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The Central Bank of Iceland's Liquidity Management System

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Ragnheiður Jónsdóttir*

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This paper aims to answer the question of what kind of liquidity management system would be optimal for Iceland with respect to two important considerations. One is the current environment of surplus reserves and the other is Iceland's specific character of being a very small, open economy with its own currency. The theory behind monetary policy implementation is discussed as well as the various origins of surplus reserves, their characteristics and implications for the conduct of monetary policy. The reasons for the steep accumulation of surplus reserves in the Icelandic banking system are considered and fluctuations in reserves are found likely to persist in a small, open economy, not least one with a managed float. Four different types of liquidity management systems at central banks are discussed in turn and the examples of Sweden, Norway and Denmark considered in that context. Finally, some conclusions are provided on the optimal system for Iceland.

Keywords: Liquidity Management, Central Bank of Iceland

JEL Classification: E51, E52, E58

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1 Introduction

Following the Global Financial Crisis (GFC), many central banks around the world made changes to the way they had been implementing monetary policy. The need for these changes mostly stemmed from measures undertaken during and following the crisis. Central banks in advanced economies overwhelmingly undertook exceptional measures to provide liquidity during the crisis and continued to develop ways of supporting liquidity conditions in the aftermath, mostly through quantitative easing. These changes indicate a period where financial stability considerations rose to the top of central bank operational priorities.

Iceland is no exception in this context, having experienced a banking and currency crisis of exceptional proportions. As in many other countries, the main source of operational changes has been the significant accumulation of surplus reserves in the system, the foundation for which started before the crisis. The main consequence was a move towards a *de facto* floor system in 2009, but in most other aspects, the framework in place in terms of facilities is unchanged. The CBI's collateral list is also significantly shorter than before the crisis. As clarity has been gained on the situation in Iceland and elsewhere there has been a move towards bringing operations up to speed with the present and take stock of the lessons learned from the GFC.

A central bank's monetary policy framework is the widest set of institutions and processes that describe how the Bank achieves its ultimate goals. This includes institutions such as the monetary policy committee (MPC), in place since 2009 and analytical operations and forecasts as well as its communication strategies.

A central bank's operational framework is a subset of its monetary policy framework, and refers to the implementation of monetary policy, i.e., all methods and tools used to propel the central bank's policy rate into the financial markets and from there to reverberate through the whole economy.

A further subset is the liquidity management system (LMS) which describes how central bank liquidity is managed to influence the target rate of monetary policy. The Central Bank of Iceland's liquidity management system is a corridor system with reserve averaging but several different systems for managing liquidity are available. This paper is mostly concerned with this last, most narrowly defined, component of the monetary policy framework.

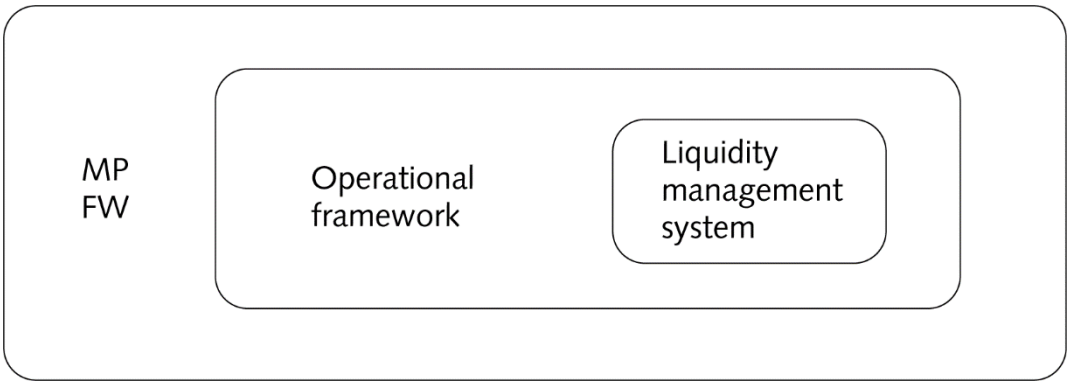

Figure 1. The liquidity management system in the context of the operational framework and the monetary policy framework

The CBI's inflation targeting framework was introduced through legislation in 2001 and its goal is to maintain inflation at 2.5% on an annual basis. The inflation targeting framework was accompanied by a floating exchange rate which was maintained until the GFC in 2008. The liquidity management system is a wide corridor framework with standing facilities (SF) on either side of the corridor and open market operations (OMO), such as seven-day collateral lending, which served as the policy rate until 2009. As mentioned earlier, the CBI has operated a floor system since then, where interest rates on various forms of deposits have constituted the policy rate, most recently the seven day deposit rate.

In order to gain insight into the optimal liquidity management system for Iceland going forward, it is useful to look into the reasons for both the significant growth in reserves and whether the structural surplus of reserves is likely to be unwound in the near future. A structural surplus of reserves can introduce complications in implementing monetary policy and may be costly to maintain on behalf of the central bank. This applies to most frameworks we look at, since modern monetary policy implementation usually entails paying interest on reserves, but especially if the intention is to maintain a functioning corridor system. As noted above, the Central Bank of Iceland (CBI), as many other central banks, moved to a *de facto* floor system shortly after the crisis. This framework (in theory) allows for a decoupling of monetary policy from the amount of reserves in the system, yet the CBI has endeavoured to drain the excess through certificates of deposit.

Another matter that has been in focus in the aftermath of the crisis is how central banks' collateral policies and lender of last resort (LOLR) frameworks should be set up to minimize moral hazard but also respond flexibly in case of a crisis. In that context, it is important that liquidity management systems in place work effectively in all circumstances.

In this paper, four main versions liquidity management systems (LMS) are explored. The wide and narrow corridor, as well as two main alternatives, the current floor system and a potential quota system. A quota system may be particularly well suited to the current surplus conditions in many countries, as a certain amount of holdings is remunerated at the policy rate and excess holdings are discouraged through a lower interest rate. In a two-sided quota system, excess borrowing is also discouraged through a higher rate. In comparison with reserve requirements, where minimum holdings are required and remunerated at a higher rate, incentives in a quota system can include both higher and lower interest rates above the quota, depending on what incentive structure is most beneficial.

Through studying the attributes of these different liquidity management systems and the operations of various other central banks, we examine whether there might be an even more advantageous set-up available for the conditions of the Icelandic economy. It should be noted that what might have worked under conditions of capital controls, may not be optimal with a freely floating currency.

Among the questions that could be asked at the Central Bank of Iceland are what system would work best in the current environment of surplus reserves as well as being robust to sign-switching of structural liquidity, and could there be some changes made that would benefit the implementation of monetary policy in a very small, open economy with its own currency. The liquidity management system lies at the core of the wider money system, and therefore an efficiently designed LMS may contribute to effective implementation of monetary policy and support the now secondary goal of financial stability.

2 Theory

Most central banks' mode of implementing monetary policy, and hence the designs of their liquidity management systems, is rooted in similar practical considerations as Bagehot's early observation that money is a commodity subject to great fluctuations of value. (Bagehot, 1910/2006, p.121). Central banks have a monopoly over notes and coin as well as central bank reserves used in interbank transactions, and by setting the terms on which these commodities are available, they achieve their policy goals (Rule 2012, p. 5). In most cases it is not enough to name the price; central banks must also engage in active liquidity management to reach their policy goals and avoid large fluctuations in the price of money, i.e. the policy rate.

Bindseil (2004b, p. 14) points out that just as in Bagehot's time, our money market, or market for reserves, is constantly hit by short-term transitory demand and supply shocks. He underscores that these fluctuations have little to do with macroeconomic developments, highlighting that any serious setting of a quantitative operational target would mean extreme noise in short-term interest rates and further out on the interest rate spectrum. When the fluctuations in short-term interest rates are not white noise, i.e. are characterized by excessive volatility, this will lead to increased volatility of medium- and long-term interest rates. That is, the rates responsible for key economic decisions, such as saving and consumption.

The liquidity management component of monetary policy implementation is stressed by Gray and Talbot (2006, p. 4) who underline that monetary instruments are not only used to implement monetary policy but are also used for liquidity management in order to prevent the short-term uncertainty and price volatility which day-to-day swings in market liquidity would otherwise cause. In order to make sense of the role of liquidity management it is also useful to see what Rule (2012, p. 6) says about the monetary operations of the central bank being crucial to the achievement of both monetary policy and financial stability goals. Rule points out that while financial stability goals are usually less tightly defined than monetary policy goals, central banks have an incentive, (in some cases duty), to reduce the possibility of economy-wide problems stemming from the banking sector. This includes contributing to financial stability on a day-to-day basis by supplying the optimal level of reserves such that interbank payments can continue to be made. To summarize: the monetary policy contribution is managing liquidity to achieve a certain interest rate, the financial stability contribution is managing liquidity so that there is enough for transactions in the market. Ideally, both conditions are met.

According to Bindseil (2004b, p. 5-13), already in 1802, central bank policy at the Bank of England was known as "Bank rate" policy and the BoE has not deviated from the short-term interest rate as an operational target to any significant extent. On the other hand, the Federal Reserve was, according to the same source, quite taken with the "Reserve Position Doctrine", where monetary policy should be implemented by targeting a reserve concept, for almost 70 years.

The Reserve Position Doctrine as a framework for implementation of monetary policy can be considered redundant today, even though some academic textbooks refer to this framework as the one in use. Neither is the money multiplier any longer seen to accurately reflect the workings of modern financial markets, although monetary aggregates can at times be used as intermediate targets (Gray 2011, p. 10). This point is very important, as the current supply of reserves in the banking system has led some to believe that this points to lax monetary policy and is bound to lead to excessive credit growth. In reality, banks make lending decisions based on whether it is profitable for them to lend, and they will create loans and deposits simultaneously. Availability of reserves is unlikely to be an important part of that decision (Rule 2015, p.12). Bindseil (2004b, pp. 7-13) credits Poole (1970) with much of the confusion still in place as regards the interchangeability of quantity and price instruments.

On the other hand, Poole (1968) wrote a paper two years earlier that is considered a very important contribution to the field. It sets out banks' reserve management in the money market as profit-maximizing decision-making under uncertainty using a stochastic model (p. 770). In a corridor system, a bank is not sure whether it will be required to borrow or deposit reserves at the end of the day or maintenance period and therefore the overnight rate will correspond to the weighted expected rate of the lending and borrowing standing facilities. Bindseil (2004b, p. 17) calls this a fundamental equation of monetary policy implementation.

The model used in this paper to describe liquidity management systems is based on Whitesell (2006, p. 1177-1195) and has been used by Keister et al. (2008), and Bernhardsen and Kloster (2010) to explain the fundamentals of monetary policy implementation. Bindseil and Würtz (2008, p. 31) present a quota version that they call TARALAC, for Target Rate Limited Access Standing Facility. In a two-sided quota system, the amount of reserves in the system should be such that the ex ante probability of aggregate use of the two standing facilities is equal. Quota or tiering systems are interesting liquidity management systems, with additional parameters compared to corridor systems, and deserve further study.

We will look at different versions of liquidity management systems later in this paper. A clear and exhaustive view of the possibility set is not yet available and there may be many more ways of shifting parameters to achieve even better mechanisms. Bindseil (2016) calls the floor system a fully asymmetric corridor approach, and claims that central banks are in fact positioned on the spectrum between full symmetry and full asymmetry depending on where the policy rate is placed in the corridor.

Bindseil's (2016, p.19) paper further clarifies that corridor systems require the specification of at least one parameter which determines the volatility of overnight rates and the money market turnover. In a symmetric corridor, the key parameter is the width of the corridor while in a fully asymmetric corridor (floor), the key parameter is the average amount of recourse to the facility at the operational target interest rate. The width of the corridor is also relevant here, but not as important as in the symmetric approach. In the case of a quota system, the relevant parameters are both the width of the corridor set by penalty rates and the limit or quota applying to the facility.

The overview of liquidity management system starts with a wide corridor system with reserve requirements and averaging and runs through three other versions; a narrow corridor, a floor system and a quota system. We will approach the main concepts as we go, including reserve requirements, standing facilities, overnight market operations, etc. However, central bank reserves, the fundamental good that is at the heart of liquidity management systems, will be discussed next.

3 Central bank surplus reserves and structural liquidity

The concepts of structural liquidity and surplus liquidity are very important for the purposes of this paper. For this reason, there will be a more detailed discussion of them later, but the examination will begin with the notion of central bank reserves.

3.1 Central bank reserves

The central bank's balance sheet is broadly defined its main instrument. Banks transact with each other across its books and any intervention on behalf of the central bank either shrinks, expands, or changes the composition of its balance sheet. A number of papers do a very good job of both presenting and explaining the importance of central bank balance sheets (Caruana (2011, p. 2), Ganley (2004, p. 4), Gray (2006, p. 4), Rule (2015, p. 8), Syrstad (2011, p. 2)). A stylized central bank balance sheet contains central bank's monetary liabilities on one side and other assets and liabilities netted out on the other. The identity can be presented as below, with notes and coin (N&C), central bank reserves (CBR) and the central bank's capital and reserves (C&R) on the liability side. On the asset side, assets and liabilities have been netted out to represent net foreign assets (NFA), net lending to government (NLG), net monetary policy operations (NMP) and other, net (NO). A version from Rule (2015, p. 8) can be seen below:

$$\text{NFA} + \text{NLG} + \text{NMP} + \text{NO} = \text{N\&C} + \text{CBR} + \text{C\&R}$$

A central bank will only directly control one of the variables, that is, net monetary policy operations. The other items on the left side are only indirectly controlled by the central bank and are usually referred to as "autonomous" factors. The autonomous factors here are net lending to government, net foreign assets and other, net.

Net lending to government in our case means flows between the banking system and government accounts at the central bank, which can often be fairly large. These flows are not "new" reserves. On the other hand, when the central bank buys foreign currency directly in the foreign exchange market, it is using newly created money, or reserves, that end up in the banking system. Net foreign assets are under the direct control of the central bank depending on whether it is bound by an exchange rate target or not and to what extent its foreign exchange and reserve policy is in the hands of the central bank itself. The withdrawal of notes and coins

also decrease banks' reserve position one for one. This item is not under direct control of the central bank and neither are capital and reserves.

Hence, reserves are endogenous in the system and can be presented as the residual resulting from a combination of autonomous factor developments and monetary policy operations by the central bank.

Changes in the supply of reserves = ΔNFA + ΔNLG + ΔNO - ΔN&C - ΔC&R + ΔNMP

In most advanced economies, flows between the treasury and the banking system, that is, net lending to government, constitute the most significant autonomous factor.

Interbank transactions do not affect the total quantity of reserves in the system, only their distribution among parties to the payment system (Aamodt and Tafjord, 2013, p. 2). Hence, a bank, buying securities from another bank will pay with reserves, which stay in the system. If the central bank buys securities, it will most likely pay with "new" reserves. If a commercial bank buys government bills in the primary market, these reserves will be paid into a treasury account at the central bank and disappear from the stock of central bank reserves until the bills fall due or the government decides to use the funds.

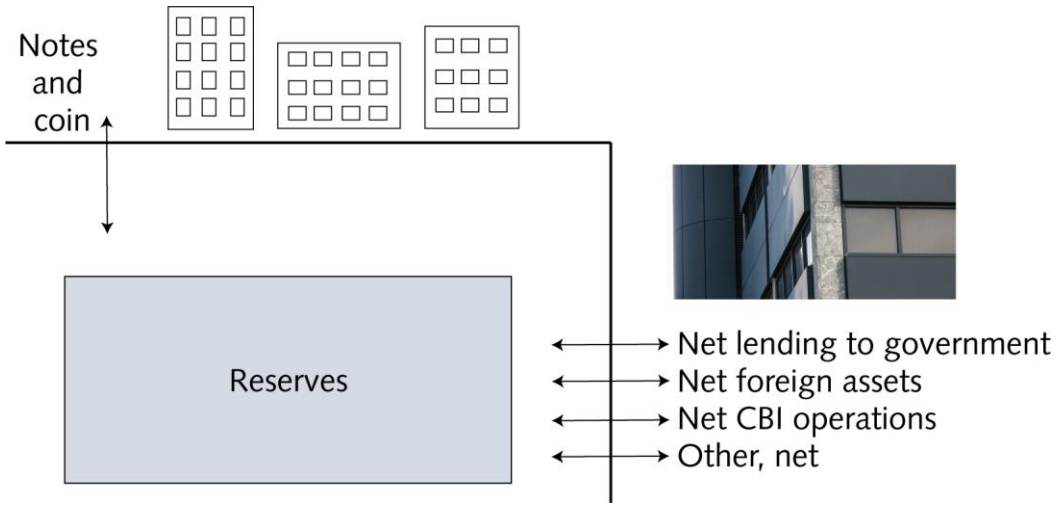

Figure 2. Domestic reserves and their entry and exit points into the financial system (vertical arrow) and central bank (horizontal arrows).

In some sense reserves can be understood as an underlying pool of rented liquidity as illustrated in figure 2. This analogy grows weaker, however, when there is present a structural surplus of reserves, especially when it is significant as

currently in the Icelandic system. Reserves, or banks' current account deposits, can travel around the payment system but banks cannot affect the total quantity of reserves on their own (Bernhardsen and Kloster, 2012, p. 2).

3.2 Structural liquidity

The structural domestic reserves position of the banking system is one of the most important concepts for central banks' liquidity management and implementation of monetary policy. Aamodt and Tafjord (2013, p. 1) define structural liquidity as the level of reserves in the banking system prior to market operations to supply or drain reserves from it. In other words, the reserve position in the absence of any intervention, lending or deposit-taking from the central bank. When the central bank is a net lender to the banking system, there is a structural deficit of liquidity in the banking system *vis-à-vis* the central bank, and when the central bank is a net borrower, there exists a structural surplus or excess liquidity in the banking system (Bindseil 2004, p. 49).

