

No. 4 | 2010

Staff Memo

Liquidity management system: Floor or corridor?

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ISSN 1504-2596 (online only)

ISBN 978-82-7553-547-2 (online only)

Liquidity management system: Floor or corridor?

by Tom Bernhardsen and Arne Kloster¹

1. Introduction

Liquidity policy aims to implement monetary policy decisions taken by central banks, normally with the objective of stabilising short-term money market rates around the key policy rate. The most common liquidity operational framework is a so-called corridor system, with standing central bank facilities that lend to and accept deposits from banks. The deposit rate constitutes a floor for the overnight money market rate, as no bank will lend money in the market to a rate of interest lower than what it can get at the central bank. Similarly, the lending rate constitutes a ceiling for the overnight money market rate, as no bank will borrow money at a rate higher than what the central bank charges (as long as it is eligible for loans at the central bank and can provide sufficient collateral). Normally, the key policy rate is in the mid of the corridor, and to keep the overnight rate close to the key rate, the central bank must adjust liquidity supply so that the key rate materialises in the overnight market.

In a floor system the key policy rate is equal to the central bank's deposit rate. Then the central bank must provide the banking system with so much liquidity that the overnight rate approaches the central bank's deposit rate. In fact, one advantage with a floor system is that the central bank can increase the supply of liquidity to the banking system without pushing short-term money market rates below the key rate. This implies that the central bank has two independent tools, the interest rate and the amount of liquidity supplied.

During the financial crisis several central banks have in practice moved from a corridor system towards a floor system, at least temporarily. The purpose of this article is to discuss the two systems and show how the measures taken during the financial crisis has changed the liquidity management framework in some countries. We do not attempt to give a complete overview of all central banks' liquidity management framework, but concentrate on the issues most relevant for the "floor vs. corridor"-discussion.

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In the next section we first go through the liquidity management system in Norway, a floor system, and show how liquidity operations have evolved in the course of the financial crisis. In section 3 we discuss advantages and disadvantages with the two systems within the framework of a simple model. Then, in section 4 we have a closer look at recent changes in the liquidity management framework for some countries (US, the euro area, UK, Sweden, Canada, New Zealand and Switzerland). With the help of the simple model we relate these changes to our floor-corridor discussion. Finally, section 5 concludes.

2. The liquidity management system in Norway: A floor system²

Monetary policy in Norway is based on an inflation targeting regime, introduced in 2001.³ The main instrument of monetary policy, the key policy rate, is the rate of interest on banks overnight deposits in the central bank. All reserves are remunerated at this rate. There are no reserve requirements in Norway, but banks need liquidity for intra-day transactions with each other. Each day starts with each bank having a certain amount of liquidity on the account with the central bank. At the end of the day banks with a liquidity deficit must borrow from banks with a liquidity surplus. Banks not able to cover a liquidity deficit by borrowing in the inter-bank market will need to borrow additional liquidity from the central bank at an interest rate one percentage point above the deposit rate.

All banks established in Norway can have a sight deposit account with Norges Bank. The sum of banks' overnight deposits in their accounts is known as the total liquidity of the banking system. The role of liquidity management is to ensure that there is sufficient liquidity in the banking system for the short-term money market rates to remain close to the key policy rate. In order to ensure that banks have sufficient deposits in Norges Bank, one needs to estimate the level of liquidity in the banking system in the absence of liquidity provisions of the central bank. This is known as structural liquidity. Structural liquidity is in particular influenced by

² This section draws on Bernhardsen et. al. (2009) and Fidjestøl (2007). In particular, Fidjestøl provides a more detailed discussion of the liquidity framework in Norway, while Bernhardsen et. al. go through measures taken by Norges Bank during the financial crisis.

³ The operational target is annual consumer price inflation of 2.5 per cent over time. The regime is flexible, so that weight is given to both variability in inflation and variability in output and employment. The key policy rate is set by the Executive Board, normally every sixth week, with a view to stabilising inflation close to the target in the medium term. Three times a year, at every third monetary policy meeting, a Monetary Policy Report is published at the same time as the interest rate decision. In the Report, Norges Bank analyses the current economic situation and publishes its economic forecasts. Since 2005 Norges Bank has published its own interest rate forecast, on which the reference scenario for the economic outlook is based.

transactions between the government and the rest of the economy, as the government holds its account at the central bank. These flows are often large, and the exact size of these payments is normally not known in advance. This implies that structural liquidity is difficult to forecast precisely.⁴

Based on a forecast for structural liquidity, Norges Bank decides whether it is necessary to supply additional liquidity. The liquidity provisions from Norges Bank are normally supplied via fixed-rate loans (F-loans). The interest rate on F-loans is usually determined by competitive multi-price auction and will in most cases be only marginally higher than the key policy rate.⁵ Chart 1 shows both structural and total liquidity, indicating that while structural liquidity is very volatile, Norges Bank provides additional liquidity to the banking system to stabilise total liquidity at the appropriate level. Like in other countries, different kinds of liquidity measures were undertaken during the height of the financial crisis. Hence, total liquidity in the banking system increased substantially in the last quarter of 2008 and stayed relatively high until summer 2009, after which it has been kept around more normal levels.

