, as some (small and open) advanced economy central banks started accumulating foreign exchange reserves. Still, as the average advanced economy central bank continues to hold a larger proportion of domestic assets relative to foreign assets, heterogeneity in asset composition between advanced and emerging economy central banks continues to be high (blue line).

By contrast, dissimilarity in central bank liabilities has fallen substantially between advanced economies and EMEs (yellow line). By undertaking recent balance sheet policies, advanced economy central banks have increased the level of reserves supplied to the banking sector. As a consequence, advanced economy central banks have become more similar in terms of liability composition to their EME counterparts that were already characterised by large reserve balance before the crisis. In this respect, EME central banks may already have valuable experiences in managing central bank liabilities that can also be helpful for advanced economy central banks.

6. Concluding remarks

In this paper we presented a framework to analyse central bank balance sheet composition. We documented large differences in balance sheet configuration, in particular among advanced economies. We also documented significant changes in balance sheet composition since the global financial crisis. The initial crisis-response in 2007–09 was broadly homogenous across advanced economies, with central banks stepping up liquidity provision to the domestic banking sector to maintain financial stability. However, since 2009 differences in central bank balance sheet configuration have again increased, as different central banks were increasingly faced with different policy challenges. Such differences in central bank balance sheets and balance sheet policies are often not taken into account in the recent literature that focusses on size measures instead. As a consequence, the results presented in this paper open up a number of questions for future research. Moreover, they can be conducive in the policy discussion going forward.

6.1 Research questions

A first question for future research refers to the rationale for differences in balance sheet composition that we have described in this paper. We have noted in section 3.2 that many different factors could be at play, both structural and policy-related factors. It would be interesting to analyse empirically whether any of these factors contribute systematically to having a specific balance sheet configuration. Potential determinants could include monetary policy strategies (inflation-targeting, exchange-rate targeting), the structure of the financial system (bank- or market-based) and the origins of the legal system (civil or common law). As for the structure of the financial system, it could be argued that there is a reciprocal relationship with

the design operational framework of monetary policy, similar to what Jobst and Ugolini (2014) discuss for the structure of the money market.

Related to this is the question why some central banks have experienced larger compositional changes in their balance sheets than others. A potential explanation could be that some economies have been hit by a larger (asymmetric) shock than others. However, a contrasting view is that economies have been hit by the same (symmetric) shock, but some central banks have been less well equipped to deal with this than others, implying a greater necessity to make innovations to the composition of their balance sheet. Another view is that greater innovations in central bank balance sheets are associated with more effective policy-making and, thus, more favourable economic outcomes.

This leads to a third research question, referring to the effectiveness of central bank balance sheet policies. The current paper has shown that the design of balance sheet policies differed substantially across central banks, in particular in terms of the asset composition. Follow-up research would analyse to what extent differences in the design of balance sheet policies contribute to differences in the impact of balance sheet policies on financial market and macroeconomic outcomes. In a related study, Christensen and Krogstrup (2014) find evidence that balance sheet expansion by the Swiss National Bank, not associated with the purchase of long-term domestic assets, still had a significant impact on domestic sovereign bond yields. Follow-up research could analyse to what extent this effect also applies to other types of innovations in central bank balance sheet composition identified in this paper.

6.2 Policy issues

Differences in the design of central bank balance sheets and balance sheet policies imply that central banks might face different risks and policy challenges going forward. Below we discuss three issues central banks might face, and how the results of the current paper could be useful in guiding policy discussions.

A first issue refers to the potential financial risks associated with recent central bank balance sheet policies. Some authors have analysed the consequences of recent balance sheet expansions on central bank profitability in the context of rising interest rates (eg Christensen et al, 2013). It is clear that the type of risk exposure depends crucially on the design of the central bank balance sheet and balance sheet policies. Thus, for example, whereas exchange rate risk would be relevant for *FX-holders, private sector lenders* would be more exposed to credit risk. Our results may be conducive in helping to identify which risks might be considered more or less relevant for different types of central banks.

Another issue refers to the interaction of monetary policy with other policy areas. For example, some authors have recently drawn attention to the issue of interaction between central bank balance sheet policies and public sector debt management. Blommestein and Turner (2012) and Cecchetti (2013) argue that recent balance sheet measures by major central banks have blurred the separation between monetary and fiscal policies. Turner (2011) poses that this could even have implied a regime shift of monetary dominance to fiscal dominance. Goodhart (2010), Allen (2012) and Blommestein and Turner (2012) argue that large government bond holdings by central banks due to recent quantitative easing policies would warrant increased coordination between central bank balance sheet policies and sovereign debt management policies. The current paper helps identify

which central banks are main holders of government bonds (presumably *treasuries holders*), and thus might be most exposed to this specific issue.