The structural position matters because it can have an impact on the effectiveness of a central bank's given operational framework. It has been suggested that when the central bank is a net lender to the banking system, it is in a stronger position to influence prices in the interbank market through its monopoly position as a provider of central bank money (Ganley, 2002, p. 6). Conversely, when the banking system has more than enough reserves for necessary transactions, the central bank most likely enters the market as a marginal taker of central bank money. In this case its influence would come from its ability to pay interest on reserves, as banks' incentives would revolve around return on their reserve assets and the opportunity cost of storing excess reserves with the central bank. It is worth mentioning here that not everyone is convinced of material differences in this regard, and in a 1994 paper, Mervyn King states that control of prices or quantities carries across, irrespective of whether a central bank is a net supplier or demander of its own liabilities (King 1994, p. 268). In any case, it is also important that the chosen liquidity management system is robust to sign-switching, i.e. swings between a liquidity deficit and a surplus without difficulty and operates effectively under both conditions.

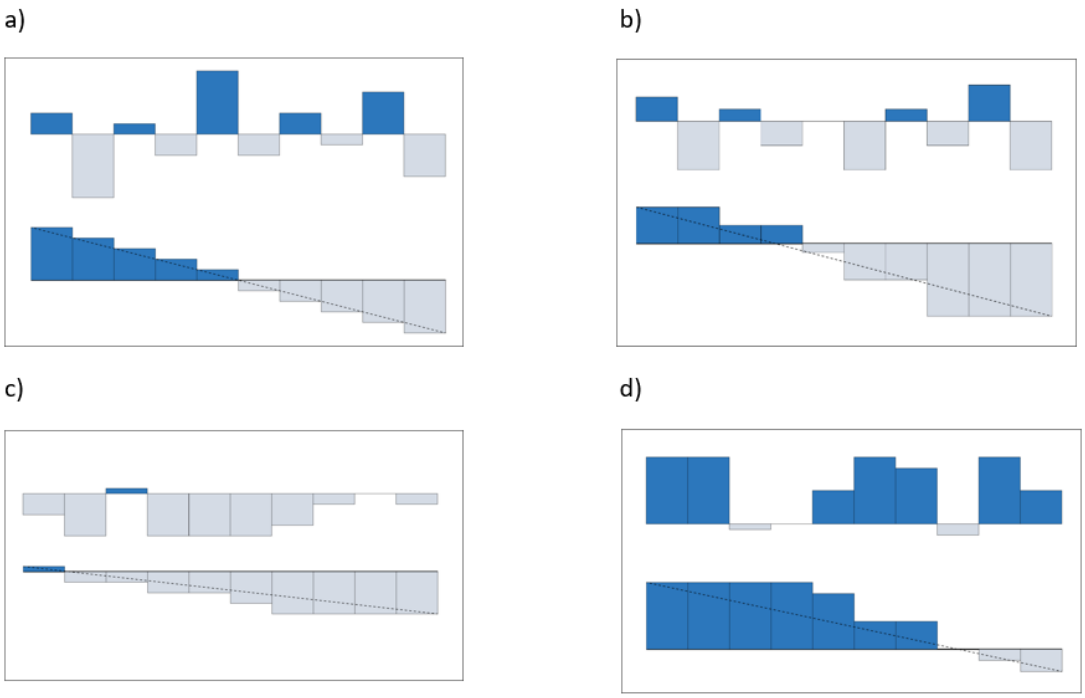

Figure 3. Different aggregate and individual structural positions in the banking system. Graphs a-d. The horizontal axis contains the individual banks and the vertical axis depicts each banks total reserves, with positive amounts above the horizontal axis and negative amounts below.

It is important to note that it is not just the sign of the structural surplus that is of significance, but also the magnitude and the individual structural positions of banks in the system. The graphs a-d in figure 3, depict different structural positions within a banking system.

In graph a), the positions of individual banks amount to zero-sum, i.e. the structural liquidity position *vis-à-vis* the central bank is zero. In this case, it is sufficient for the banks to distribute liquidity among themselves in the interbank market. Autonomous factors are bound to affect total liquidity in the system, but should be offset by the central bank and the individual positions may continue to be more or less in balance. Demanded central bank reserves (D) equal the supply of central bank reserves (S) in the interbank market and there is no need for additional central bank interventions (I).

Graph b) shows a banking system which has more banks in a liquidity deficit but still there is some potential for interbank trade. The area below the line is bigger than the one above, and central bank interventions will have to amount to at least demand less supply in the interbank market, $I = D - S$. Meanwhile, interbank activity should preferably equal the supply. The question here becomes whether the deficit is large enough to be sustained even in the face of autonomous factor flows. Bindseil (2008, p. 38) notes that a negligible deficit is unfavourable

for at least three reasons; the small size of open-market operations and few participating banks may lead to a noisy outcome, autonomous factor shocks may swing the deficit into surplus, leaving the central bank on both sides of market interventions, and lastly, the market may be easily manipulated by small, strategic recourses to standing facilities.

Graph c) shows a banking system with a significant structural deficit. These circumstances have traditionally been the most common, and some have suggested that monetary policy implementation under deficit conditions is easier and more effective as seen from the central bank. Certainly in this setting, banks have no option but to rely on reserve provision from the central bank, while conversely a surplus may be drained, or not, according to preferences of the banks.

Graph d) illustrates precisely what a significant surplus looks like. There may, or may not, be deficit banks that would benefit from interbank trade and the surplus banks may, or may not, want to transact with them in the market. The difficulties of precise draining in these circumstances may lead to low interest rates as surplus banks compete to lend out their reserves. If there is a small number of deficit banks, they may also have difficulties borrowing, leading to widespread holdings of precautionary reserves, and high interbank rates for the few that are still in deficit. Graph d) is closest to situation in the Icelandic banking system at this writing[1] and we will discuss later what measures can be taken to adapt to such circumstances.

3.3 Surplus liquidity

Foreign exchange build, monetary financing and bank rescue have traditionally been identified as the three main sources of surplus liquidity in an economy (Gray 2006, p. 5). Many central banks around the world found themselves in a situation, albeit of their own creation, of significant stocks of central bank reserves in the wake of the global financial crisis. We can therefore identify a fourth main source of surplus liquidity as being the provision of exceptional liquidity during or following a crisis or recession; so-called unconventional monetary policies or quantitative easing.

Appendix I and II show that the expansion of the CBI balance sheet and hence the proliferation of reserves in the Icelandic banking system, can be seen as having three main parts. First, the run-up to the crisis where a collateral-loan driven expansion of central bank reserves was driven by Eurobond issuance, commercial banks' issuance of covered bonds and the associated broadening of the central

[1] Gerður Ísberg, verbal communication, August 2017.

bank's collateral requirements. Secondly, this last part evolved into crisis lending in 2008 with the collateral later placed in the CBI's holding company ESÍ (Eignasafn Seðlabanka Íslands). Thirdly, regular purchases and interventions of the central bank in the market for foreign exchange starting in 2011.

There is an important distinction between excess reserves, which are here taken to mean reserves in excess of required reserves, and surplus reserves, which are balances in excess of demand (Gray 2011, p. 7). Excess reserves may be demanded by commercial banks or not, and the willingness to dispose of excess reserves may depend on market conditions as well as the opportunity cost of holding them. When reserves are remunerated, particularly at the policy rate, banks will be much more likely to want to hold them than if they were unremunerated. Surplus reserves are more akin to unwanted reserves.

When banks try to dispose of surplus reserves, this tends to lead to an easing of monetary conditions. Either, those efforts push down short–term interest rates as banks try to lend the funds to other banks, or they weaken the exchange rate as banks try to sell surplus domestic currency balances for foreign exchange with knock-on effects on inflation. The opposite occurs if actual reserves are below demanded levels as banks bid for the same small stock of available reserves and a monetary tightening is implied. Central banks endeavour to square the system so that supply and demand is matched and if there is uncertainty as to the level of surplus reserves, the central bank has to try to estimate it (Gray 2011, p. 6-7). This applies especially to maintaining a symmetric corridor framework, as reaching the target of monetary policy rests on active interbank trading and maintaining the exact amount of reserves required to clear the market.

As has been noted above, monetary policy implementation, when the banking system is characterized by a significant structural surplus, may become complicated. If beliefs, or experience, suggest that monetary policy implementation is best carried out under conditions of liquidity deficit, there are mainly two ways of creating such a deficit. In order to maintain demand for reserves from the banking system above the existing supply, it is necessary to either conclusively increase demand or to drain supply.

It is possible to create additional demand for reserves from the banking system for example by establishing or increasing reserve requirements for banks beyond what banks would otherwise ask for. Another way is to tie up the excess liquidity, by issuing liquidity-absorbing debt certificates, in other words by draining liquidity. The deficit position that is the result of such measures might be kept

sufficiently large in order to ensure that the resulting structural position does not swing frequently between surplus and deficit.

Neither method mentioned above, reserve requirements or draining, is a definitive solution to the challenge of surplus reserves, nor will they affect the underlying structural position. However, they can tide a central bank over for a period of time until a surplus position is unwound, or other methods of implementing monetary policy are introduced. Some central banks may find success with operating under a significant surplus. Efforts to create additional demand from banks may have notable consequences, including that reserve requirements, especially when unremunerated, can lead to money market distortions. Another significant problem for central banks is that draining liquidity from the market is costly and can lead to concerns about loss of central bank independence (Gray, Talbot 2006, p. 6). Appendix V looks at the cost associated with the CBI's interest payments on reserves as well as additional draining efforts from 2006 to 2018.

For the abovementioned reasons, several banks that originally used corridor systems sought alternative methods of managing liquidity in the system during and after the crisis, as extraordinary liquidity provision led to the proliferation of central bank reserves in their systems. Many banks, including the Central Bank of Iceland, resorted to a floor, as we will see also in the chapter on a floor system. Other reasons than those mentioned above, such as excessive interest rate fluctuations, led banks to narrow their corridors for a period of time during the crisis.

In Norway, surplus reserves were to a high degree caused by banks borrowing reserves from the central bank and then placing them in deposit accounts at the Bank. These precautionary reserves were therefore acquired by the banking system for a few basis points and in the floor system they preferred to hold on to these reserves rather than trade in the interbank market. This is subtly different from a situation when surplus reserves are non-borrowed, as banks face different choices in trying to dispose of them, and these reserves are furthermore often remunerated, without the associated cost of borrowing.

The surplus reserves that have been floating around in the Icelandic banking system since the crisis have to a large degree been caused by crisis lending on the one hand and central bank purchases of foreign reserves on the other. Both actions constitute public goods, but can entail a significant cost to the central bank. As was mentioned above, monetary policy implementation may be more challenging under a structural surplus than a deficit. Many other central banks are dealing with similar issues and to some extent in uncharted waters. The case of central

bank liquidity management in an environment of non-borrowed surplus reserves and the optimal incentive structure for banks in these circumstances therefore deserves to be studied further.

3.4 FX flows and sterilisation

As mentioned, the stock of central bank reserves in the Icelandic banking system can, to a significant degree, be traced to crisis lending in the first instance and FX purchases by the central bank in the second instance. FX inflows have a very different impact on central bank reserves depending on whether the exchange rate is fixed or floating. In the case of a floating exchange rate, consecutive flows of foreign currency compete for the same amount of domestic reserves in the system. This leads to a gradual rise in the price of the good that is being bought, domestic reserves, and a strengthening of the domestic currency. The reverse happens in case of foreign currency outflows.

When the exchange rate is fixed, the central bank will normally try to avoid a change in the price of the domestic currency and intervene to buy or sell foreign currency, changing the amount of central bank reserves in the system. Traditional textbooks will report that a change in the money supply should be offset by sterilisation to avoid a change in monetary conditions. As we have discussed, in corridor systems central banks offset autonomous factors to square the interbank market through open market operations so that demand equals supply. Quota and floor systems are more robust to less precise steering of reserves. However, when reserves are remunerated, or the central bank aims to drain part of the surplus with longer-term instruments, costs to the central bank increase.

Danmarks Nationalbank (2009, p. 73) points out in this context that if interest-rate targeting is applied in monetary policy, as is the rule, an intervention is sterilised if the transaction does not impact on short-term money market rates. On the other hand, if short-term money market rates are affected, the intervention is non-sterilised. The Danish central bank has added to its toolbox a mechanism to discourage speculation in the domestic currency, see chapter on quota systems.

Appendix I shows how the balance sheet of the Central Bank of Iceland continues to be very large, despite some winding down of crisis legacy issues. This is largely due to significant interventions of the CBI in the interbank market for foreign reserves. Appendix IV shows recent turnover in the interbank market for foreign reserves as well as the CBI's share through interventions. As long as there is in place a managed float, large fluctuations in the stock of domestic reserves can be expected. Small, open economies with their own currencies may always be subject to exaggerated fluctuations. Even so, it may be possible to design the

liquidity management system in such a way as to bring stability to the market for domestic reserves and deal effectively with surplus reserves.

4 Main liquidity management systems in use – comparison and examples

As mentioned before, in order to gain insight into what liquidity management system might be best suited for Iceland, some representative types of systems will be discussed below with examples of their use. The wide corridor with reserve requirements and averaging is typical for large economies as well as the euro system. A narrow corridor has been used in Australia, Canada and New Zealand as well as Sweden, which is used as an example. A floor system, which can also be categorized as a corridor with the policy rate at the floor of the corridor, characterized many advanced economies' monetary policy implementation following the GFC, as can be seen later in the paper. The example taken is the floor system in Norway, which Norges Bank has written extensively about. Norway is again the example in the chapter on quota systems, since Norges Bank made the change to a quota from a floor to try to avoid some of the pitfalls of a floor system. The Danish liquidity management system is also used as an example here, as it has some characteristics of a quota system. The Nordic countries are useful examples for the purposes of this paper, as there is a close dialogue between market operations departments in these countries and extensive knowledge of these systems exists at the CBI. However, other quota systems, such as the one in operation at the Reserve Bank of New Zealand, would also be worthy subjects for further examination.

4.1 A wide corridor system with reserve requirements and averaging

The corridor system is the most common liquidity management framework. We will discuss two versions, a wide corridor with reserve requirements and averaging and a narrow corridor with no reserve requirements. The former is the subject of this chapter and represents well monetary policy implementation in many countries, including Iceland and the United Kingdom as well as large monetary areas such as the euro system. The narrow corridor will be discussed in the next chapter.

A corridor has standing facilities at either end of the corridor that lend to and accept deposits from banks. The deposit rate constitutes a floor for the overnight money market rate, as no bank will want to lend to other banks at a rate lower than it gets at the central bank. The lending rate forms the ceiling of the corridor as banks will not want to borrow from other banks at a higher rate than they will be offered by the central bank. Demand for reserve balances falls with the overnight rate in the market and given demand the equilibrium interest rate in the overnight money market is determined by the supply of liquidity. Total supply is determined

by the amount supplied by the central bank in addition to autonomous factors. The supply curve is independent of the interest rate and hence vertical as can be seen in figure 4 (Bernhardsen, Kloster 2010, p. 5).

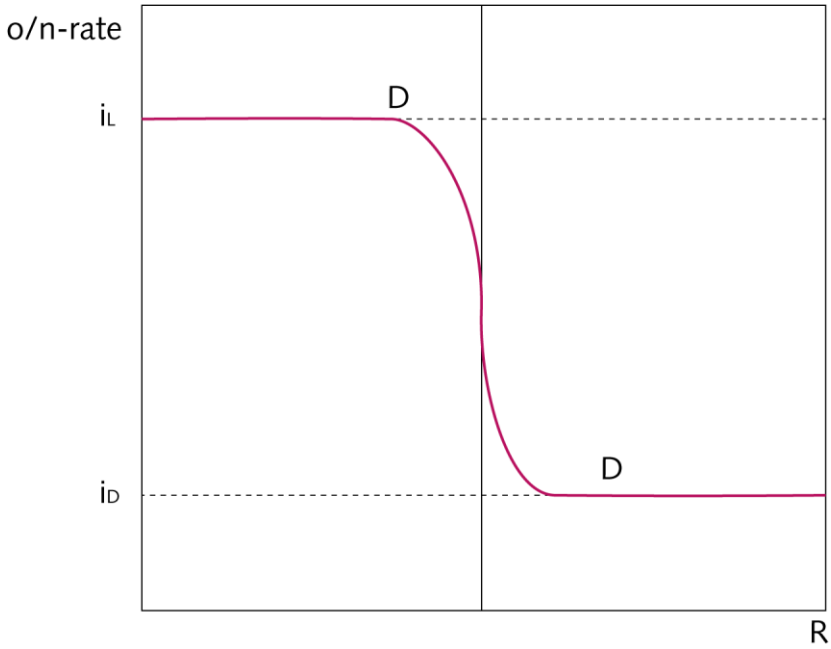

Figure 4. Wide corridor system. The vertical axis denotes the interest rate, and the horizontal axis the amount of reserves. The overnight interest rate will settle where the demand curve (the red line) meets supply (the vertical line). From Riksbank (2014, p. 46).

The implementation of monetary policy in such a framework means keeping the level of reserves in the system such that there is an equal probability that banks need to use either facility at the end of the day. With punitive interest rates on either side, banks with opposite liquidity positions will have an incentive to trade rather than use the central banks standing facilities and the equilibrium interest rate will end up in the middle of the corridor (Bindseil, Jabłecki p. 14). To keep the overnight rate close to the target rate, the central bank has to adjust liquidity supply, usually through open-market operations (OMO) so that this rate materialises in the overnight market. If that fails, either because of an inaccurate liquidity forecast or because the central bank does not intend to fully offset the deficit or surplus, interest rates may jump quickly to either extreme with an associated impact on market rates (Gray, Talbot 2006, p. 10). The latter scenario will be discussed further in the chapter on floor and quota systems. Instances where interest rates in the money market are below or above the limits set by the standing facilities can happen when certain institutions do not have direct access to the central bank's facilities, other distortions exist in the market or in times of distress.