The key rate forms a floor for short-term money market rates, as banks will not lend money at rates lower than what they achieve at the central bank. Chart 2 shows the deposit rate (the key policy rate) and the overnight lending rate together with the money market rate at the shortest maturity, tomorrow-next.⁶ Evidently, the tomorrow-next rate has remained close to the floor of the corridor.^{7,8}

⁴ Norges Bank is both the government's bank and the banks' bank. Government revenues and expenditures result in daily transfers of deposits between banks' accounts and the government's account. This leads to major fluctuations in banks' deposits in Norges Bank during the year, see Fidjestøl (2007) for more details.

⁵ In a multi-price auction, also referred to as American auction or ordinary auction, banks submit bids for the desired amount and interest rate. In the distribution, Norges Bank decides the aggregate amount. The banks' interest rate bids are ranked in descending order and distributed until the aggregate amount is reached. The banks who are awarded an amount in the distribution pay the interest-rate bid submitted.

⁶ In Norway the over-night money market rate is not very liquid, and the tomorrow-next rate is considered as the most liquid rate at the shortest maturity.

⁷ It is possible to observe tomorrow-next rates below the deposit rate. Since only banks with a head office or branch in Norway are allowed to take part in Norges Bank's deposit and lending facilities, foreign operators with a surplus of NOK have to make deposits at other banks with access to Norges Bank's facilities. This may on some occasions bring the shortest money market rate below the deposit rate at the central bank. On some rare occasions the tomorrow-next rate has also increased above the overnight lending rate at the central bank, partly because of foreign banks' need for NOK and partly because Norges Bank's overnight lending facility requires collateral.

⁸ Like in other countries, however, during the financial crisis the risk premium on money market rates, the difference between money market rates and the key policy rates, increased.

Chart 1. Total and structural liquidity in Norway. Billion kroner.

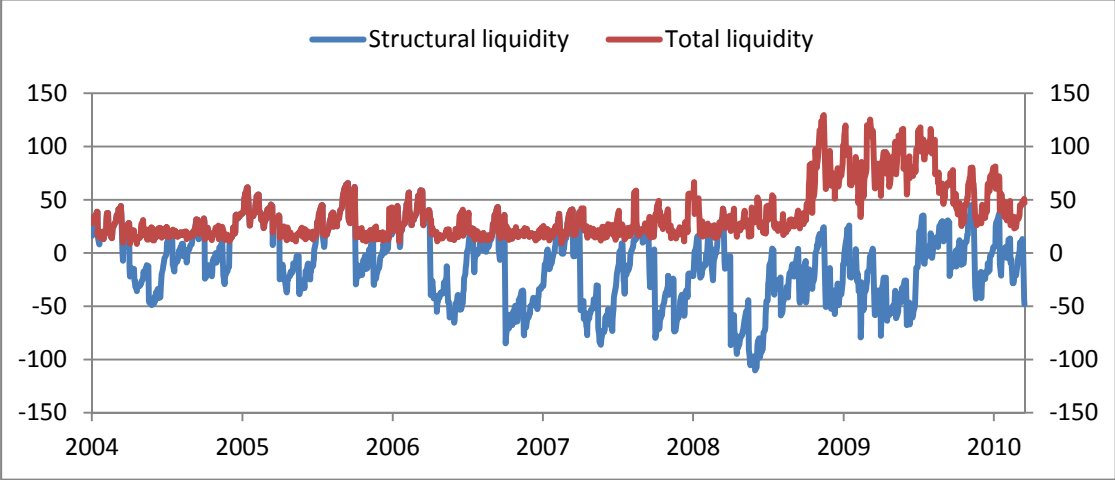
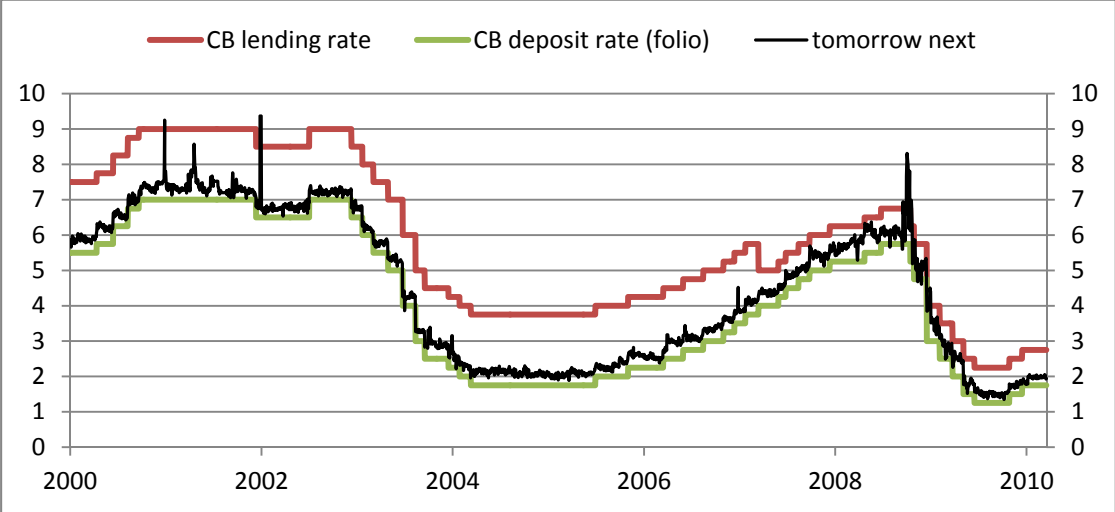