Finally, the results in this paper can be informative in the discussion on exit strategies from current unconventional monetary policies. As noted by Turner (2014), currently there is no consensus on post-crisis central bank balance sheets, nor whether this would coincide with pre-crisis practices. The results in this paper confirm that for some central banks the pre-crisis balance sheet configuration is more distant than for others. Moreover, as the pre-crisis configuration of central bank balance sheets was very heterogeneous across central banks it would seem unlikely that central banks would converge to a similar design of their balance sheet in the new normal. However, as has been noted by Borio (2001), such differences across central banks are typically not associated with differences in the efficacy of monetary policy implementation.

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Appendix: Construction of data not included in IFS-dataset

Australia:

Source: Reserve Bank of Australia Monthly Statement on Liabilities and Assets

Table A1

Data construction Reserve Bank of Australia

Assets		Liabilities	
FX	Gold and foreign exchange	Bn	Notes on issue
L	Loans and advances	Rs	Exchange settlement balances
	Clearing items		RBA term deposits
	Other AUD securities		
	Other assets		
G	Australian government securities in AUD	Rg	Deposits of governments and instrumentalities

New Zealand:

Source: Reserve Bank of New Zealand Assets and Liabilities (monthly)

Table A2

Data construction Reserve Bank of New Zealand

Assets		Liabilities	
FX	Current account advances	Bn	Currency in circulation
	Marketable securities denominated in foreign currencies		
	IMF: Holding of SDRs		
	Foreign assets		
L	Advances to settlements institutions	Rs	Deposits of settlement institutions
			Other deposits
			Reserve Bank bills
G	Advances to Crown settlement account and Treasury	Rg	Deposits of government
	Government securities		

Norway:

Source: Norges Bank Balance Sheet Figures (monthly), excluding Government Petroleum Fund/Government Pension Fund Global

Table A3

Data construction Norges Bank

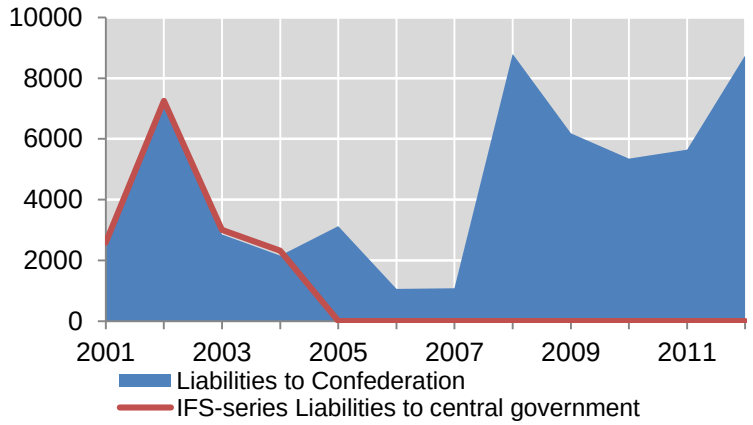
Assets		Liabilities	
FX	Foreign assets Other assets in foreign currency Gold	Bn	Notes and coins in circulation
L	Lending Other assets Other assets in domestic currency	Rs	Domestic liabilities: Other deposits
G	Securities	Rg	Domestic liabilities: Treasury deposits

Switzerland:

Most of the data for the balance sheet of the Swiss National Bank is included in the IFS-dataset. However, from 2005 onwards the IFS-data does no longer include information on the level of government deposits at the SNB (Rg). Therefore, from 2005 onwards we use SNB data to complement the available IFS-data. Both series are displayed in Figure A1.

Figure A1

SNB government deposits



Note: Plane displays SNB-data. Line displays IFS-data.

United Kingdom:

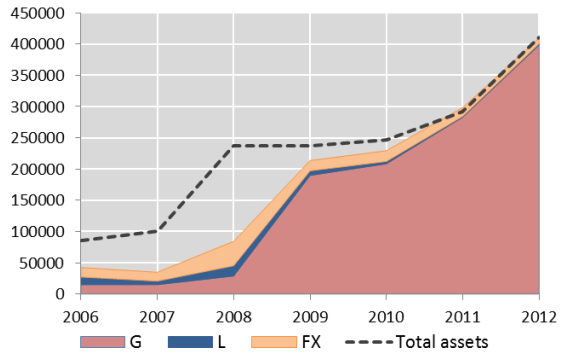
Most of the data on the balance sheet of the Bank of England is available in the IFS-dataset. However, IFS only includes data on the net position of the central bank versus the domestic public sector. Therefore, to calculate both G and Rg, we complement the IFS-data with data from the dataset "Central bank's contribution to MFIs' consolidated balance sheet (Expanded version)", available on Bank of England website. Moreover, for reasons of confidentiality the Bank of England does not report all claims on banks and building societies in the context of the IFS Central Bank Survey.[18] As shown in Figure A2 this results in a large discrepancy between the cumulative figure for the three asset classes as reported in the IFS-dataset (coloured planes) and total assets as reported in the Bank of England's consolidated Bank return (dashed line). To correct for this we will assume that this difference refers entirely to lending to the private sector.