When reserve averaging is combined with the corridor, this produces a flatter demand curve around the target interest rate. The flexibility afforded by reserve averaging makes demand more elastic and lowers volatility in short-term interest rates. However, Bindseil and Würtz (2008, p. 3) note that reserve requirements create a complex inter-temporal structure for liquidity demand and run counter to the aim of stabilizing short-term interest rates. It is common to see interest rate volatility increase significantly on the last day of the maintenance period. The Bank of England and the ECB adopted a narrow interest rate corridor on the last day of the maintenance period to counteract this phenomenon.

It is useful to elaborate on the usefulness of required reserves, however, as they are still used for a variety of reasons. Required reserves were likely originally established mainly to ensure that banks had enough liquidity for settling their internal transactions. Their ratio to the broad money supply subsequently achieved a status in the theory as the main determinant of activity in the economy as was mentioned in the chapter on theory above. They were thought to impact monetary control through two main channels, the money multiplier and the impact of RR on interest rate spreads (Gray 2011, p. 10).

Unremunerated required reserves (URR) can lead to distortions as they add to banks' financial intermediation costs and increase the spread between commercial banks' deposit and lending rates. But for the same reasons they can be of use in certain circumstances. For example, central banks have used a marginal URR as a temporary measure to tackle strong credit growth or lean against capital inflows which increase deposits in the banking system. Banks may lower their deposit rates or raise their lending rates, or both, and in this way monetary policy can be tightened without encouraging short-term capital inflows (Gray 2011, p. 6-12). Brei and Moreno (2018, p. 3) found that banks responded to higher reserve requirements by raising loan rates but tended to keep deposit rates unchanged during normal times. Additionally, banks were found to either keep deposit rates stable or decrease them during periods of large capital inflows, relieving pressure on the capital account.

Reserve requirements can also be used change the structural liquidity position of the banking system as was mentioned in the chapter on surplus reserves. (Rule 2015, p. 13-14).

In June 2018 the CBI amended its arrangements on credit institutions' reserve requirements by splitting the 2% reserve requirement (of the reserve base) in two parts, 1% fixed reserve requirement bearing no interest and the other 1% with averaging as before bearing the same interest as deposits on current accounts. The

intention was not to change the monetary stance but to reduce the cost to the Central Bank in holding large international reserves while the interest rate differential with abroad remains as wide as it currently is.

A well-known trade-off in the design of liquidity management systems is between accurate short-term interest rate steering and activity in the interbank market. The wider the corridor, the higher the penalty for depositing or borrowing through the central bank standing facilities. This gives banks increased incentives to trade in the interbank market, but with more potential for fluctuations in the interbank interest rates. The narrower the corridor, the less fluctuations in the short-term interest rates but with decreased activity in the interbank market and more central bank risk-taking. This will be discussed in some more detail in the next chapter on narrow corridor systems.

It is sometimes considered an advantage of corridor systems that with increased interbank activity and less recourse to the central bank there is less need for holding collateral of the type used in transactions with the central bank. The majority of interbank market transactions are still unsecured and any changes to this would lead to higher collateral intensity overall. In a corridor system, total liquidity will be slightly above zero, as the aim is for banks' positions to amount to zero-sum. In a floor system, total liquidity will need to be substantially higher to bring short-term rates down to the central bank's deposit rate. Increased central bank lending requires more collateral (Bernhardsen and Kloster, 2010, p. 10).

Bindseil and Jabłecki (2011, p. 6) note that historically central banks were only liquidity providing and for example the Federal Reserve only introduced remuneration on deposits during the GFC which will be described later in the context of the floor framework. According to their paper, the Bank of Canada (BoC) was the first central bank to introduce a corridor system in 1994, with a width of 50 basis points. Before, the BoC had not imposed reserve requirements and been faced with considerable short-term interest rate volatility. The Swedish central bank was also an early adopter of the framework in 1994.

Although we are preoccupied with symmetric corridor systems, asymmetric versions are also known. Intuitively, a symmetric system is easy to grasp from the probabilistic point of view, where at some point in time there is equal probability of recourse to either standing facility. When the penalty for undershooting on reserves is high, banks will bid such that they will be long at the end of the day and when the penalty for overshooting is high, banks will bid for funds so that they will be short at the end of the day. Bindseil and Würtz (2008, p. 27-31) show that short-term interest rate volatility will be lower the closer the target rate is to

either of the boundaries and suggest sticking to either extreme, i.e., either fully symmetric or fully asymmetric approaches.

4.2 A narrow corridor system without reserve requirements

The second common version of a corridor system is the narrow corridor, often symmetric with a width of ±25 basis points and usually operated without reserve requirements. Instead it benefits from daily open market operations to lower volatility due to fluctuations in liquidity conditions. Hence the system does is not characterized by the flat area around the policy rate that is present in a wider corridor with averaging, but the narrowness of the corridor can on its own lead to less volatility in short-term interest rates (Gray, Talbot 2006, p. 15). This framework has been used for example in Australia, Canada, New Zealand and Sweden (Bindseil 2016, p. 5).

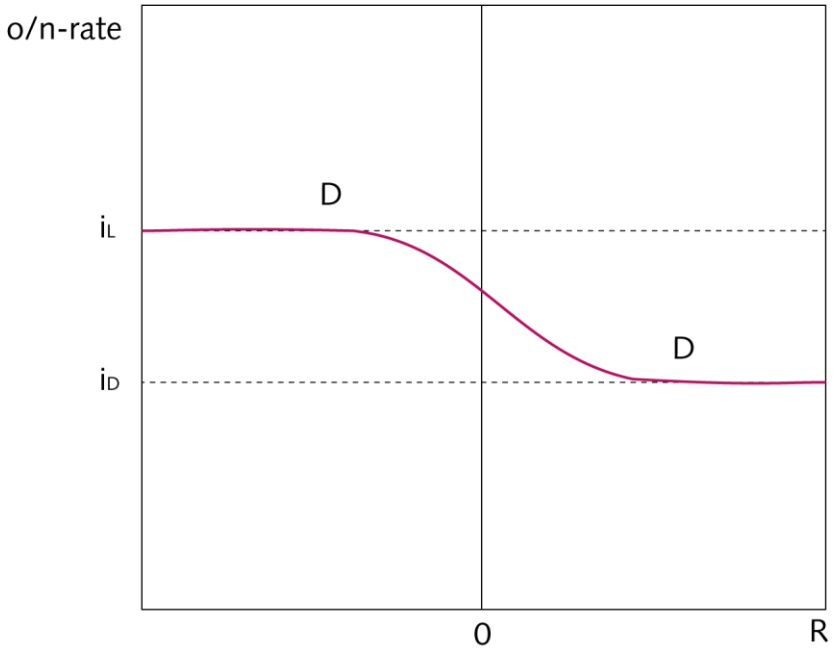

Figure 5. Narrow corridor system. The vertical axis denotes the interest rate, and the horizontal axis the amount of reserves. The overnight interest rate will settle where the demand curve (the red line) meets supply (the vertical line). The margin for fluctuations is narrower than in the wide corridor system. From Riksbank (2014, p. 46).

The narrow corridor system works in the same way as a wide corridor except reserve averaging is usually left out as the narrowness of the corridor on its own can restrict interest rate fluctuations. The narrow corridor has sometimes been associated with more automaticity and less need for fine-tuning operations. However, this depends on the circumstances as can be seen from the Swedish example below.

We have already mentioned the trade-off between increased interbank trading (with a wider corridor) and more accurate interest-rate steering (in the case of a narrow corridor). It is useful to think about what happens in a zero corridor system where the target rate and standing facilities are all at the same level. Assuming that there are non-zero transaction costs in the interbank market, all banks would seek recourse to the central bank and there would be no interbank trade. With a gradual widening of the corridor, its width will eventually surpass transaction costs and interbank trade becomes profitable. Generally, there is a threshold above which little additional turnover is created, while interest rate volatility increases significantly. This threshold varies with the level of transaction costs (Bindseil and Jabłecki 2011 p. 19-20).

However, one might wonder whether the benefits of interbank trading suffice to justify the efforts inherent in maintaining active interbank markets. There is some literature to support that interbank trading improves financial stability through increased bank monitoring of other banks as unsecured lending only takes place if the lender considers the borrower as safe (Bernhardsen and Kloster 2010, p. 9). Presumably with this in mind, the Bank of England designed their operational framework so that banks "test their name" regularly in commercial credit markets (Bindseil and Jabłecki, 2011, p. 10). On the other hand, Bernhardsen and Kloster (2010, p. 9-10) posit that as most interbank trading is on the short end of the yield curve, incentives to monitor long-term solvency position are lacking, while this is what matters for financial stability.

A more important consideration might be whether trade in the interbank market and market-driven formation of the shortest rates in the money market is required to implement monetary policy. While banks are faced with certain effective rates through transactions with the central bank, these rates may not be known in the public domain and their information value is therefore potentially lost. Linzert and Schmidt (2007) maintain that the central bank must ensure that the overnight rate in the interbank market is close to its policy rate as it is the first step in the transmission of monetary policy (Riksbank 2014, p. 39).

However, it seems questionable to place great importance on central bank risk-taking under normal conditions when the prevailing expectation is for the central bank to become even more predominant on the interbank market and in bilateral operations as soon as conditions tighten. To be fair, Bindseil and Jabłecki (2011, p. 22-23) show that in times of crisis, both central bank and interbank intermediation increase in scope and that the share of liquidity provision depends on the width of the corridor in place.

An example of a narrow corridor is the liquidity management system operated by Sveriges Riksbank. The Riksbank employs a fairly narrow corridor framework with the width delimiting the standing facilities with a few exceptions at ±75 bp, but the Bank also conducts frequent fine-tuning operations with an inner corridor of ±10 bp. The Bank does not formally designate the overnight interest rate level as a target but its monetary policy decisions focus on its repo rate which is in the middle of the corridor. The Bank uses the repo rate in its open market operations in the form of one week repos or certificates.

The liquidity management framework is characterized by precise steering of reserves in the system, so that the Bank aims to counteract almost exactly in- and outgoing autonomous factors through its open market operations such as repos and certificates. Hence, the Riksbank squares the liquidity in the system but leaves it to the banks themselves to even out individual structural positions with the aim of maintaining activity in the interbank market.

The Bank started to provide additional liquidity in the run-up to the global financial crisis and before that fine-tuning operations had been minimal. Following the extraordinary liquidity provision, and even after 2010, the banks preferred daily liquidity certainty and longer-term deposit instruments became almost obsolete, leaving massive amounts in daily fine-tuning operations. During the provision of exceptional liquidity the o/n rate was pushed down, but only by approximately 10 pb to the inner floor of the corridor since the banks could always rely on depositing with Riksbank at this rate.

The development of structural liquidity in Sweden has impacted how monetary policy is implemented. The Riksbank supplied the banking system with liquidity from 1997-2007 but during the summer of 2008 the repos were getting smaller. This indicates that the structural deficit of the banking system was decreasing and there was a risk that the Bank would have to drain and supply liquidity to the system in alternating weeks. This was seen as an unnecessary complication for monetary policy counterparties and the Riksbank responded by performing a long-term structural operation that entailed swapping foreign currency for reserves and continued to supply liquidity through repos.

As 2008 wore on, it became clear that unrest in global financial markets was affecting financial markets in Sweden and the Riksbank launched various loan instruments with different maturities, also in FX. The reserve surplus was drained through various measures, from fine-tuning to repos to longer-term certificates. Even though the extraordinary measures have expired, the banking system is still in surplus, mostly due to the Riksbank's annual payments of profit to the Treasury,

but also caused by less public demand for notes and coin (Sveriges Riksbank, 2014, p. 72-84).

Many central banks narrowed their standing facility corridors during the financial crisis although this action is not necessarily what established facts might prescribe in the circumstances. Loss of liquidity in interbank markets might in fact suggest a widening of the corridor to increase incentives for interbank trade. On the other hand, the loss of predictability and the resulting volatility of overnight rates might suggest a narrower corridor (Bindseil and Jabłecki, 2011, p. 11).

Bindseil and Jabłecki (2011, p. 12) point out that in some cases corridors were widened again fairly quickly, citing Hungary and the euro system. One lesson that Bernhardsen and Kloster (2010) draw from the crisis is that ex-ante flexibility could be built into systems, with a wide corridor width under normal conditions in order to encourage interbank activity and narrow under stressed conditions to enable supply of excess liquidity while at the same time retaining control over short-term interest rates (Bernhardsen and Kloster, 2010 p. 29). Another approach might entail retaining the flexibility to turn a corridor into a floor when the central bank's priorities shift to liquidity provision.

Steinsson (2004, p. 76) suggested that Iceland take up a narrow corridor system similar to the one in use by the Bank of Canada. The article identified several changes that could be made to increase the efficiency of the money markets as well as reduce fluctuations in the target interest rate. Those include transferring the treasury account from the central bank into the banking system, lowering the fee for repo transactions at the stock exchange so that banks could conduct short-term repos with each other, allowing pension funds to conduct short-term repos with banks and establishing a formal market where banks could conduct anonymous repos with each other.

4.3 Floor system

The functioning of the corridor system that we discussed in the two previous chapters is dependent on the central bank maintaining reserves in the system exactly so that demand and supply is matched in the interbank market. If there is a surplus of liquidity in the system, banks will seek to place their surplus reserves in the central bank's deposit facility rather than earning no return on those assets and market interest rates will reflect this recourse. This happens automatically in the case of the CBI's counterparties as their current accounts are also their transaction accounts in the settlement system. Interbank rates will sink below the policy rate and towards the floor of the corridor (Gray and Talbot, 2006, p. 14).

Hence, the system can also be referred to as a fully asymmetric corridor system, where the positioning of the policy rate prescribes whether it is a floor or a ceiling.

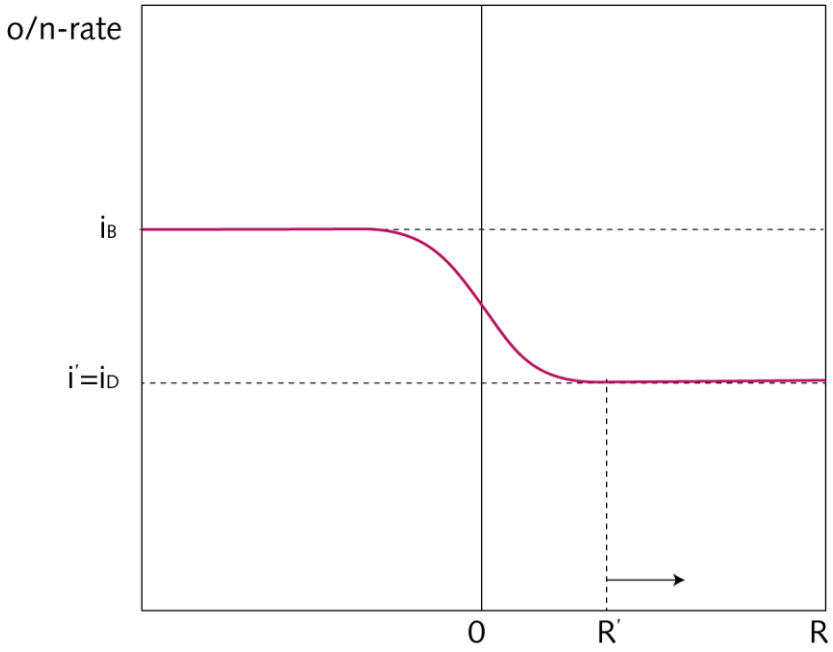

Figure 6. Floor system. The vertical axis denotes the interest rate, and the horizontal axis the amount of reserves. Reserves in the system are above what banks need for daily transactions and the overnight rate will settle at the floor of the corridor. From Riksbank (2014, p. 50).

In a floor system, the policy rate is equal to the central bank's current account rate, which is then the rate of interest the central bank targets in the overnight market. To achieve this goal, the central bank must supply enough liquidity to make the supply curve shift to cross the demand curve on the flat part, where it is no longer responsive due to hitting the central bank deposit rate (Bernhardsen and Kloster, 2010, p. 5-6). There can be several reasons for this development, notably if the central bank is not able, or willing, do drain all surplus liquidity in its open market operations. Alternatively if surplus reserves have grown due to e.g. FX interventions or exceptional liquidity support.

The main advantage, according to Keister et. al. (2008, p. 51), is that monetary policy can be divorced from money. The central bank can supply any amount of extra liquidity without pushing shorter money market rates below the policy rate. Hence, the interest rate can be set to achieve monetary goals, while the quantity of liquidity in the banking system can reflect the achievement of other goals, the most important one being financial market stabilisation. In times of financial stress, central banks may want to increase reserve balances either as an intended policy or a side effect of different kinds of asset purchases. In a floor system, increasing the amount of reserves in the system will not conflict with the monetary policy

goals of stabilising short-term money market rates close to the key policy rate (Bernhardsen and Kloster, 2010, p. 6). During the crisis, the need to supply more reserve balances meant that many central banks found it necessary to move towards a floor system, in order to break the link between reserves and the overnight interest rate (Bernhardsen and Kloster, 2010, p. 27-28).

Since changes in demand for reserves do not have great effects on the short-term interest rate in the floor system, this can be a useful attribute when it is difficult for the central bank to make forecasts about the development in autonomous factors and especially when the treasury's accounts are in the central bank. Large in and outflows from the accounts are easier to handle when there are considerable amounts of reserves in the system (Syrstad, 2011, p. 8).

Among the disadvantages is that banks have less incentives to distribute reserves among themselves and the central bank becomes more predominant in liquidity supply. As an example, if one bank needs to borrow reserves to clear the day and all other banks have deposits remunerated at the policy rate at the central bank, they will not be willing to lend unless they are compensated for the effort which can lead to a significant rise in the short-term interest rate. A floor system has therefore not under all circumstances been associated with less interest rate volatility. The banks' opportunity cost for holding significant reserves is low (even if borrowed, except for the collateral cost and margin between borrowing and depositing). As borrowing from other banks can be expensive, the holding of reserves becomes a precautionary necessity. The central bank is then forced to supply increasing amounts of reserves in order to keep interest rates at the desired level and in a sense loses control over the growth of reserves as was the experience in Norway (Syrstad, 2011, p. 9).