Chart 2. Norges Bank’s lending and deposit rate and tomorrow next money market rate



3. A model for the liquidity system

In this section we outline a model, which illustrates the basic features of both a corridor and a floor system. The model is analysed in detail in Whitesell (2006) and further used by Keister et. al. (2008) to characterise recent changes in the liquidity system operated by the Federal Reserve (Fed). While the model is mathematically rich, the intuition behind it is straightforward. For our purpose a simple graphical outline of the main ideas of the model will be sufficient.

Banks need reserve balances held at the central bank for clearing purposes. As intraday transactions between banks are uncertain, each bank's need for reserve balances at the end of the day is also uncertain.⁹ A bank holding a positive amount of liquidity will need to use the central bank's deposit facility, while a bank with a liquidity deficit will need to use the lending facility. As explained above, the deposit rate constitutes a floor for the overnight rate, while the lending rate provides a ceiling.

Between the lending rate and the deposit rate the demand for reserve balances falls with the overnight rate in the market, as illustrated in chart 3.¹⁰ Given demand, the equilibrium interest rate in the overnight money market is determined by the supply of liquidity.¹¹ Total supply is determined by the amount supplied by the central bank in addition to autonomous factors, outside the influence of the central bank. The supply curve is independent of the interest rate and hence vertical. In a corridor system the key policy rate is normally equal to the mid-point between the lending and the deposit rate. This is the rate of interest the central bank aims for in the overnight money market. To achieve this it must provide exactly so much liquidity that total supply crosses demand in the mid of the corridor, as illustrated with the supply curve S1.

In a floor system, however, the key rate is equal to the central bank's deposit 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 so much liquidity that the supply curve crosses the (lower) flat part of the demand curve, as illustrated by the supply curve S2. For any supply crossing demand on the flat part of demand, the money market rate will be equal to the deposit rate.

⁹ In the model the private bank's end-of day position at the central bank is assumed to be stochastic with a symmetric zero-mean distribution, i.e. the bank's position may be positive or negative, of equal size, with the same probability.

¹⁰ When the overnight rate is high (close to but below the central bank's lending rate) the opportunity cost of using the central bank's deposit facility is high. Then it is more costly to use the deposit facility than the lending facility. Hence for a bank it is more risky to end up with large reserve balances (which have to be deposited at a low rate of interest at the central bank) than running short of reserve balances (in which case the bank can borrow additional reserves from the central bank at a rate of interest not much higher than the market rate anyway). Hence, when the overnight rate is "high", the demand for reserve balances is "low". Similarly, when the overnight rate is low (close to but above the central bank's deposit rate) it is costly for the bank to use the central bank's lending facility and cheap to use its deposit facility. Then, when the overnight rate is "low", the demand for liquidity is "high".

¹¹ One should note that this does not mean that the central bank must adjust the supply of liquidity in order to implement a change in the monetary policy stance. The central bank can achieve this by announcing a new target rate and adjust the rates on its standing facilities correspondingly. This will lead to a shift in the demand curve, and the supply of reserves may remain at the same level as before. See Disyatat (2008) for a further discussion of this issue.