As a cross-check to this assumption the right-hand panel shows three series for lending to the private sector by the Bank of England. The red line refers to the IFS-series (the blue plane in the left-hand panel). The blue line refers to the sum of short-term and long-term open market operations and repo's reported in the Bank of England's Consolidated Statement. The dashed black line refers to our revised IFS-series by assuming the part of the balance sheet that is not included in the IFS-data refers to lending operations to the private sector.[19] The graph shows the revised series and lending operations to the banking sector reported in the Bank of England consolidated statement are closely aligned, except for 2007. However, this difference largely reflects emergency lending by the Bank of England to Northern Rock, which is included in "Other assets" on the Bank of England's consolidated statement, and can thus reasonably be included in lending to the private sector (Northern Rock was nationalized in 2008; HM Treasury, 2009).

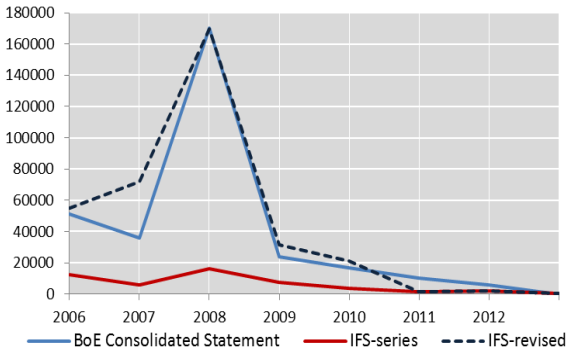
Bank of England assets and lending to private sector

Figure A2

Total assets and IFS-components[1]



Lending to private sector[2]



[1] Total assets obtained from Bank of England Consolidated Statement. Components obtained from IFS-dataset. [2] "BoE Consolidated Statement" includes items "Short-term open market operations" and "Longer-term sterling reverse repos". "IFS-series" refers to item "Claims on private sector". "IFS-revised" is computed by adding the difference between the coloured planes and black dashed line in the left-hand panel to "IFS-series".

18 IFS-metadata: http://dsbb.imf.org/Pages/SDDS/DQAFBase.aspx?ctycode=GBR&catcode=AAC00

19 We can only cross-check the different time-series after 2006, due to different reporting format of the Bank of England's balance sheet before 2006.

Euro area:

Source: Eurosystem Consolidated Weekly Financial Statement and ESCB dataset on minimum reserves and liquidity.

Data construction Eurosystem

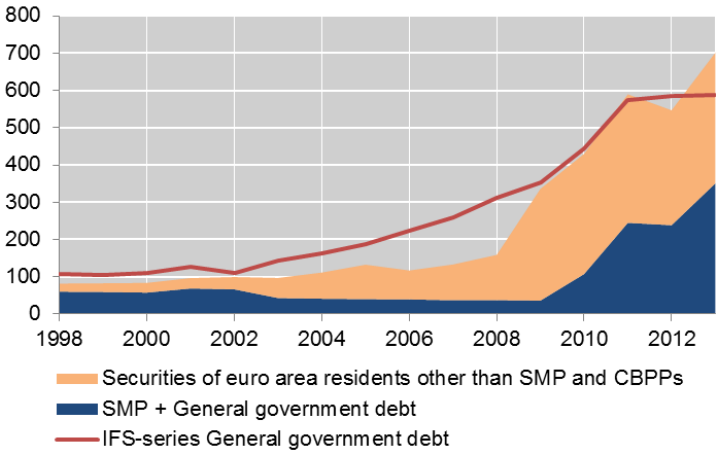
Table A4

Assets		Liabilities	
FX	Gold and gold receivables	Bn	Banknotes in circulation
	Claims on non-euro area residents in foreign currency		
	Claims on non-euro area resident in euro		
	Claims on euro area residents in foreign currency		
	Other assets		
L	Lending to euro area credit institutions related to monetary policy operations	Rs	Current accounts
	Covered Bond Purchase Programmes[1]		Deposit facility
			Fixed term deposits
			Fine tuning reverse operations
			Deposits related to margin calls
			Other liabilities to euro area credit institutions
			Debt certificates issued
G	Securities Markets Programme[2]	Rg	Liabilities of other euro area residents denominated in euro: of which general government
	General government debt		
	Securities of euro area residents denominated in euro, other than the SMP and the CBPPs[3]		

[1] Data obtained from ESCB dataset on minimum reserves and liquidity. [2] Matches the size of Eurosystem weekly liquidity absorbing tender. [3] Based on labelling this balance sheet item may refer to eiter private or public sector securities. Classified as government debt to match IMF IFS data series, see Figure A3.

Consistency ESCB data with IFS data on general government debt holdings

Figure A3



Note: Planes display ESCB-data. Line displays IFS-data.

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