Bernhardsen and Kloster (2010, p. 15-27) review the experience of several advanced country central banks over the course of the global financial crisis and suggest that many of them approached at least temporarily something resembling a floor system in an environment of surplus liquidity and weaknesses in the financial system. This includes the ECB, Federal Reserve, Sweden's Riksbank, Bank of Canada and Reserve Bank of New Zealand. They take the view that all measures that make it less costly or less likely for banks to use the central bank's facilities are a move from pure corridor systems towards a floor. Syrstad (2011, p. 10) points out that the shift to a floor is simple and merely entails announcing that all reserves are remunerated at the policy rate.

In the case of the Federal Reserve, it required emergency legislation that allowed the Fed to begin paying interest on reserve balances, including required reserves

which had until then been unremunerated. Before that, the Federal Reserves' liquidity management system had been a pure reserve requirement system. However, that particular version could have be seen as an asymmetric corridor system with the lower bound at zero with the asymmetry caused by the fixed distance between the two lending facilities while the corridor widens as interest rates are raised but the floor stays at zero.

Norway is an important example. The functioning of the floor system, and reasons for the shift to a quota system, provide some key lessons for other countries, especially those operating under a floor system. Like Iceland, Norway introduced an inflation targeting regime in 2001 and has had a floor system in place even longer, since the mid-1990s. In the floor system, the policy rate was the interest on banks overnight deposits in Norges Bank and all reserves were remunerated at this rate. The Bank addressed autonomous factors by supplying additional liquidity via fixed-rate loans at a rate marginally higher than the key policy rate. Thus total liquidity could be maintained at an appropriate positive level although structural liquidity was fairly volatile and fluctuated around zero (Bernhardsen and Kloster, 2010, p. 3).

Voluntary reserve holding was assumed and banks with a liquidity deficit had to borrow from banks with a liquidity surplus. If banks could not borrow from each other, they would have to take recourse to a borrowing facility, D-loans, at Norges Bank. The rate was one percentage point above the policy rate and formed a ceiling for the shortest money market rates. Banks could borrow reserves at the F-loan rate and deposit at the policy rate, with a cost of only a few basis points (Norges Bank, 2014, p. 4). Borrowing in the interbank market was expected to take place within the one percentage point corridor, and in fact the interbank rate stayed close to the floor for most of its duration (Bernhardsen and Kloster, 2010, p. 2-4).

The floor system performed well in many respects. The policy rate was fairly well realised, the payment system worked efficiently and the system was robust under the financial crisis of 2008. On the other hand, the system was not seen to sufficiently incentivise interbank trading of reserves. Reserves demanded by the banking system grew over time and Norges bank lost control over their level (Syrstad, 2011, p. 14-15). In the next chapter we will take a closer look at the system chosen as a replacement by Norges bank, a tiering, or quota, system.

4.4 Quota system

The quota system is similar to a floor system in that reserves are remunerated at the policy rate. Instead of all reserves being remunerated, this only applies to a certain quota, and all reserves above the quota are remunerated at a higher or

lower rate. The quota system is also similar in that the central bank will aim to steer reserves in the system to a slight surplus above the quota, so that banks' interest rates will decline towards the interest rate on deposits.

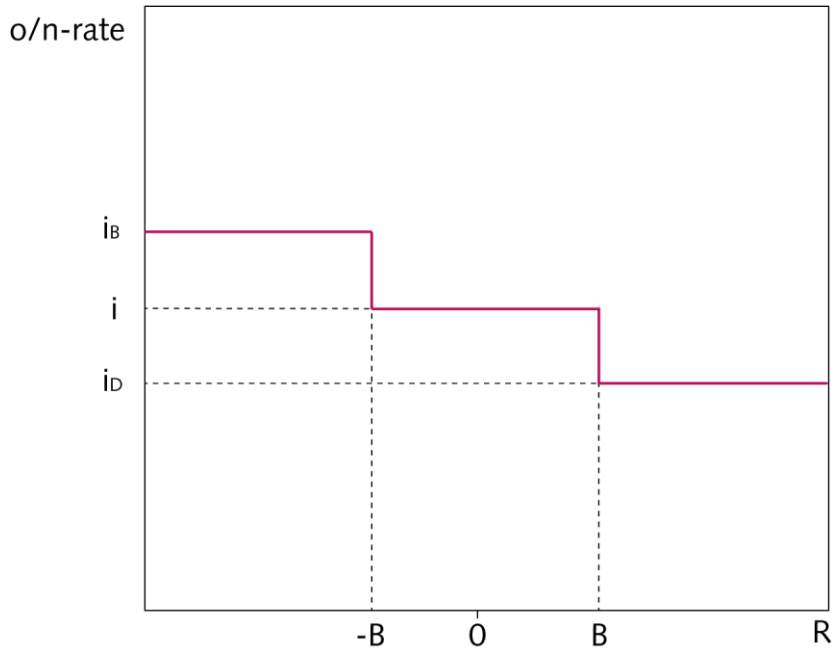

Figure 7. Quota system. The vertical axis denotes the interest rate, and the horizontal axis the amount of reserves. All lending and borrowing that falls within the quota, denoted by [-B, B], will be remunerated at the policy rate. The penalty rates above and below will discourage additional holdings of reserves. From Riksbank (2014, p. 48).

Figure 7 gives a version presented by Bindseil and Würtz (2008, p. 2) under the name TARALAC, an acronym for Target Rate Limited Access Standing Facility. The system includes access to a standing facility which is offered at the policy rate, i.e. without a penalty spread, but only up to a certain limit. Figure 7 depicts a two-sided version which has two standing facilities, one for borrowing from the central bank and the other for depositing with the central bank. In this version, any amount of reserves above the quota is remunerated at a lower rate and any amount of reserves borrowed in excess of the quota carries interest at a higher rate. The central bank needs to steer reserves in the system such that the probability of the banking system needing to borrow more than B is the same as the probability of needing to deposit more than B. The larger B becomes, the less probability of the banking system falling outside of the interval [-B, B], the more stable the overnight rate and the weaker the incentives for interbank trade (Riksbank, 2014, p. 49).

The choice of standing facility as well as interest rate levels and size of quota can be adjusted according to countries' principal goals as we shall see later in this chapter. According to Bindseil (2016, p. 17-24), this system has been implemented

in New Zealand since 2007 as a tiering system, and in Norway since 2013 as a quota system and can be regarded as an alternative to reserve requirements or narrow corridors. This paper will first consider the example of Norway which made the switch from floor to quota in 2011. We will then consider the example of Denmark which corresponds in many ways to a one-sided quota system.

A quota system has several advantages, among others that it does not call for reserve requirements (Bindseil, 2016, p. 24-5). As the need to steer reserves with extreme accuracy is missing from the central bank's point of view, forecast issues also matter less in a quota system as they do in a floor system (Norges Bank, 2014, p. 7). This is partly due to the fact that the quota forms a natural target for banks' liquidity management as long as it encompasses most of banks' daily transactions.

A quota system frames the reserve position for daily liquidity management by the banks and disincentivises holdings outside of that. There are some similarities with reserve requirements, although in this case banks are "trusted" to maintain the necessary liquidity and instead of aiming for a minimum through reserve requirements (albeit at beneficial interest rates), the aim is to encourage the right amount through incentives. This can work both ways in a two-sided quota system, where deposits and lending within the quota receive the policy rate, but borrowing above and depositing above the quota carry penalty rates.

The quota system usually presents more incentives for interbank trade compared to the floor system, but slightly less than a corridor system. When the interest rate on excess reserves is lower than on reserves within quota, banks that are within the quota are sometimes less motivated to fill their quota by borrowing reserves than banks above the quota are to lend theirs out (Syrstad, 2011, p. 15). This would seem counterintuitive as both counterparties stand to gain from trading reserves in the middle of the margin presented by the quota rate on the one hand and excess reserves rate on the other. However, it seems that the impulse to save is in these circumstances stronger than the impulse to gain.

Norway implemented a one-sided quota system in October 2011 where reserves below the quota are remunerated at the sight deposit rate, or policy rate, and reserves above the quota obtain a lower rate ("reserve rate"). The main purpose of changing the system was to limit bank demand for central bank reserves and to provide a stronger incentive for banks to trade reserves in the interbank market. The shift was successful in that interbank activity increased and central bank reserves stabilized at the level targeted by the central bank. Norges Bank did a review of the quota system in 2014 and reported that banks had adapted fairly quickly to the new arrangement and found it to function efficiently, although some

suggestions for improvements were made. Norges Bank (2014, p. 6-7) has characterized the quota system as a compromise between a floor system and a corridor system.

As with the floor system, the central bank aims to maintain enough reserves in the system so that the overnight rate stays close to the policy rate. However, short-term market interest rates can approach the policy rate from above or below, as the new effective floor for interest rates is the reserve rate on reserves above quota. Banks with surplus reserves will be willing to lend them out at less than the sight deposit rate to avoid depositing with the central bank at the reserve rate (Norges Bank, 2014, p. 7). The well-functioning of the system depends on banks with unfilled quota being active in accepting reserves from other surplus banks in the interbank market. The market maker banks on NIBOR were considered best positioned to play this role and hence were given the largest quotas (Syrstad, 2011, p. 16).

Interbank transactions in Norway have been affected by financial stability regulations and this has notably led to higher reserve deposits and consequently higher interest rate volatility at end of quarter and end-year results. Depositing reserves with the central bank rather than another bank will have an advantageous effect on both capital and buffer requirements under CRD IV as well as the Liquidity Coverage Ratio (LCR). This choice can also affect banks' fee to the Norwegian Banks' Guarantee Fund (Norges Bank, 2014, p. 20). Norges Bank notes that deviations of interbank overnight rates from the policy rate and quarter- and year-ends is not unique to Norway and unlikely to be specific to the quota-based liquidity management system itself.

Structural liquidity in Norway has neither been strictly on the surplus or deficit side since 2004 (Bernhardsen and Kloster, 2010, p. 4). Between 2011 and 2013 graphs show regular annual fluctuations and swings over to a deficit position at least once a year. On the other hand, Norges Bank has kept total liquidity in the system at a positive level, and at particularly high levels during the GFC (Norges Bank, 2014, p. 8).

The Danish liquidity management system is an interesting system that is relevant to our discussion. It has features which are reminiscent of a quota system, although it is usually not identified as such. As opposed to the Norwegian quota system, where the reserve rate is lower than the current account rate, the reserve rate in Denmark started out higher than the current account rate. Danmarks Nationalbank conducts regular open market operations once a week, in monetary-policy loans or certificates of deposit, to square liquidity in the banking system. At other times, banks are expected to distribute liquidity among themselves based on

the margin between the lending rate and the rate of interest on CD's. The Bank makes sure that there is always the appropriate level of liquidity in the system to prevent either overdrafts or the breaching of the current account limit.

As long as the banking system as a whole is within certain limits on its current accounts at the end of the day, defined by Danmarks Nationalbank, all reserves receive the current account rate. If the banking system as a whole is over a certain limit, all reserves above the limit on individual banks' current accounts are automatically converted into certificates of deposit. The Bank's counterparties can also transfer funds into CD's on their own volition. The purpose of the limit is to prevent the build-up of large current account deposits that can be used for speculation in interest-rate and exchange-rate changes if the krone is under pressure. If the customers of the monetary policy counterparties wish to speculate against the krone for a larger amount than the current account limit allows, the additional amount must be borrowed from the Bank, at terms unknown at the time of the speculative transaction. CD's can be used as collateral in the payment system intraday as well as traded among monetary policy counterparties at a premium (Danmarks Nationalbank, 2009, p. 1-28).

The objective of monetary policy is to ensure the stability of the Danish krone against the euro and the Danish central bank categorizes the short-term interest rate as a primary target and the exchange rate as an intermediate target. However, FX interventions are usually the first line of defence in case of exchange rate fluctuations. In case of ongoing pressure on the krone, interest rates may be used as well. Interest rates are primarily used to affect the exchange rate and other economic variables are not taken into account. Interest rates in Denmark mirror those of the ECB for the euro area unless there is pressure on the exchange rate.

Structural liquidity in Denmark was last in deficit during the crisis in 2008 and the recent surplus can most likely be traced to FX purchases on behalf of the Danish central bank. The Bank has observed that when the net position is negative, money market rates settle close to the lending late, and when the net position is positive, the dominant interest rate is the interest on certificates of deposit.

Danmarks Nationalbank has a number of instruments at its disposal that it can calibrate to achieve its target, including flexible interest rates, flexible ranking of facilities in terms of interest rates, flexible quota size and the ability to affect liquidity in the system with open market operations. Bindseil and Würtz (2008, p. 26) give the Danish system high marks with respect to automaticity but it is criticised *inter alia* for the lack of a borrowing standing facility and maintaining asymmetry in its interest rate corridor. The Nationalbank explains that it leaves a

borrowing standing facility out on purpose, as the context of a fixed exchange rate requires that money-market interest rates can respond if the krone comes under pressure (Danmarks Nationalbank, 2009, p. 45).

In recent years, with current account deposits carrying zero interest and certificates of deposit at negative interest rates, the division of deposits reduces costs in the banking system. However, the Bank can vary the size of the limits so that a significant share of reserves lie outside, making the negative interest rate bite at the margin, while shielding a portion of the bank's assets. In fact, the Bank has recently stated that it considers a limit to how much more negative interest rates can be lowered still. It is considered essential that money market rates are affected since they determine the krone-euro exchange rate (Mosenlund Jensen and Spange, 2015, p. 1-2). However, the Bank likely finds it beneficial that retail deposits have been shielded from negative rates which could lead to mass withdrawals of cash. Danmarks Nationalbank seems to have in place a rule of keeping the limits lower during normal times and higher during market unrest (Jørgensen and Risbjerg, 2012, p. 67).

In a quota system reserves are usually remunerated at the policy rate and all reserves in excess of that are remunerated at either a lower rate. As we have seen, the Danish and Norwegian systems started out along different tracks. Norges Bank discouraged excess reserve holdings by remunerating them at lower rates, while Danmarks Nationalbank did the same by automatically converting excess holdings into certificates of deposit, but instead remunerating them at a higher rate. However, Danmarks Nationalbank has stated its intention to be fully commited to flexible rules (Danmarks Nationalbank, 2009, p. 28) and at the time of writing (March 2019) certificates of deposit carry a negative interest rate of 65 bp while interest rates on current accounts are zero

Along with the combination of deposit interest rates, the size of the limit, or folio, can be adjusted so that the weighted effective interest rate is in line with the desired monetary stance. When the negative interest rate on CDs was introduced, current account limits were adjusted upwards by a factor of 3 to reduce the strain on monetary policy counterparties (Jørgensen and Risbjerg, 2012, p. 67). This amounts to adjusting the effective interest rate on the total stock of reserves. The Danish central bank currently maintains a folio of around 30 bn krone, while the stock of certificates of deposits is significantly larger, at just under 200 bn krone. As was mentioned before, the Bank places most emphasis on the transmission to money market rates as that is what matters most for the exchange rate.

5 Central bank independence – two perspectives

A central bank's liquidity management system does not exist in a vacuum and is affected by the surrounding environment, institutions, markets and regulations. Its design should ideally take these factors into account. The remainder of the discussion on the central banks operational and liquidity management framework will be framed within the concept of central bank independence from two points of view. Caruana (2013, p. 1) theorized that the nature of challenges to central bank independence has evolved in recent years with fiscal, financial and expectations dominance entering the stage. As Iceland did not engage in the typical quantitative easing, financial dominance does not seem to be an issue at present and with fiscal policy at least partly pulling policy in the right direction, neither fiscal nor expectations dominance are major concerns. It would seem that in addition to the more traditional matter of operational independence, the most pressing issue would fall into the category of "international dominance" where maintaining an independent monetary policy in a small, open economy with its own currency poses significant challenges. Operational independence, i.e. independence from political interference and global independence, i.e. independence from international developments are therefore discussed separately below.

5.1 Operational independence

The setup for large parts of a central bank's operational framework stems from concerns about making losses from the implementation of monetary policy. Such aspects include the bank's collateral framework, counterparty access and LOLR arrangements. As already mentioned before, the parties to transactions with reserves are optimizing their respective functions; banks focus on cost, opportunity cost and return while the central bank's utility function is a social welfare function (Bindseil, 2004b, p. 32 and Bindseil and Jabłecki, 2011, p. 24-25). Therefore, the central bank is not solely concerned with loss, but it does have to keep one eye on its balance sheet to preserve its credibility, and thereby ability to implement monetary policy.

When a central bank lends to the banking system, which almost invariably occurs through a secured transaction, the central bank acquires an asset through taking collateral and produces a liability through providing the corresponding bank with reserves. These reserves remain in the system even though the central bank's collateral and by extension its capital buffer, can fluctuate in value through the conventional channels of credit, market, liquidity and operational risk. If a central bank's capital is negative over a sustained period, it must approach the national

government for a capital injection. The losses can be made up in a variety of ways, but whichever method is chosen, a beholden central bank may face questions about its policy independence. In isolation, the potential reputational damage of losses can have the same detrimental effect (Rule, 2012, p. 6-7).

Irrespective of central bank relations with the fiscal authority and the need to balance its finances for independence reasons, it is not a good idea to leave holes in central bank balance sheets over a protracted period. Central banks can run with losses for a long time, but economy-wide accounting issues, the potential imperative to reverse the presence of excessive surplus reserves in the system for cost reasons as well as inflation concerns, require that central bank finances are eventually put on an even keel. Even though the quantity of reserves is not key variable it was once considered to be in relation to the quantity of broad money, a long-term excess can nevertheless influence bank behaviour and may lead to complications with liquidity management as we have seen.