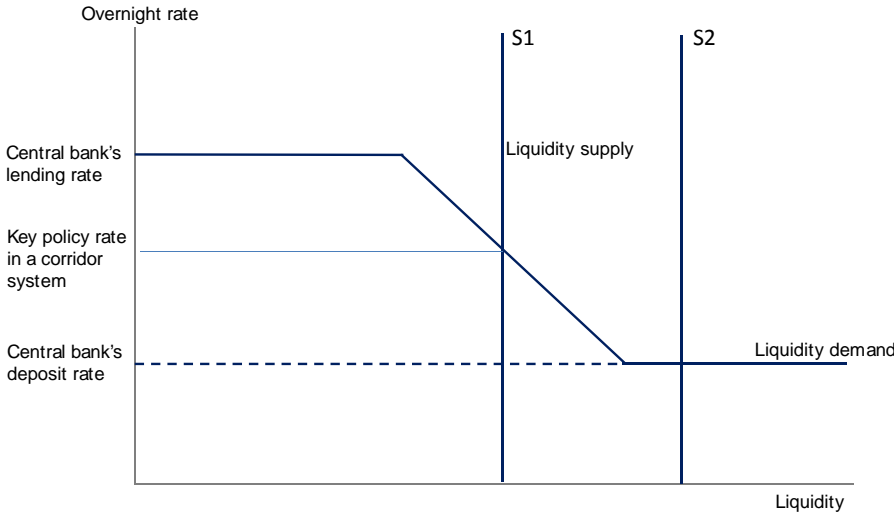
Comparing the two liquidity systems, in particular three issues seem important.

1. The need to increase liquidity in times of financial instability

The main advantage of a floor system is, to phrase Keister et. al. (2008), that monetary policy can be divorced from money. The central bank can (for whatever reason) supply any amount of extra liquidity without pushing short-term money market rates below the key 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 probably being financial markets stabilisation (Goodfriend 2002). In times of financial stress central banks frequently want to increase reserve balances, either as an intended policy or as a side-effect of different kind of assets purchases. In a floor system, supplying more reserve balances will not conflict with the monetary policy goal of stabilising short-term money market rates close to the key policy rate.

As will be discussed below, several central banks have moved in the direction of a floor system during the recent financial crisis. The main reason for this has probably been the desire to maintain clarity about the monetary policy stance in an environment with very high levels of reserve balances in the banking system, i.e with a supply curve like S2 in Chart 3.

Chart 3. Demand for and supply of liquidity in a floor system and a corridor system



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2. The need of fine-tuning liquidity operations

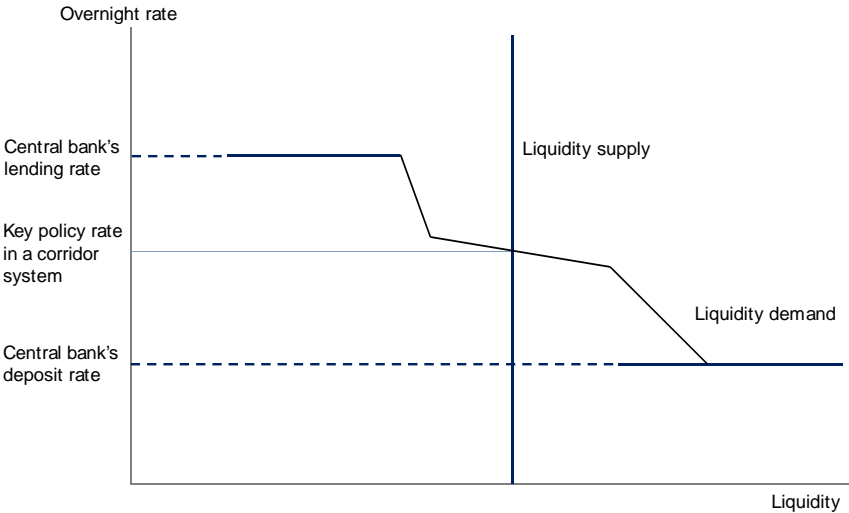
Another advantage with a floor system is that fine-tuning liquidity operations are not necessary. Looking at chart 3, in a corridor system small changes in demand for and supply of liquidity may lead to changes in the overnight rate (depending on the elasticity of demand). To keep the overnight rate in line with the key rate, the central bank must encounter these changes by adjusting the supply of liquidity correspondingly. This requires very accurate liquidity forecasts and frequent liquidity operations. In contrast, in a floor system supply of and demand for liquidity may change considerably without having any effect on the short-term money market rates.