Bindseil (2016, p. 28) underscores that the set of eligible counterparties in central bank operations is a key issue for a central bank's monetary policy operations as well as its LOLR framework. In particular he highlights the question of whether counterparty criteria is relevant for the ability to control the overnight interest rate or the smoothness of monetary policy transmission. This seems to be the case, as it has been shown that policy objectives are best achieved when counterparties have equitable access to a central bank's facilities (Rule, 2012, p. 8). Bindseil (2016, p. 29) also suggests that in a crisis, broadening the set of counterparties will probably make sense, presumably because intermediaries will struggle in the face of a widespread credit shock (Chailloux et al., 2008, p. 38).

The Icelandic banking system is characterized by very few counterparties, which can have advantages and disadvantages. For a central bank, this allows a good overview of the market and counterparties. However, trading can reveal a significant amount of information which can potentially lead to banks bypassing the interbank market and making use of their recourse to the central bank. A significant relative size difference can also be problematic.[2]

A central bank practices active risk management by taking collateral. However, a collateral framework and the implicit policy can have other benefits than protecting the central bank against losses, including to promote a level playing field for the central bank's counterparties and support wider market functioning, both actions that facilitate the achievement of policy objectives. Central banks'

[2] Gerður Ísberg, verbal communication, August 2017.

collateral choices are influenced by several internal and external factors that were neatly summarized by Rule (2012). With respect to the counterparty set, a central bank can open the door to a larger group, as long as they are all handing over the same collateral, as opposed to having to perform costly due diligence for each counterparty (Chailloux et al., 2008, p. 38).

At a minimum a central bank will want to make enough collateral available to cover the size of its operations and as we have seen this can vary considerably depending on the operational framework (Rule, 2012, p. 1-10). For example a central bank has influence over the quantity of outstanding operations through its choice of reserve requirements. The higher the reserve requirements in a structural deficit environment, the more need for collateral, whereas a considerable structural surplus is unlikely to generate the same kind of demand (Chailloux et al., 2008, p. 43). Frameworks such as wide corridor systems are often less collateral intensive as they incentivise interbank transactions. The same applies to narrow corridor systems that minimize reserve holdings.

The financial markets infrastructure and the availability of domestic assets represent an external constraint on the central bank's collateral options (Chailloux et al., 2008, p. 13). Modern financial systems tend to be increasingly collateral intensive, owing to the private use of collateral and the need to collateralize payments systems. Collateral supply issues can for example arise in a situation of persistent fiscal surpluses or where there is lack of other suitable domestic assets. In this case the central bank could accept foreign exchange or nondomestic assets although this is to some extent dependent on time-zones and financial infrastructure (Chailloux et al., 2008, p. 14 and 42). After 2009, unconventional easing through outright purchases of domestic assets in the UK and US led to a decrease in open market operations. By contrast, large-scale easing through term lending saw pledged collateral grow in Japan and the Eurosystem (BIS, 2013, p. 16-19).

The issue of cost, and concerns about central bank independence, might be taken into account when designing liquidity management frameworks. Government paper might be one option for diverting domestic reserves into longer-term instruments. In that case, there would have to be incentives in place, in the form of higher interest rates than on current accounts in the central bank. This can potentially be achieved with some kind of quota system, where interest rates on excess reserves are lower than on reserves within quota. This possibility hinges on several considerations. The government would have to be willing to issue government paper and fiscal consolidation may lead to decreasing appetite for issuing debt. Secondly, for reserves to be diverted out of the system, the purchases have to take

place in the primary market. Thirdly, the central bank's collateral policies as well as prudential regulation will have an effect on the assets banks are willing to hold.

Appendix VII shows the outstanding amount of eligible CBI collateral. Currently, almost no collateral is required owing to the structural liquidity position of the banking system. It would take fundamental changes for the system to reach a stage of significant collateral intensity. There might be good reasons to think that establishing a secured interbank market in tandem with a move from a floor system would encourage interbank trading to rise from the very low levels. Such a change would affect the collateral intensity of the system. According to Sweden's Riksbank, some lessons can be learned from the Swiss as regards support for secured interbank trading (Riksbank, 2014, p. 28). It should also be noted, that in the event of tight liquidity conditions, it might be in the interest of all parties that banks are in possession of high quality collateral.

Tucker (2014, p. 17) explores how to design the LOLR framework such that banks are prevented from taking on excessive liquidity risk and central banks are prevented from oversupplying liquidity insurance or providing solvency support. In his view, an updated Bagehot, supported by a strict ex-ante governance framework and an accountability regime, must be accompanied by a fiscal carve-out and a cardinal rule not to lend to insolvent banks under any circumstances. Bindseil (2016, p. 39) seconds clear ex-ante rules and underlines a complementary role for regulation. However, the paper maintains that it would be over-ambitious to aim at a full ex-ante set of rules and pre-commit against ex-post flexibility.

Most operational frameworks have an LOLR component built into their everyday operations. It is possible to imagine two extremes. A permissive LOLR framework where the central bank to lend against all assets, the standing facility is zero and the normal times LOLR framework covers all possible needs for a solvent bank. Under a restrictive LOLR framework the central bank would only lend against very secure assets, choose safe counterparties, and pre-commit to zero flexibility and no emergency liquidity assistance (ELA). Bindseil (2016, p. 29-39) claims that most central bankers believe that the optimum lies on the spectrum between these extremes, supported by financial regulation.

The delineation of monetary policy implementation and liquidity provision for financial stability in normal conditions is also an important issue and one that could perhaps be addressed within the liquidity management system. The BoE's makes a distinction between the two goals using its collateral policy. Operations to implement monetary policy are provided against high-quality collateral at a spread of 25 basis points over the Bank rate while liquidity insurance is provided against a broader range of less liquid assets such as asset-backed securities with

higher fees to reflect the underlying collateral and amount of borrowing. The liquidity insurance facility supplies gilts that can be used to acquire reserves in the secured money market and hence the liquidity provision does not affect the aggregate liquidity position of the banking system (Clews et al., 2010, p. 298).

As was noted before, the run-up to the crisis saw a repeated widening of the CBI collateral pool, which led to sizeable crisis lending in an attempt to save the banks from a fall. In all likelihood, the strategy of the pre-crisis CBI was to aim for a degree of constructive ambiguity as regards the Bank's actions in the event of a crisis. As is suggested above, the exercise of creating a rules-based LOLR could be a productive one, and the fiscal authority may want to consider accompanying this with a fiscal carve-out.

5.2 Independence from global developments

Gray and Talbot (2006, p. 8-17) present the complexities of what is usually referred to as the trilemma in international economics. In order to maintain an independent domestic monetary policy, most countries have chosen to accept a floating exchange rate and focus on supporting the stability of the chosen short-term interest rate. The policy rate is normally that used for open market operations. In a fully liberalized system, including on the capital account, it is impossible to maintain both independent monetary policy and an exchange rate target. Market imperfections or capital controls might enable a central bank to temporarily have separate targets for domestic monetary policy and the level of the exchange rate but such policies tend break down over time.

Rey (2013, p. 21-22) posits that due to a global financial cycle, instead of being able to choose two out of three of the advantageous options of an independent monetary policy, fixed exchange rate and free capital flows, policy-makers can in fact only choose one. So that in addition to not being able to implement an independent monetary policy under the conditions of a fixed exchange rate, independent monetary policy is not on offer with a flexible exchange rate either; unless the capital account is managed, directly or indirectly. However, Rey does not suggest to completely restrict the capital account but rather to target the common culprits of financial crises directly, that is excess credit growth and leverage, through either cyclical or structural measures. Targeted capital controls might be appropriate when direct cross-border lending is significant and the banking system is circumvented.

Obstfeld (2015, p. 19) notes that countries that do not peg their exchange rates have the opportunity to vary short-term nominal interest rates independently of foreign nominal interest rates. The paper cites research that shows that even

countries that dampen exchange rate fluctuations still enjoy some short-term interest rate independence, although not as much as those who float freely. Hence, Obstfeld counters that having a flexible exchange rate is always beneficial to some extent and that the trilemma does in fact hold.

Taken together, Rey and Obstfeld's papers might suggest a partial trilemma or a spectrum between a dilemma and a trilemma. The observation that not even a fully floating exchange rate can protect against global financial flows indicates perennial trade-offs rather than full insulation. Obstfeld notes in his conclusion that smaller economies face downsides in living with globalisation. A small economy with its own currency such as Iceland, is unlikely to be able to ignore financial stability considerations, which complicates policy-making with only one tool (the interest rate). The solution points to some kind of management, as pointed out by Takatoshi Ito in his discussant's remarks to Obstfeld's paper, and therefore likely to incur associated costs. This might suggest looking for automaticity in the choice of instruments and frameworks.

Ito highlights the recommended package of countermeasures to sudden surges in capital inflows; citing a bit of currency appreciation, some intervention, a withholding tax on short-term inflows and imposing a loan-to-value ratio to prevent a bubble in the domestic economy. This follows naturally from another observation made by Ito which must be key in small open economies, rephrased slightly to say that well-managed inflows are more likely to lead to well-managed outflows. Most of the policy measures mentioned by Ito have been used in Iceland in recent times, albeit not all at the same time (Obstfeld, 2015, p. 61-63).

In the interest of fostering an independently sustainable financial sector, many of the measures mentioned in Rey's paper have also been steadily implemented in Iceland in recent years. The Central Bank of Iceland has implemented a range of regulations that aim to limit risks for individual financial institutions, but also have a macroprudential aspect due to the risk that accompanies free flow of capital in a small, open economy.

Banks need to fulfil rules on a maximum net open FX position, which may not exceed 10 percent of the capital base. The rules are meant to prevent that excessive currency mismatches build up on or off the institutions' balance sheets. They do not limit FX lending to unhedged borrowers, but the CBI was given a mandate to issue such regulation in Spring 2017. It should be noted that the rules apply to the banks' net position and therefore do not address the underlying size of banks' balance sheets in FX or maturity mismatches in FX. However, in addition, changes to the rules in 2018 introduced a limit to the amount of the banks' permissible net

position in order to limit how large the imbalance can get. Rules on stable funding were introduced in 2014 to address maturity mismatches

Rules on the Net Stable Funding Ratio (NSFR) in foreign currencies were implemented in 2014 and build in most important aspects on the NSFR issued by the Basel Committee on Banking Supervision, but the regulatory minimum only applies to the ratio in FX. In 2007-8 the Icelandic banks funded long-term FX assets with short-term debt to a fairly large extent. The regulation is intended to ensure that banks fund long-term or illiquid FX assets with long-term or stable FX funding and thus limit the risk stemming from maturity mismatches in foreign currencies.

In 2013, new liquidity rules were issued that were based in almost all respects on the Basel Committee's LCR but had a special minimum for FX liquidity in addition to the LCR minimum for all currencies combined. The rules were updated in 2017 to ensure consistency with ECB's issuance for LCR, however, maintaining the special minimum for FX liquidity. The liquidity rules that were in place prior to 2013 and dated back to 1999 had a wider definition for eligible assets, did not differentiate between deposit owners regarding associated risk, and importantly, did not have a specific minimum for foreign currencies. Hence the banks fulfilled liquidity rules even if they were short on liquid FX assets compared to FX on demand deposits and short-term obligations.

Other traditional macroprudential measures have been taken, such as authorizing the Financial Supervisory Authority (FME) to set rules on maximum loan-to-value (LTV) and debt-to-income (DTI) ratios. The FME implemented rules on maximum LTV in July 2017.[3]

The Central Bank of Iceland also introduced a capital flow management measure in the form of a Special Reserves Requirement on new foreign currency inflows in 2016. The measure was designed to temper and affect the composition of capital flows into Iceland and intended to reduce temporary risk accompanying excessive capital inflows, support other parts of domestic economic policy and contribute to macroeconomic and financial stability (Central Bank of Iceland, 2016, p. 49).

All the above measures work on different aspects of the financial system, aiming inter alia to foster good management of inflows so that the financial system and individual institutions are robust to potentially sudden and significant outflows as well. Domestic reserves are certainly a subject of the LCR. However, liquidity rules operate with a time lag and are targeting a broader composite stock than purely

[3] Guðrún Ögmundsdóttir, written communication, September 2017.

the stock of domestic reserves. The Norwegian example has also shown, that the various prudential measures affect banks' and thereby the central bank's liquidity management.

As the domestic reserve stock is at the core of the broader financial system, and often the first stop for payment flows before heading in other directions, it might be rational to consider whether a stronger framework in the market for domestic reserves might be a useful tool in addition to the measures already mentioned above.

6 Challenges and potential solutions – an overview

Bindseil (2004a, p. 7) notes that monetary policy implementation consists of three elements; the selection of the operational target of monetary policy, the establishment of an operational framework that allows the central bank to control the selected operational target and finally the daily use of instruments in order to achieve the operational target. Bindseil and Würtz (2008, p. 39) underline that frameworks for monetary policy implementation should be efficient and universal and note that mainly central banks of large monetary areas have allowed themselves the luxury of complex frameworks. Building on this, Bindseil (2016, p. 45) sets out the qualities that should characterize the optimal operational framework: It should be effective, lean and automated, it should support financial stability, financial market functioning and financial efficiency. It should also be neutral with regard to relative financial prices, honest and ideally universal.

Bindseil (2016, p. 4) claims that a general consensus had been reached in 2007 with respect to the optimal operational framework. In practice, each country's mode of implementing monetary policy is idiosyncratic in its details, shaped by years of gradual and carefully calibrated convention that comes from managing the unique realities of the immediate environment. Many parts of the infrastructure can affect the implementation of monetary policy, including fiscal and financial policies, legal frameworks and regulations, as well as the market structure immediately surrounding the operational target, the interbank and wider money markets and beyond.

The liquidity management system currently in place in Iceland is a wide corridor system with reserve requirements and averaging of the type we have discussed above. Since 2009 it has operated as a floor system, as surplus reserves led to a lowering of the interbank market rate towards the floor of the corridor. However, that does not mean a formally designated floor system is in place, and that the policy rate will remain at the bottom of the corridor for the foreseeable future. That will depend on several factors, not least how structural liquidity develops.

The CBI's monetary instruments were reviewed in 1998 and were adapted to the development of financial markets. Their design also took into account the proposed instruments of the ECB, which were considered state of the art in central banking at the time (Kristinsson, 2000, p. 40). The ECB presides over a system that comprises twenty central banks and almost five thousand credit institutions. The Euribor interbank market has approximately 20 participants. The corridor system has been known to work well in normal times as the structure incentivizes transactions in the interbank market, which is thought to help transmit interest

rates further out on the interest rate curve and potentially support market discipline.

The Icelandic system is characterized by very few counterparties and limited interbank market activity, see appendix III. An advantage of wide corridor systems is that a wider corridor gives larger incentives to trade reserves in the market instead of using one of the central bank's standing facilities at an unfavourable rate. However, a wider corridor may lead to larger interest rate volatility. Required reserves with averaging are typically introduced to smooth interest rate fluctuations although there often remains significant volatility on the last day of the maintenance period. The question arises whether maintaining a wide corridor is useful when activity in the interbank market is in any case low.

Additionally, the corridor system requires precise management of reserve liquidity such that demand and supply in the interbank market are exactly matched, or else the volatility of interest rates is liable to rise considerably. Implementing monetary policy under circumstances of a structural surplus is often considered less effective than with a structural deficit. Shifting the system to operating under a deficit could entail setting reserve requirements that are higher than the structural surplus (to compel depository institutions to operate on the deficit margin) or endeavouring to tie up most of the surplus in longer-term deposit instruments, so that again, the system is operating under deficit at the margin.

The CBI currently remunerates all reserves on current accounts, including reserve requirements, at 0,5 percentage points below the policy rate on 7 day term deposits at the CBI. There is therefore significant cost attached to remunerating these reserves, even if CBI counterparties leave them in current accounts,and even higher in the case of tying them up in longer-term deposit instruments, see appendix V. Conversely, due to the immense overall surplus, the reserves are non-borrowed and the cost to banks of holding them is negligible.

Reserve requirements are currently binding to a very limited degree, see appendix II.[4] It may therefore seem to serve little or no purpose to maintain reserve requirements, not least with the added complexity of averaging. However, the Central Bank's recent measure to split reserve requirements into a fixed no-interest bearing part and another with the customary current account rate and averaging, has reduced the cost to the bank, albeit to a very small degree, of maintaining sizeable foreign reserves in an environment of low international interest rates, while the reserves are financed in the high-yielding domestic currency.

[4] Gerður Ísberg, verbal communication, August 2017.

With policy rates at the floor of the corridor, draining surplus reserves has not been strictly necessary either. This may apply especially in case of a restricted capital account which was the case for several years after the crisis. Capital controls have since been removed. However, this is also true generally, as has been explained by Keister et al. (2008) and others. Until the CBI finds a way to effectively steer the quantity of central bank reserves in the system or operate in a deficit environment through either effective draining through long-term instruments or setting reserve requirements higher than the surplus, maintaining a functioning corridor system may not be a viable option.

A corridor system can also have the advantage of being less collateral intensive than other systems, for example a floor system. This can be beneficial when there is a shortage of eligible collateral, or safe assets, available in the economy. This does not apply to Iceland at the current juncture, see appendix VII. However, that might change with a secured interbank market or the structural surplus evolving into a deficit.

Forecasting autonomous factor flows on behalf of the central bank has been complicated by the lack of detailed information on treasury movements in and out of the central bank. This can be dealt with by tightening up on information-sharing, moving the treasury's accounts out of the central bank to lessen volatility in structural liquidity, or potentially choosing a system of liquidity management which does not rely in the same measure on the accuracy of liquidity management. As we have seen, both floor and quota systems allow for leaving a certain amount of reserves in the system and especially the floor system requires reserves to be at a very comfortable level for the interest rate to sink towards the floor.

The solution to some of these issues might be to switch to a narrower corridor, a floor system or a quota system and we will study the advantages and disadvantages of each in turn.

A narrow corridor system without reserve requirements would have the advantage of less potential for fluctuations in short-term interest rates since the standing facilities bookending the corridor are standing closer apart. The trade-off is that there are less incentives for interbank trading with implications for the transmission of interest rates, market discipline and central bank risk-taking. With the current low interbank activity this may not be an issue for the CBI at present. However, high transaction costs may crowd out incentives for trade even as developments in the structural liquidity position might otherwise encourage more interbank trading.

The narrow corridor makes the same demands of the central bank for accurate liquidity management. Hence, the issues with forecasting would be the same. On

the other hand, more frequent operations to counteract autonomous factors might lead to better short-term liquidity management and keep fluctuations in interest rates at bay. Sweden is fairly unusual in that the treasury accounts have been in the banking system for a long time, which considerably lessens autonomous fluctuations. However, if a managed float continues to be practiced in Iceland, this may also cause significant fluctuations in the reserve position. It is also not a given, that moving the treasury out of the central bank and into the banking system, would be optimal with respect to size of flows and small set of counterparties.

The issue of keeping reserves in the system at just the right amount to clear the market and maintaining the policy rate in the middle of the corridor is the same in a narrow corridor as in a wide one, and the difficulties with bringing this about in the current environment has been discussed. The conclusion therefore is that a narrow corridor would not be optimal at present either.

The floor system as used in Norway was a designated floor and as we have seen it turned out to have some significant disadvantages which led to the switch to a quota system. There were also advantages to turning the liquidity management system in Iceland from a corridor to a floor overnight. The CBI could take advantage of the fact that the precise amount of reserves in the system is not as important in a floor by not draining surplus reserves with complete accuracy.

The floor system does not seem to be altogether dependent on interbank trade to effect the interest rate since the central bank's deposit rate influences the policy rate at the margin. This fits well with the overall indifference that characterises the interbank market at present, see appendix III. It has the advantage, at present, of very little volatility in the interbank overnight interest rate. However, the floor may be associated with some kind of inertia and may well be useful while there is a transitional period either during or following a crisis. It seems evident that most central banks try to graduate from this system to a more effective, dynamic one, as soon as conditions normalize. On the other hand, if interbank trade were to be found redundant, a floor might be a good option.

The quota system seems, at least in the cases we are familiar with, to be a good fit where there is an effort to disincentivise significant excess reserve holdings by banks. "Excess" would here apply to banks holding precautionary reserves above what is needed for everyday transactions instead of lending them out to other banks when they don't need them. The current lack of interbank activity is associated with potentially hampering the transmission of monetary policy along the yield curve and impacting financial stability through lack of interbank surveillance.

The Icelandic banking system is also an environment of significant surplus reserves, as we saw in figure 3 in the chapter on structural liquidity. How banks can be discouraged to hold reserves when they are to a large extent non-borrowed is an open question, as well as what banks should do with them instead. One way to encourage interbank trade can be seen in figure 8.

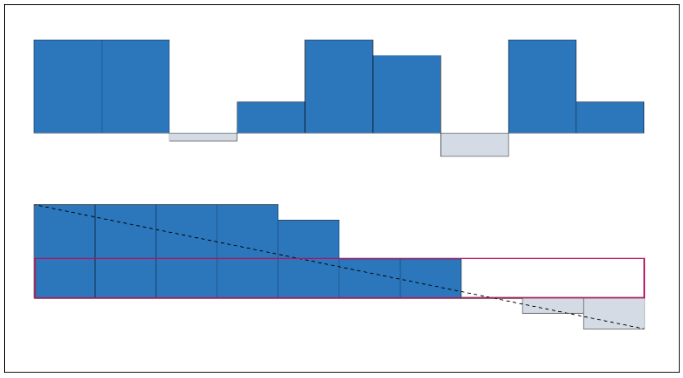

Figure 8. A banking system with aggregate and individual surplus positions and a quota delimiting the portion needed for daily transactions.

With a quota delimiting the amount of reserves needed for daily liquidity management, banks' basic reserves are remunerated at the current account rate, which is also the policy rate. Surplus banks then benefit from lending to deficit banks what is above the quota and remunerated at a lower rate. Even banks that are within the quota would benefit from borrowing from banks with excess reserves to fill their quota and receive the reserve rate on the full amount. This system might therefore encourage interbank trading. However, as we noted in the case of Norway, this is sometimes not considered to be worth the effort. Two very simple stylized examples with different priorities are given for the type of surplus conditions present in Iceland in appendix VI.

The quota system has the benefit of being able to frame the daily liquidity needs to a fairly accurate extent and redirect the remainder into other instruments through incentives or some kind of automaticity. From the examples we know, in Norway and Denmark, the system appears to be fairly robust to swings in liquidity. It would probably be a preferred mode of liquidity management for the central bank to conduct open-market operations to match changes in government flows (NLG) and FX interventions (NFA).

In the chapter on central bank independence, we noted that central bank losses can lead to concerns about its independence and ability to implement monetary policy. With a two-tier liquidity management system, it might be possible to incentivise banks to place their surplus reserves in government bills or bonds instead of employing costly CDs. It should be noted that in order for the reserves to be fundamentally directed out of the system, they would have to be invested in

primary market government paper. This again depends on the treasury's willingness to issue such paper.

Further considerations as to central bank independence are the collateral and counterparty sets as well as the set-up of the LOLR framework. The counterparty set in Iceland is narrow and whether this should be redefined could be open to consideration. We have discussed that liquidity management systems that are less collateral intensive are sometimes considered optimal. However, incentivising banks to hold some amounts of good quality collateral is probably beneficial. This can be done by defining what kind of collateral is accepted in various operations and facilities, whether the time frame is intraday or to a longer period. The extent of the LOLR can also be set out in more detail and might be accompanied by a fiscal carve-out. We have already seen that converting from a corridor to a floor can be useful in a crisis. In the same way it would be possible to shift promptly from a quota to a floor by increasing drastically the size of the quota or announcing that the interest rate on excess reserves will be aligned with the policy rate.

The chapter on independence in the context of international developments concluded that despite various measures that affect different aspects of the financial sector, there is no measure apart from the liquidity management system itself that directly targets the stock of domestic reserves. It might be inferred that a liquidity management system with strong incentives or some kind of automaticity in converting surplus reserves would be beneficial to support monetary policy and financial stability goals.

7 Conclusions

The paper finds it doubtful that a corridor system would be optimal for Iceland under the current circumstances. Interbank activity is very low and measures to bring the system to a point of increased activity such as setting very high reserve requirements or drain liquidity to the point of effecting a deficit do not seem feasible or realistic due to cost and incentive issues. The current floor does not seem to be advantageous to the medium term either, due to the lack of interbank activity. Even though interbank interest rates hover just above the floor and show very little volatility, there could be doubts about transmission along the yield curve with the lack of tension in the market. However, the Central Bank's recent application of fixed, no-interest bearing, reserve requirements might point to further uses of a system with minimum reserve requirements, such as the floor is currently.

The paper posits that a small, open economy with its own currency and the potential for extreme swings in the structural liquidity position might benefit from a quota system with some of the characteristics of the systems currently in place at Norges Bank and Danmarks Nationalbank. The former relies on incentives to maintain the optimal liquidity position while the latter mixes incentives with automaticity, but both aim to maintain a frame around the daily liquidity management of banks and disincentivise holdings of liquidity beyond that amount. This can be done through incentives at the margin or by converting the surplus into longer-term instruments. The latter option is an even stronger tool to maintain the desired liquidity in the system and interest rate differentials can also be deployed if there is a need to target the exchange rate channel specifically.

A quota system could also be a feasible way of incentivising interbank trade, with lower interest rates on excess reserves. The option of investing in government paper to the longer term at slightly higher interest rate than on excess reserves might also be considered by the banks instead of tying excess liquidity up in central bank instruments. This would have favourable consequences for the central banks' cost structure and safeguard its independence as well as effectiveness of monetary policy.

Several considerations are important in this respect. One is the government's willingness to issue government paper. Fiscal consolidation may lead to less need and appetite for issuing debt instruments. Second, in order for domestic reserves to be diverted out of the system, the purchases would have to take place in the primary market. Thirdly, the central bank's collateral policies as well as prudential regulation will have an effect on the assets banks are willing to hold.

This paper has taken as a given certain priorities of the Central Bank of Iceland. This includes activating the interbank market for the successful transmission of monetary policy. It is also assumed that the Bank would prefer to define, or potentially minimize, the amount of domestic reserves in the form of current accounts at the central bank, not least with a view to the potential for free reserves to enter the market for foreign currency.

However, it is very important to note that liquidity management systems, and the environments they operate in, are constantly evolving and that no system is perfect. It may be possible to arrive at an optimum, but this requires defining priorities and goals for the central bank as well as the whole economy. It is hereby suggested that such an exercise might be undertaken by the Central Bank of Iceland. It is also a conclusion of this paper that the dynamics of implementing monetary policy under a significant surplus, in the context of either borrowed or non-borrowed reserves, as well as the robustness of liquidity management systems to the sign-switching of structural liquidity could use more study.

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Appendix I – The CBI balance sheet 2002-2018

The figure below shows the evolution of the CBI's balance sheet from 2000 to 2018. The past ten years have seen enormous shifts, with an upward trend that begins in the middle of 2005. Over this whole period the CBI's balance sheet was at its absolute leanest in April 2005 but was yet to grow eighteenfold before reaching its highest point in February 2012, approximately 1.638 bn ISK, equivalent to almost 100 percent of GDP.

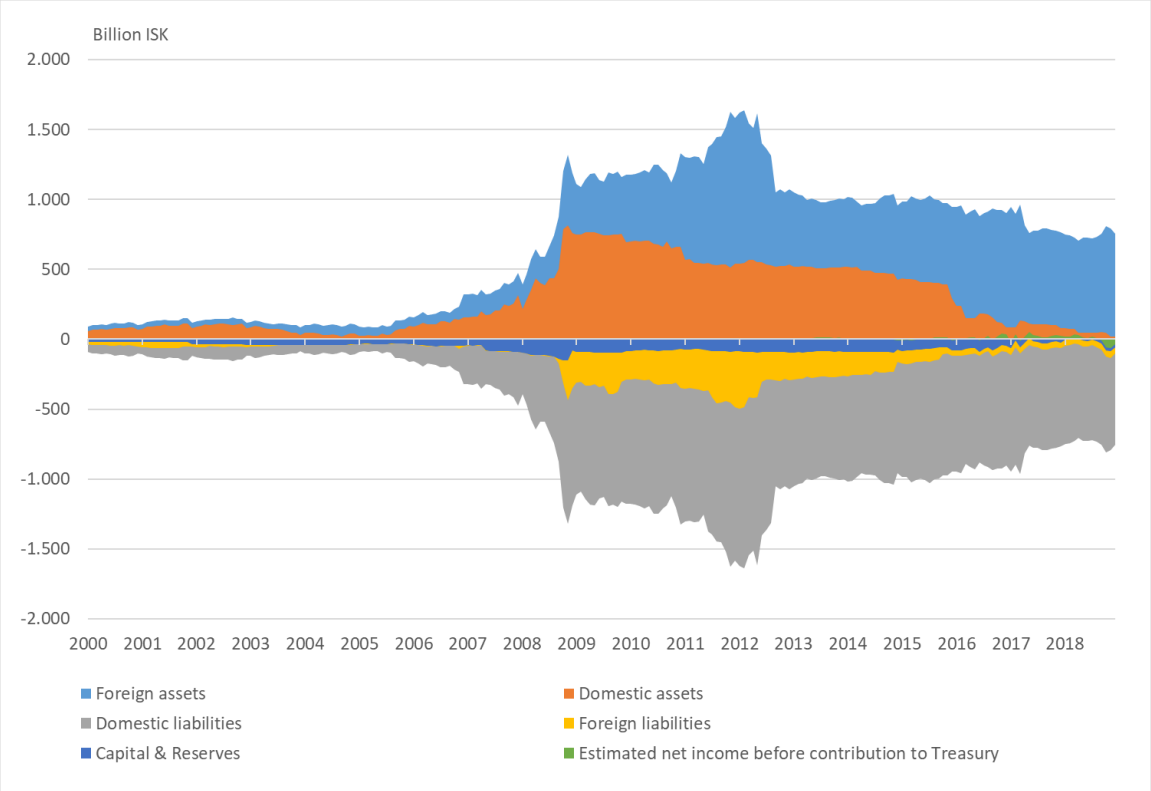

Figure 9. The development of the CBI balance sheet 2000-2018. Source: Central Bank of Iceland, Balance sheet of the Central Bank.

Iceland is not alone in experiencing this development over the past ten years. Caruana (2011) shows that the combined balance sheets of Canada, the euro area, Japan, Sweden, Switzerland, United Kingdom and the United States had lengthened from measuring at around ten percent of GDP in the middle of 2007 to just over twenty percent of GDP in 2011. Recently the Bank of Japan's balance sheet amounted to ninety percent of GDP, higher than any of the top four central banks.

A broad strokes reading of the balance sheet indicates that domestic assets were at their highest in November 2008 just after the fall of the three commercial banks. The CBI had taken collateral to secure its lending which was placed in an asset

management company, ESÍ, a wholly owned subsidiary of the central bank. Its assets were slowly liquidated over the past ten years to currently negligible amounts. Domestic assets also comprised a bond issued by the government to recapitalize the central bank in the aftermath of the crisis.

Domestic liabilities were likewise high, as reserves and other liabilities had increased alongside the collateral lending. In addition to liabilities to operational financial institutions, this category contains some unusual items such as foreign exchange deposits and time deposits in foreign currency belonging to the estates of the fallen banks, also referred to as financial institutions in dissolution process. Among domestic liabilities were assets of the central government in the central bank, including time deposits in foreign currency, treasury foreign exchange deposits and the treasury current account.

Foreign assets have also grown as the central bank has increased its foreign reserve holdings, particularly foreign securities. FX reserves were initially externally financed through IMF and other bilateral programme loans, later to be replaced with domestic financing as the central bank intervened in the foreign exchange market. Although the size of the balance sheet peaked in February 2012, which was mostly attributable to crisis lending, the purchase of foreign exchange has to some extent replaced those assets, leading to a still-inflated balance sheet and sustaining a sizeable pool of reserves.

It is also worthwhile to look into what was happening with respect to central bank facilities and the development of central bank reserves and related concepts over this same time period. Collateral lending on behalf of the central bank started to increase in 2005 and reached a high point in September 2008. Current account and term deposits grew alongside. The treasury current account also grew, but the deposits do not count as reserves. However, they are an indication of what could become domestic reserves at a later stage. There are several notable events in the period of 2005 to 2008 which partly explain the developments in collateral lending as well as CD issuance. To begin with, the first króna-denominated Eurobond issuance took place in August 2005 (Ólafsson, 2005, p. 61). Secondly, three of the commercial banks started issuing unsecured bonds which were used as collateral for borrowing with the central bank. Thirdly, collateral eligibility was extended in three consecutive steps by the central bank of Iceland.

The widening of the CBI's collateral set developed into fully-fledged crisis lending and at the fall of the banks, the collateral behind the seven-day and overnight lending was placed in the CBI's asset management company, ESÍ, as stated earlier.

The cumulative net purchases of the CBI over the period 2010-2018 amount to almost 900 billion ISK. That number does not include transactions taking place in special auctions held by the Central Bank as part of its strategy to remove capital controls. The acquisition of foreign reserves through central bank purchases result in an increase in domestic reserves in the banking system, while foreign borrowing to supplement FX reserves has no such effect. This position of reserves could be unwound in several ways; *inter alia* the CBI might purchase large amounts of domestic reserves with its foreign reserves, the treasury might absorb them over a long period with a surplus fiscal position, or they might exit as notes and coin. In any case, it would take significant developments for the banking system to be back in a structural deficit position.

Appendix II – Liquidity in the Icelandic banking system 2000-2018

As we have seen, structural liquidity is defined as the level of reserves in the banking system prior to market operations to supply or drain liquidity from it, i.e. in the absence of any central bank intervention. Figure 11 shows that the period 2000 to 2016 can be divided into two main parts, a prevailing structural deficit until 2008 and a structural surplus after 2008.

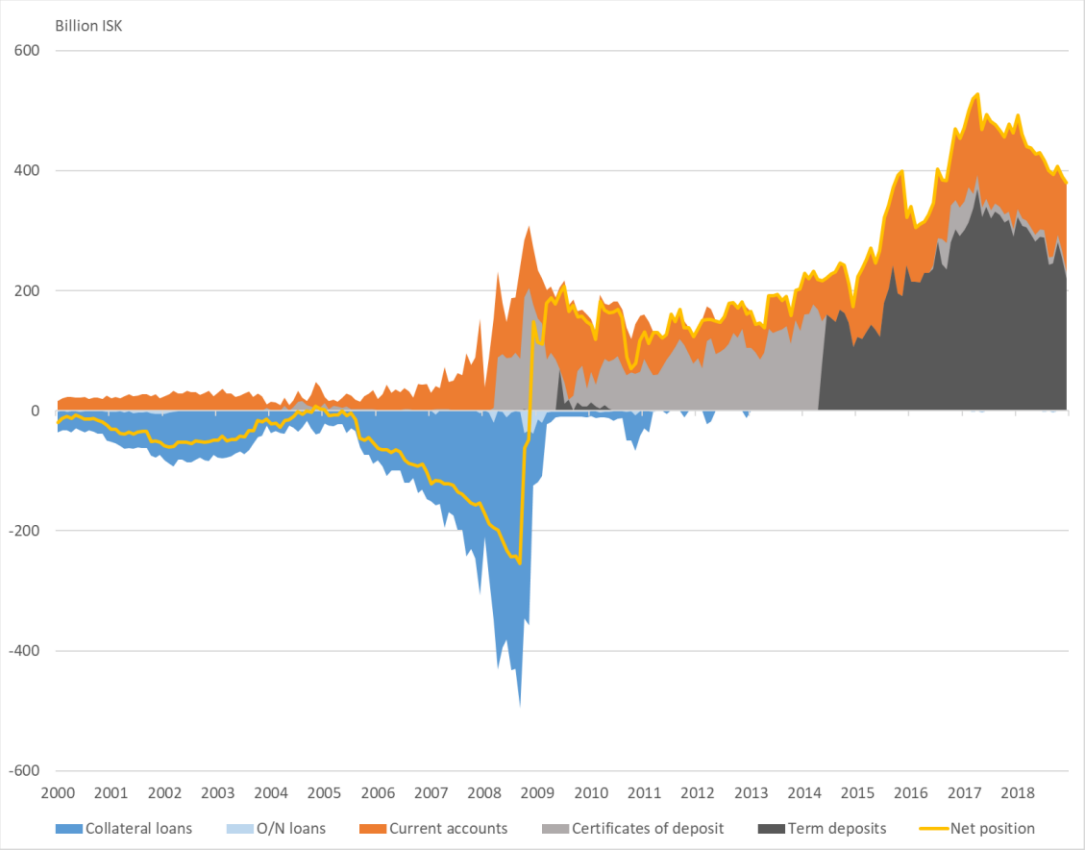

Figure 10. Structural liquidity in the Icelandic banking system 2000-2018. Source: Central Bank of Iceland, Balance sheet of the CBI.