One should note, however, that reserve requirements may modify the need to undertake fine-tuning operations, depending on how the reserve requirements are set up. Reserve requirements are reserve balances that banks are to hold at the central bank. If banks are required only to hold a daily average level of reserve balances over a certain period (the so-called maintenance period), banks may hold more balances at the beginning than at the end of the period (or opposite). What matters is the average daily figure. This will stabilise short-term money market rates. If the overnight rate is higher than it is expected to be later in the maintenance period, a bank should lend money in the market and run short of the daily average requirement. Later in the period, when the overnight rate is lower, the bank should borrow reserves in the market and hold more balances at the central bank to fulfil the daily average requirement. This will tend to reduce the overnight rate when it is high, and increase it when it is low. Moreover, this mechanism will work more properly if the central bank can credibly convince market participants that the overnight rate will be close to the key rate on the final day of the maintenance period. In fact, as will be discussed below, some central banks have taken measures to convince the market that the overnight rate will be very close to the key rate on the last day of the maintenance period.

In terms of our model, with reserve requirements (averaged over a maintenance period), the demand curve becomes flatter for values of the interest rate around the mid-point of the corridor, as illustrated in chart 4. With more elastic demand, changes in supply affects the interest rate less, hence volatility in short-term money market rates will be lower. One should note that the elasticity of demand, i.e. the extent to which the demand curve is flat, depends on the remaining number of days in the maintenance period. In particular, on the last day of the maintenance period the demand curve is steeper, as in the original model illustrated in chart 3.

The reason is that on the last day, the banks cannot substitute more (or less) reserves today for less (or more) reserves tomorrow.¹² This is the reason why some central banks have introduced measures with the aim of stabilising the overnight market rate close to the key rate on the last day.

Chart 4. Demand for and supply of liquidity in a corridor system with reserve requirements over a maintenance period



4

3. Activity in the interbank market

In a corridor system banks will have a strong incentive to trade reserve balances with each other, and more so than in a floor system. Below we discuss why this is so, and to what extent high activity in the interbank market is important.

In a corridor system the amount of liquidity supplied must be equal to what banks need for clearing purposes, in practice, an amount somewhat larger than zero. Then, if a bank runs a reserve balance deficit, there will be one or more banks with a liquidity surplus. The deficit bank wants to avoid using the central bank’s lending facility and seeks to borrow the necessary amount of liquidity in the market (because it is cheaper). Similarly, any surplus bank wants to avoid using the central banks deposit facility and seeks to lend the money in the

¹² Whitesell (2006), on which our analysis is based, develops an analytical tractable (though mathematically demanding) model for two periods, the settlement day and the pre-settlement day. In the model, on the settlement day the demand curve is equal to the demand curve in a model without reserve requirements. On the pre-settlement day the demand curve is flatter because banks can substitute reserve balances held at the central bank between the pre-settlement day and the settlement day. Whitesell claims that for longer periods than 2 days a closed-form solution of the model is not available. However, he argues that “a longer period would engender a greater range of high elasticity.

market (because it is more profitable). Hence both the deficit and the surplus bank have strong incentives to trade liquidity overnight. The point is that when the overnight rate is different from the interest rates on the central bank's standing facilities, the banks seek to avoid using these facilities. This is sometimes called the "hot-potato problem"; if there is excess liquidity, no one wants to keep it, but pass it on (as a loan) to someone else.¹³

In a floor system there will be less incentive for banks to trade than in a corridor system. In a floor system the central bank provides sufficient liquidity to bring the overnight rate close to the central bank's deposit rate. The liquidity is supplied at a rate only slightly higher than the central bank's deposit rate. Hence it is not costly to use the central bank's deposit facility, and it does not make a big difference whether surplus liquidity is lent in the market or deposited at the central bank. The hot-potato problem disappears.¹⁴

In the literature it is argued that high interbank trading activity improves financial stability through more inter-bank monitoring (Rochet and Tirole, 1996). A bank will lend unsecured to other banks only if it regards the borrower as safe. To convince the creditor of the solvency of the debtor, banking business must be transparent, and banks must accept that other banks (or monitoring institutions) scrutinise their balance sheets and business in general. This, in turn, will lead to sounder banking business, and a banking system more robust to shocks and financial crises.

However, the larger share of inter-bank trading is at the very short end of the yield curve, as banks need to restructure liquidity for clearing purposes over night. In fact, also in well functioning corridor systems inter-bank trading activity concentrates on the shortest maturities. Then, what matters for a creditor bank is that the counter party does not go bankrupt during the next couple of days. The creditor bank does not necessarily have a strong

¹³ To understand the hot potato problem, it is crucial to understand the nature of central bank liquidity. Importantly, the banking sector cannot change the amount of central bank reserves in the banking system. During the day money is transferred between banks and at the end of the day transactions are netted out by adjusting banks' deposits at the central bank. In the evening the total amount of liquidity may be differently distributed across banks, but the total amount will be the same. Then, after the transactions have been settled, banks with a liquidity surplus are forced to use the central bank's deposit facility. Since the deposit rate is lower than the overnight rate in the market, banks will try to lend liquidity in the market, they will try to throw the hot potato to someone else.

¹⁴ Indeed, a bank will still earn a few basis points by lending liquidity in the market and not using the central bank's lending facility, but compared to a corridor system the opportunity cost of using the central bank's deposit facility is virtually zero.

incentive to monitor the debtor's long-term solvency position, which is what really matters for financial stability.

Moreover, prior to the financial turmoil starting in August 2007, the US, UK and the euro area had well established and efficient interbank markets, presumably with relatively high activity. Then, according to the argument above, interbank monitoring should have provided transparency, sound business and a common understanding of what was going on in the banking sector. The events during 2008 and 2009 suggest that the evidence for such mechanisms should not be overstated.

Moreover, one should recognise that an efficient market with high activity is not required to secure the socially optimal price in the market for reserve balances. In a "normal" market, supply of goods increases with the price because of increasing marginal costs of production. Changes in supply and demand move prices, which in turn give a signal to consumers and producers. Central bank liquidity, however, is not costly to produce (for the central bank, just press a button and liquidity is there). The social correct price can be set by the board of the central bank, and does not require much market activity to materialise. This does not imply that the rate set by the central bank is the "correct one" regarding achieving the monetary goals. The central bank may misunderstand the economic situation and make bad forecasts, but once the central bank has set the key policy rate, high interbank trading activity is not necessary to implement it. It is sufficient that the central bank brings the short-term money market rate in line with the key policy rate, let it be within a corridor or a floor system.

One advantage with a corridor system concerns the amount of collateral required to be deposited at the central bank. If there is a structural liquidity shortage in the banking system, the central bank needs to provide additional liquidity to the banking sector through collateralised loans. In a corridor system total liquidity will be slightly above zero, while 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. More loans require more collateral. Hence banks need less collateral in a corridor system than in a floor system.

For example, in Norway there is frequently a structural liquidity shortage in the banking system (blue line in Chart 1), while the historical average level of total liquidity in normal times (2004-2007) has been around 25 billion NOK. Hence because of the floor system, banks

need to deposit additional collateral of this magnitude more than would have been required in a corridor system. Collateral is costly, because a share (whenever small) of banks' funding must be deposited as collateral at the central bank and cannot be lent to the public.

4. Liquidity operations in other countries

In this section we will have a closer look at liquidity systems in other countries, with a particular focus on the development during the recent financial crisis.

The liquidity system in the US

In the US, banks demand reserve balances both for clearing purposes and because they need to satisfy reserve requirements. Reserve requirements must be held in the form of vault cash or deposits with Federal Reserve Banks. Reserve requirements need to be met only on average over the maintenance period, lasting one or two weeks, depending on the financial institution.¹⁵ Until October 2008 reserves held at the Fed were not remunerated. In terms of our model, this can be illustrated by a falling demand curve with a floor equal to zero, as illustrated in chart 5. Fed's lending rate to banks constitutes a ceiling for the overnight rate (Fed funds rate)¹⁶ and to keep it close to the key policy rate (the Fed funds target) total supply of liquidity must be equal to S_1 .

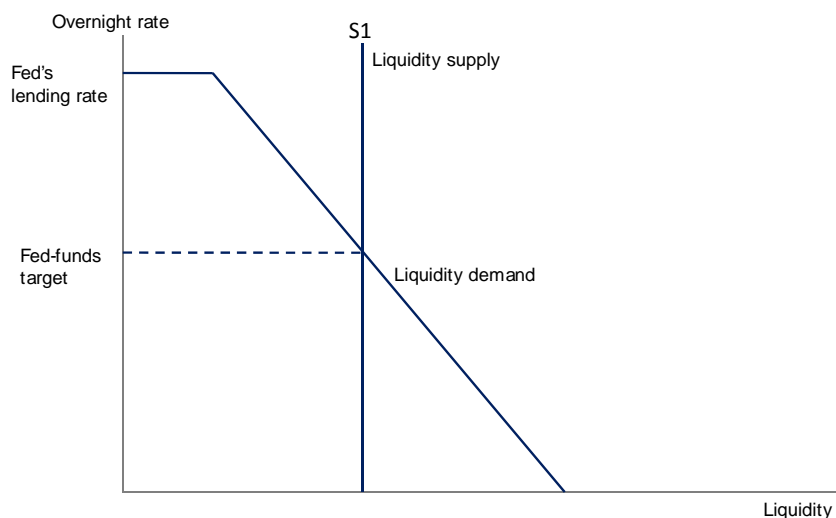
During the financial turmoil, the Fed cut the key rate to very low levels, 0-25 basis points, and since October 2008 reserves held at the Fed have been remunerated. In the press release from 6 October 2008 the Fed states *...The payment of interest on excess reserve balances will give the Federal Reserve greater scope to use its lending programs to address conditions in credit markets while also maintaining the federal funds rate close to the target established by the Federal Open Market Committee...*¹⁷ Later on, from December 2008, the Fed decided to remunerate, not only required reserves, but all reserves at the rate of 25 basis points.