At the end of 2018, total reserves amounted to just over 380 billion ISK. Of this number, almost 219 billion was tied up in longer-term deposits and around 150 billion was sitting in current accounts. When pondering the alternatives to central bank instruments, it should be kept in mind that outstanding treasury bills amount to approximately ten billion ISK. However, other long-term government paper might be considered as well.

Reserve requirements have been added to figure 13, showing that they are not currently binding to a significant degree in the banking system.

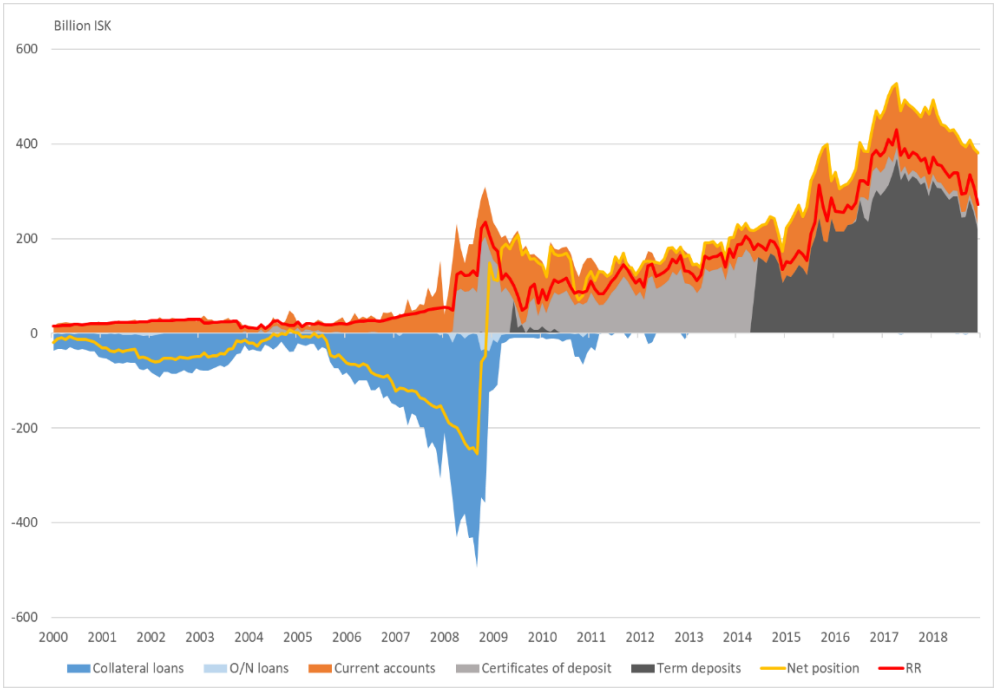

Figure 11. Structural liquidity in the Icelandic banking system 2000-2018 showing the ratio of required reserves to current accounts. Source: Central Bank of Iceland, Balance sheet of the CBI.

Figure 12 shows how large the system would be if the government accounts were taken out of the central bank and placed in the banking system. It also shows the amount of notes and coin is circulating in the economy.

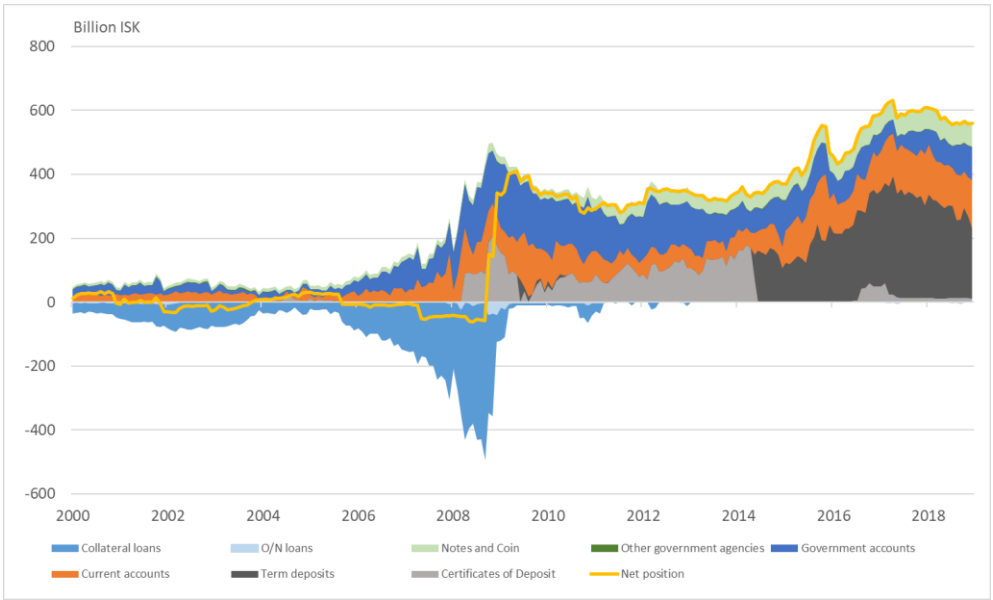

Figure 12. Structural liquidity in the Icelandic banking system 2000-2018 with government accounts and notes and coin added in. Source: Central Bank of Iceland, Balance sheet of the CBI.

Appendix III – The interbank market for krónur

The CBI publishes interbank lending volumes on its website. The data is given in monthly intervals which masks the fact that some days see very little activity in the market. As can be seen in the figure 12, one week lending ceased from April 2008, and only surfaced again in November 2010.

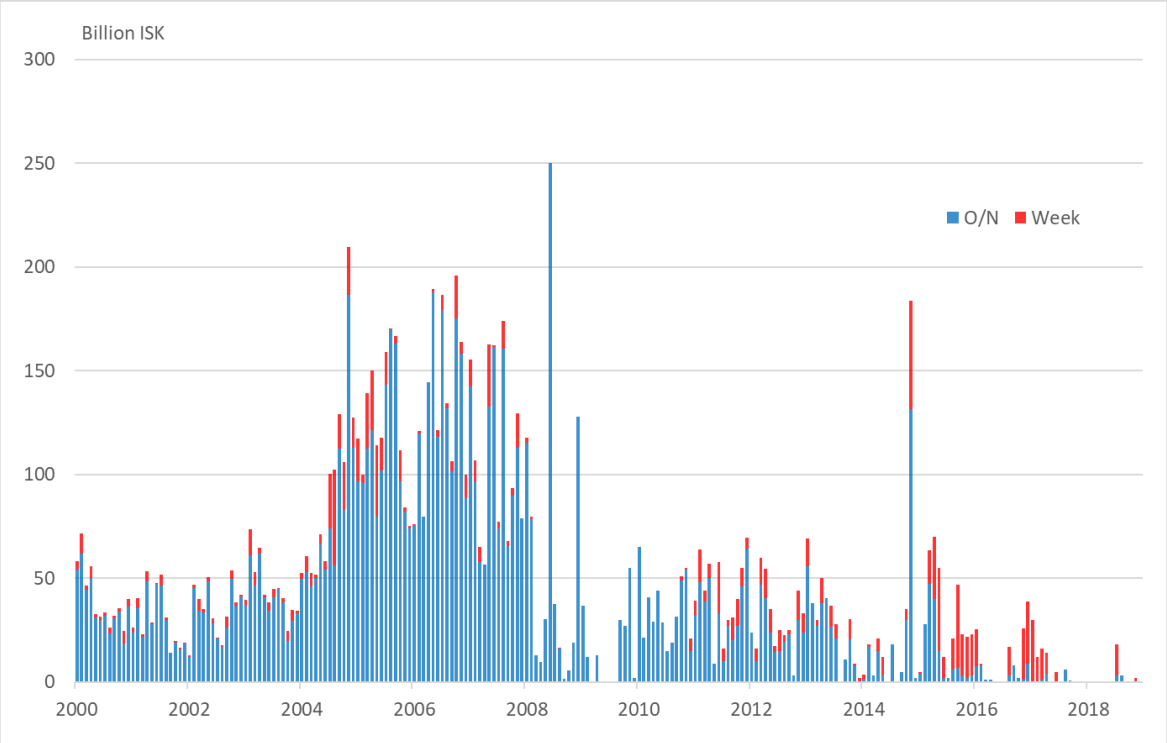

Figure 13. Turnover in the interbank market for krónur 2002-2018. Source: Central Bank of Iceland, Interbank market for Icelandic kronur.

The limited activity in the interbank market can be traced to the very few counterparties in the market and the significant structural surplus of the banking system which deters interbank trading. However, figure 13 shows that interbank rates have stayed fairly close to the floor since its inception in 2009 and have recently shown very little volatility.

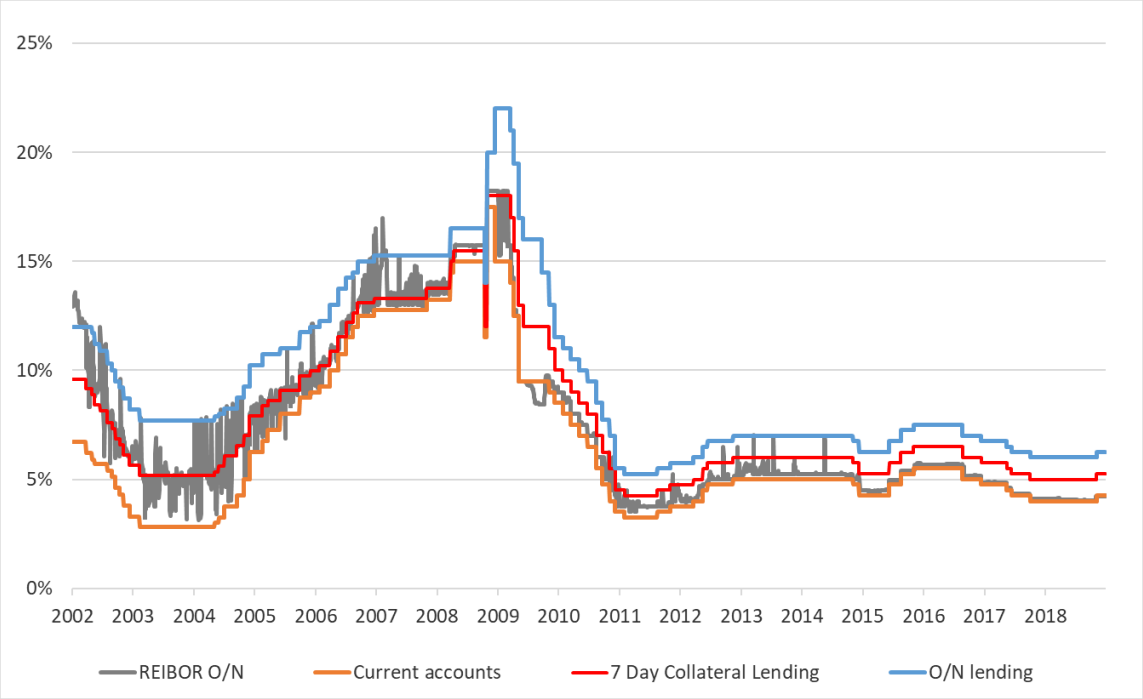

Figure 14. The Central Bank of Iceland corridor of interest rates as well as o/n interest rates in the interbank market (REIBOR). Source: Central Bank of Iceland, Central Bank interest rates and DataMarket, Reibor.

It should be noted that the REIBOR rates are quoted rates, as opposed to actual transaction rates in the interbank market. Banks may price themselves out of the market if there is not willingness to transact. The CBI could consider to publish rates similar to Norges Bank's NOWA (Norwegian Overnight Weighted Average), Bank of England's SONIA (Sterling Over Night Index Average) and ECB's EONIA (Euro Over Night Index Average). This rate might be referred to as Icelandic Overnight Weighted Average (IOWA) or Króna Over Night Index Average (KONIA).

Appendix IV – The interbank market for foreign currency

For some perspective, it is of interest to look at the development of the Icelandic interbank market for foreign exchange over the past fourteen years. Recent turnover is minimal in comparison to the two or three years leading up to the global financial crisis. Another comparison which may be of interest, is that turnover at its height in 2008 reached almost 1200 billion ISK on a monthly basis, a number similar to the amount of foreign reserves at their absolute highest in November 2011. The number 1200 billion ISK was also approximately Iceland's nominal GDP in 2006. During the period 2008-2009 the CBI purchased just over 68 billion ISK in the foreign exchange market.

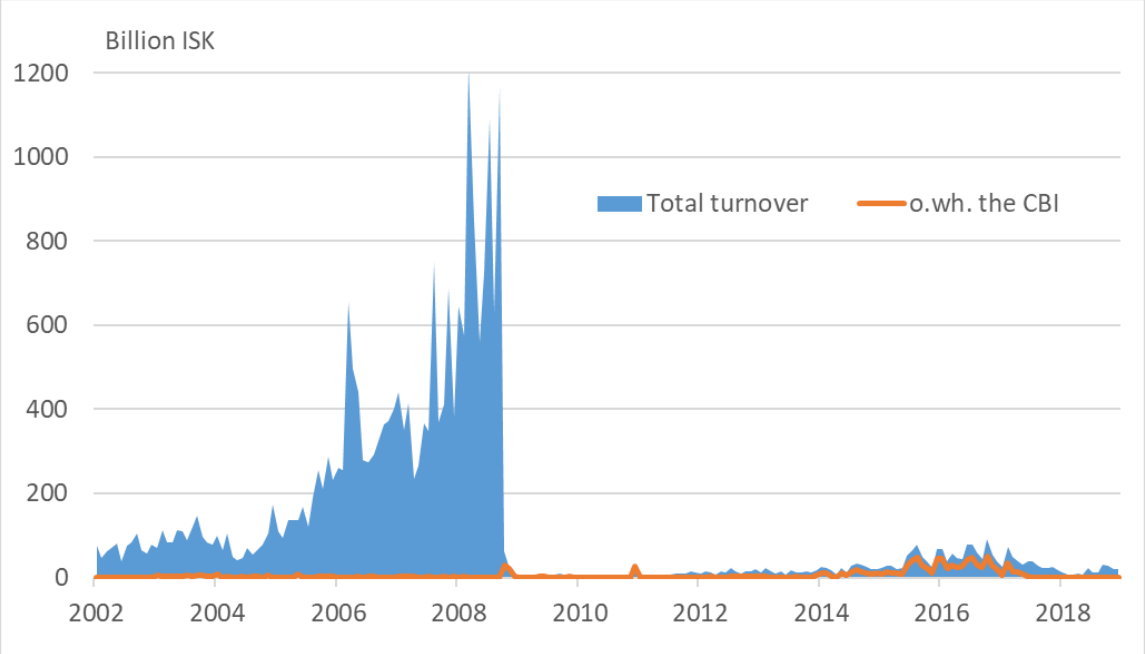

Figure 15. Turnover on the interbank market for foreign currency including the share of the Central Bank of Iceland's interventions. Source: Central Bank of Iceland, Interbank market for foreign exchange.

On the other hand, to focus only on the latter part of this period, we can see that the volume is on a substantially smaller scale, by more than a factor of ten. The CBI's interventions in the foreign exchange market in recent years have also formed a much larger part of total turnover. The CBI started regular purchases of foreign currency in 2002, to enable the Treasury to service its foreign debt and to support foreign reserves. These regular purchases were suspended in May of 2017 due to the size of foreign reserves.

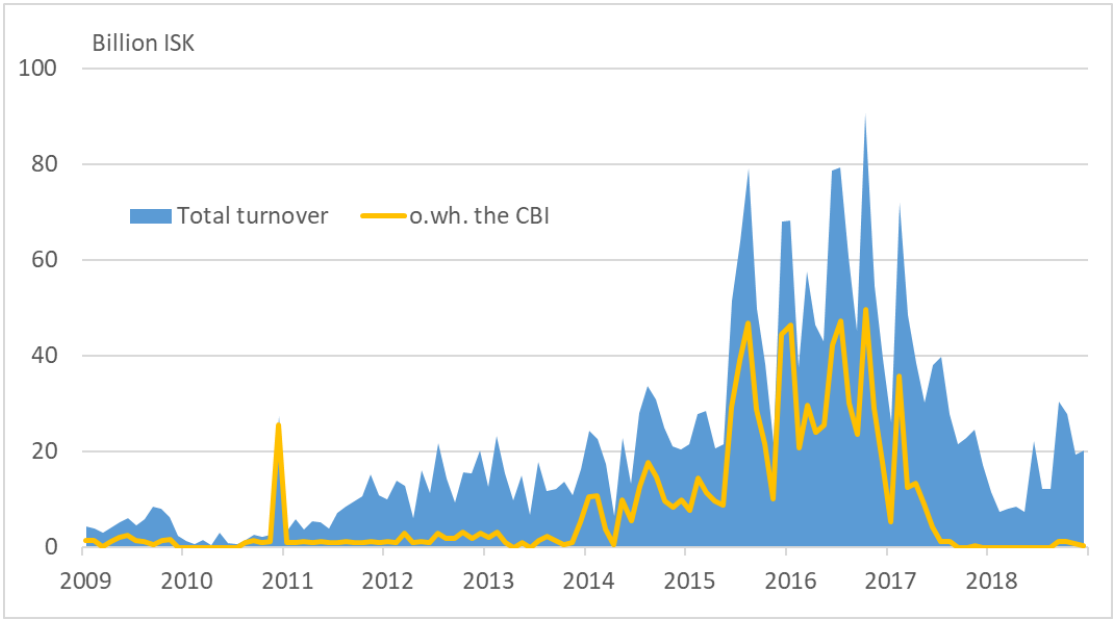

Figure 16. Turnover on the interbank market for foreign currency, including the Central Bank of Iceland's interventions. Source: Central Bank of Iceland, Interbank market for foreign exchange.