¹⁵ See www.federalreserve.gov/monetarypolicy/reservereq.htm for details

¹⁶ The modifications discussed in footnote 7 also applies here.

¹⁷ See www.federalreserve.gov/monetarypolicy/20081006a.htm for details

Chart 5. Demand for and supply of liquidity in the US

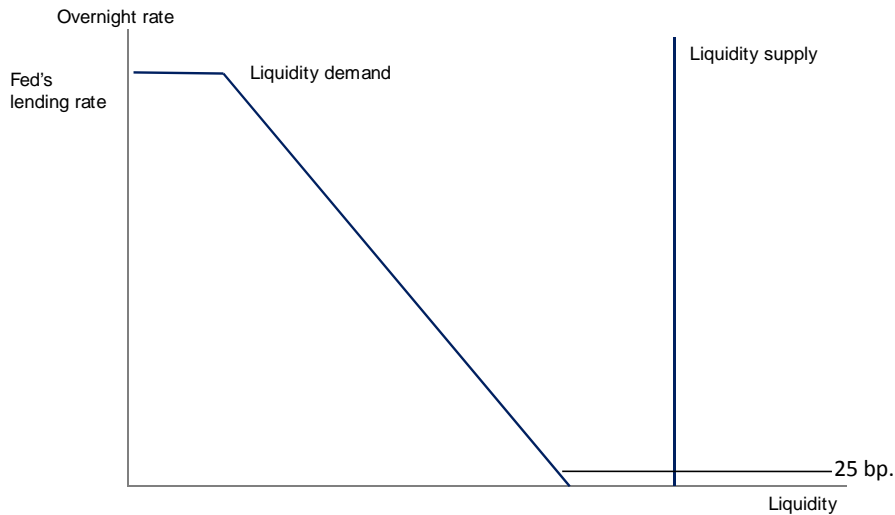


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In terms of our model discussion, what the Fed communicates is that higher supply of liquidity in the banking system will not harm the objectives for monetary policy when reserves are remunerated. This can be illustrated by chart 6, where supply of liquidity crosses the floor of 25 basis points, the interest rate on reserves. One should note, however, that when the key rate and the rate at which reserves are remunerated are close to zero, as in the case of the US, there is no big difference whether the central bank pays interests on reserves or not. This was recognised by Professor Gregory Mankiw in New York Times on 17 January 2010 when he said...*The Fed has a new tool: it can pay interest on reserves. With short-term interest rates currently near zero, this tool has been largely irrelevant. But as the economy recovers and interest rates rise, the Fed can increase the interest rate it pays banks to hold reserves as well...*

What Mankiw indicates can be illustrated in our model. In principle, the Fed can tighten monetary policy by increasing the rate at which reserves are remunerated. In this way, a higher Fed funds rate can be achieved without having to drain liquidity from the banking system, see chart 7. Hence the potential advantage of paying interest on reserves is not so evident when interest rates are close to zero, but becomes clearer when it is deemed necessary to tighten monetary policy sometime in the future. Without paying interests on reserves the central bank would have to drain all excess liquidity in the banking system (i.e. push the supply curve to the left) in order to tighten the monetary policy stance.

Chart 6. Liquidity demand and liquidity supply in the US, with ample liquidity and reserves being remunerated at 25 basis points