Appendix V – The cost of sterilization 2010-2018

The CBI's outstanding facilities can be seen in appendix II. Below are interest payment on these same facilities from 2006-2018 in monthly increments as well as the development of total deposits. It is possible to talk about two periods here; the volume of financial institutions' total deposits with the central bank rose highest in late 2008 and reached similar levels again in 2015, although deposits continued to rise after that. On the other hand, as can be seen below, the total cost is significantly higher in the former period, as interest rates were considerably higher. On the other hand, in the previous period, the CBI received interest payments on collateral loans to financial institutions, netting out some of the cost.

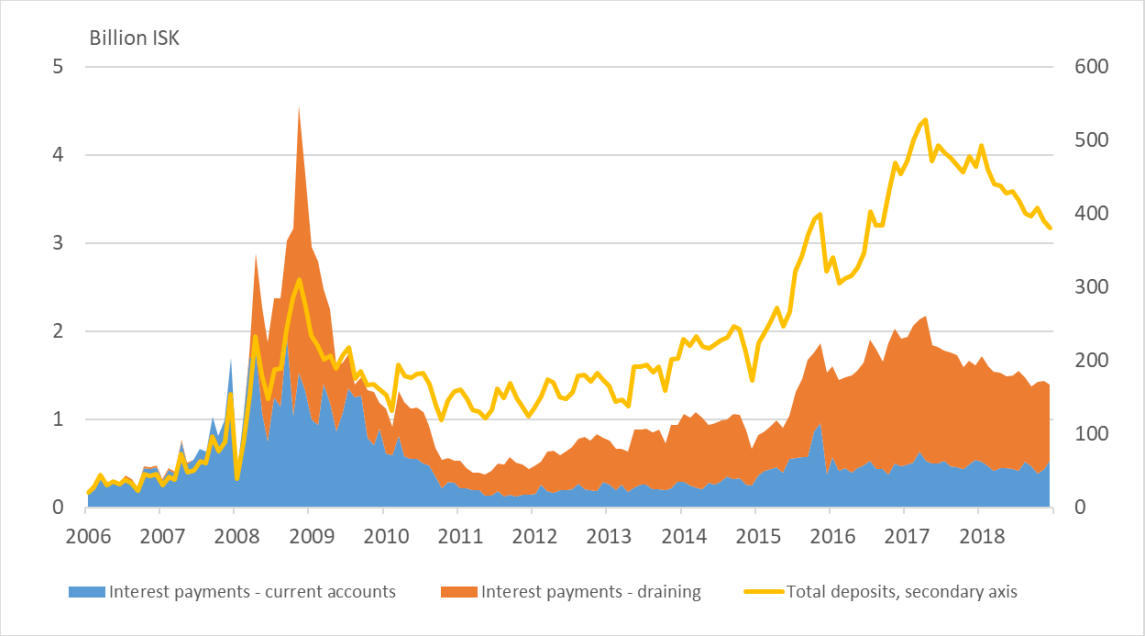

Figure 17. The Central Bank of Iceland's approximate interest payment expenses in 2006-2018. Monthly numbers. Source: The Central Bank of Iceland, Balance sheet of the Central Bank and Central Bank interest rates.

During 2010-2018 the Central Bank of Iceland spent a total of 121 billion ISK in interest payments on financial insitutions' deposits with the banks. Thereof, just over 39 billion was due to current account positions and the larger part, around 82 billion was paid on CDs and term deposits. Even so, since the CBI pays interest on current accounts, the actual cost of draining is the margin between the current account interest rate and longer-term deposit rates. The cost of draining over the period was roughly six and a half billion ISK.

The floor became effective for monetary policy implementation in April 2009. From that time and until the capital controls were lifted at the end of 2016 it

might not have been strictly necessary to drain excess reserves, since capital controls were in place for much of the period and a working corridor was in any case not in place.

Appendix VI – Quota system, a stylized example

It is interesting to do a quick run-through of what a quota system might look like in a structure loosely resembling the one in place in Iceland. In this example, seven banks, A-G have individual reserves ranging from 1-100 billion and total reserves amounting to 213 billion ISK.

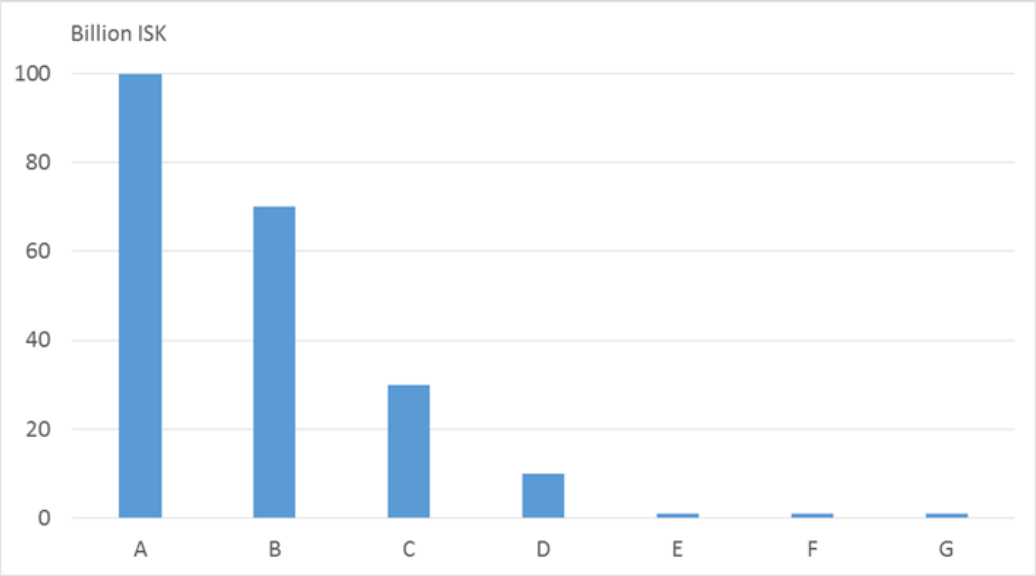

Figure 18. Stylized example of a banking system with a significant structural surplus. Banks A-G have initial individual reserves of 1-100 billion ISK.

This example takes as a given that one would want to frame fairly accurately the liquidity needs of the system. Another example might have as a priority to maximize trade such that the banks do not need to access facilities of the central bank, in which case all quotas would be larger.

The incentive structure is such that an overnight lending standing facility is at the upper end of the 200 bp corridor and the interest rate on reserves in excess of quota, which we can call the reserve rate, at the lower end. The current account rate, that we can call the frame/quota rate, is in the middle, with 7-day lending omo just above and a 7-day deposit facility just below the frame/quota rate. OMO can be regular or irregular and issued to a week or longer. They can also be issued specifically to offset treasury movements and foreign exchange interventions.

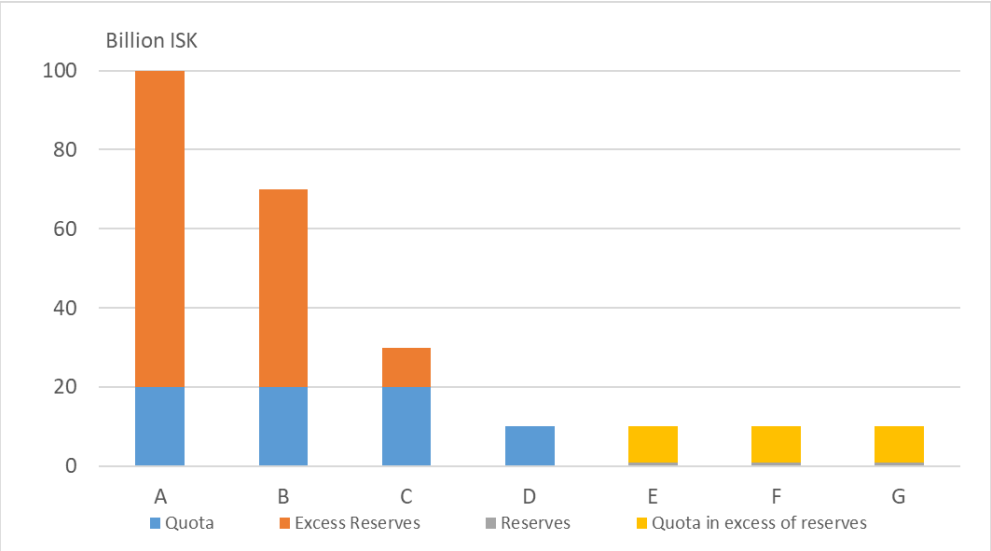

Figure 19. Stylized example of a banking system with a significant structural surplus. Banks A-C have quotas ranging from 5-20 billion ISK. Banks A-D have excess reserves while banks E-G have space within their quotas.

Assuming that banks are given quotas according to their previous liquidity needs, banks A-C have quotas of 20 billion and banks D-G have quotas of 10 billion each. Bank D has a quota that frames its reserves needs exactly and hence will not partake in any trading. In the Norwegian system banks were split into three groups according to size and each group allocated a reserve level, or quota. This scenario is different in that the groups are two and keeping in mind that the Norwegian banks were given ample room within their quota as market makers. Here the smaller banks are given more generous quotas to begin with.

As the quotas are remunerated at the policy rate, (current account rate or frame rate) and excess reserves are remunerated at the reserve rate, 100 bp below the policy rate, this will incentivise banks to find other uses for their reserves. In the first instance they might think about placing them with banks that have space on their quota. The three smallest banks would be able to receive 27 billion in total at a rate between the quota rate and the reserve rate and in this example we assume that equal amounts are supplied by the three largest banks. Since the central bank is also conducting OMO at around the policy rate, and would aim to drain a substantial part of the excess, the interbank rate would also likely hover around the policy rate.

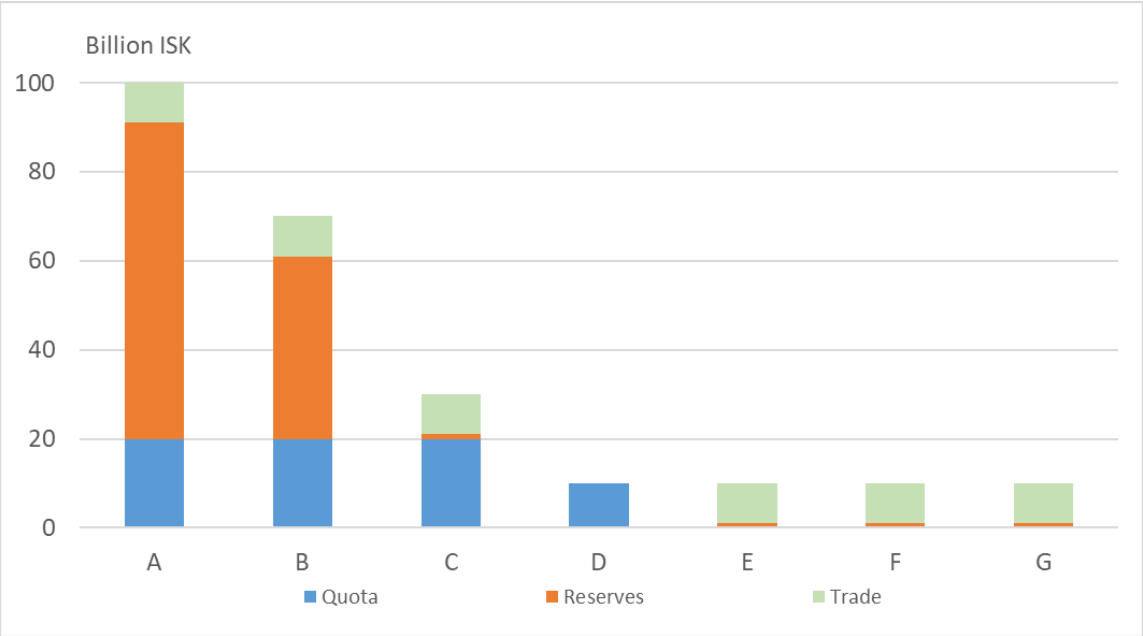

Figure 20. Stylized example of a banking system with a significant structural surplus. Banks with excess reserves could place them with banks which have space on their quota. The green area represents the amount of trading.

As the Icelandic banking system is comprised of almost only non-borrowed reserves, banks cannot really be incentivised to reduce permanently the size of their surplus but on the other hand they can be encouraged to place them in other assets, either central bank term deposits or treasury paper. Recent issues of treasury bills have amounted to 1-3.5 billion ISK.

In reality, the central bank would have to be active in open market operations to provide an alternative and keep the interbank rate close to the policy rate. However, the central bank would endeavour to square the numbers so that enough is left for trade to take place. Another scenario that might maximize interbank trade would be to calibrate the quota sizes so that all banks would benefit from trading and the market would be cleared. The Danish solution to excess reserves is the automatic conversion into certificates of deposit.

Appendix VII – Collateral eligibility and collateral intensity

What is notable about the CBI collateral situation at present, is that the collateral intensity of the system is negligible. As could be seen in appendix II, the CBI is not offering the seven-day collateral loans that were traditionally the backbone of the bank's operations and outstanding o/n loans are very rare. Figure 20 below shows the evolution of the collateral that is currently in the CBI's collateral pool and what would be considered to be the safest assets available. It is therefore not representative of the time around the global financial crisis in 2008-9 when the collateral eligibility was broadened considerably.

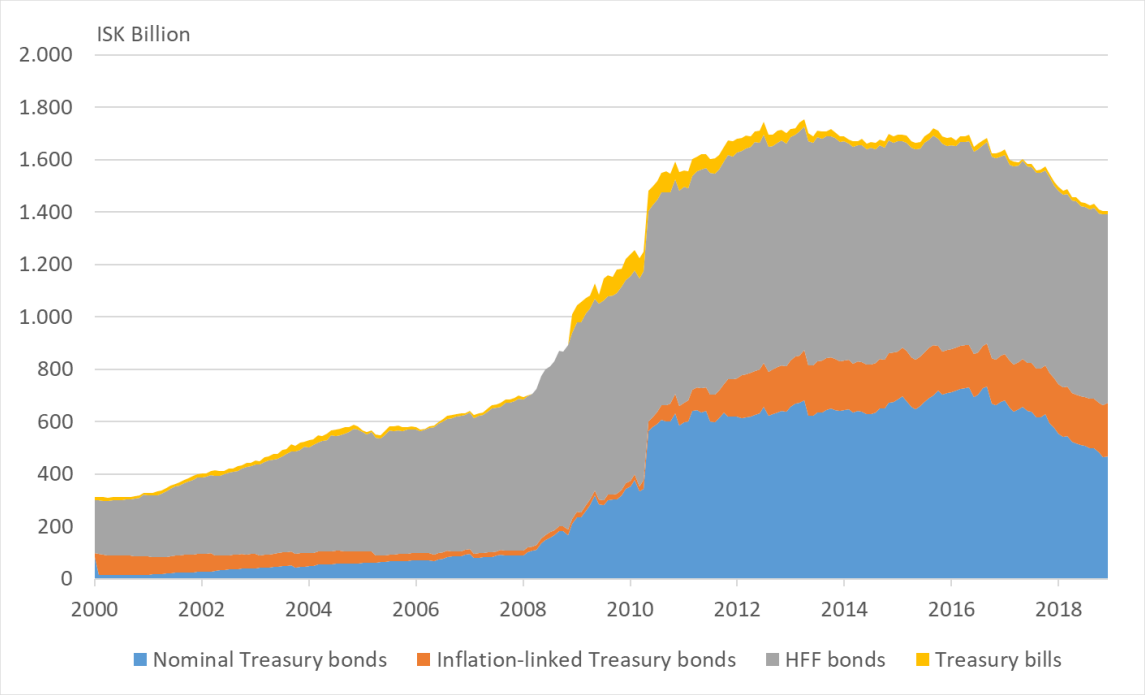

Figure 21. Eligible collateral 2000-2018 according to the CBI's current rules. Source: Central Bank of Iceland, Marketable Securities.

In addition to these instruments, term deposits can also be used as collateral in the payment system. Adding the approximately 200 billion ISK of term deposits that can be seen in figure 11 in appendix II, eligible collateral would have amounted to a ballpark figure of 1800 billion ISK at year-end 2016. The collateral needs of the RTGS system, hovering around 20 billion ISK, can be covered many times over by only term deposits. It should be noted, however, that markets for these instruments are very shallow. Due to the number and size of domestic institutional investors, many of the longer-term debt instruments are not currently in the market and available as collateral.

Figure 20 also shows that the issuance of government bills has decreased steadily, although the treasury might consider to issue more short-term instruments as part of its liquidity management. Such instruments would also be a practical substitute for CD issuance on behalf of the central bank. The CBI could also consider widening its collateral pool, for example by accepting covered bonds.

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