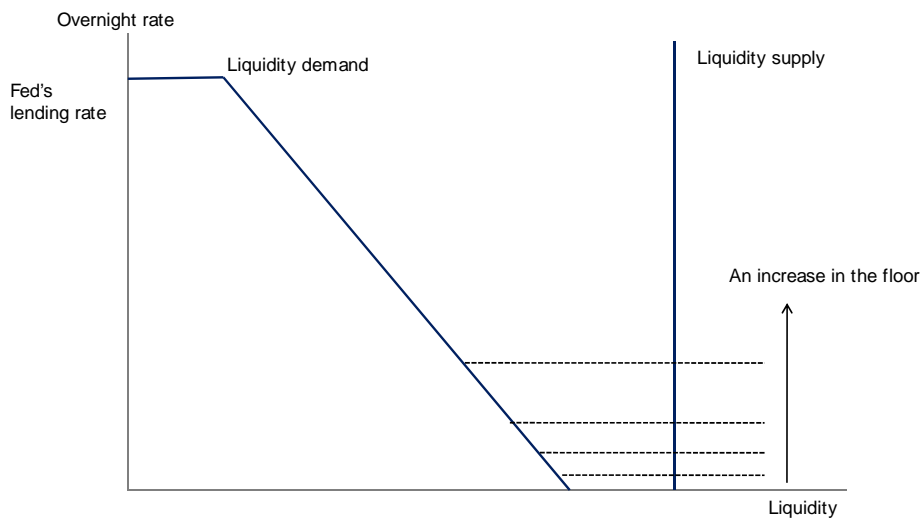


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Though we, of course, do not try to anticipate the Fed’s exit strategies, we merely illustrate how it in principle is possible for the Fed to keep a large amount of liquidity in the system, while at the same time tightening monetary policy by remunerating reserve balances at a higher level. In a recent speech Bernanke discusses the Fed’s exit strategies¹⁸: *...The Federal Reserve has a number of tools that will enable it to firm the stance of policy at the appropriate time. Most importantly, in October 2008 the Congress gave the Federal Reserve statutory authority to pay interest on banks' holdings of reserve balances. By increasing the interest rate on reserves, the Federal Reserve will be able to put significant upward pressure on all short-term interest rates, as banks will not supply short-term funds to the money markets at rates significantly below what they can earn by holding reserves at the Federal Reserve Banks...*

¹⁸ “Statement prepared for the Financial Services U.S. House of Representatives, February 10, 2010, see www.federalreserve.gov for details.

Chart 7. Liquidity demand and liquidity supply in the US.
An increase of the rate at which reserves are remunerated



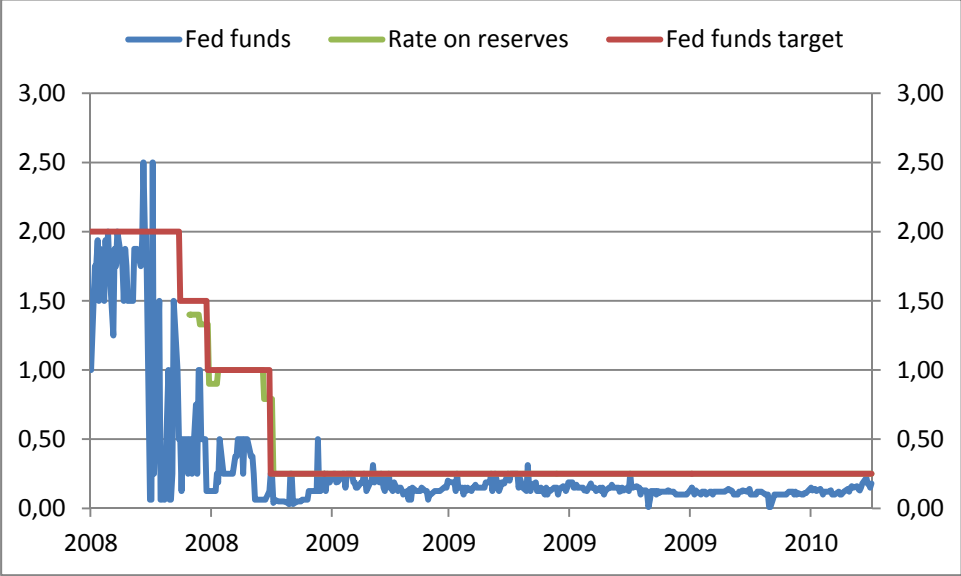
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In practice, things are somewhat more complicated. As discussed above, the overnight money market rate may on occasions be higher than the central bank's lending rate and lower than the central bank's deposit rate. In particular, institutions without access to the central bank's standing facilities may contribute to bringing the overnight rate outside the range determined by the two facilities. In the US, Government-sponsored enterprises do not have access to the Fed's deposit facility. Supply of liquidity from institutions without such access may push the overnight interest rate down to a level somewhat below the deposit rate at the Fed. Chart 8 shows the Fed funds (overnight rate), the Fed funds target (the key policy rate) and the rate at which reserves are remunerated. Bech and Klee (2009) discuss this issue in detail.

In sum, compared to the liquidity system in operation prior to the change in October 2008, when reserves were not remunerated and the floor was equal to zero, one can say that the Fed has moved in the direction of a floor system, as the Fed can now tighten monetary policy by just increasing the rate of interest paid on reserves without paying attention to the supply of liquidity in the banking system.¹⁹

¹⁹ Bowman et. al. (2010) discusses interest on reserves as a monetary policy instrument. In particular, they discuss to what extent these rates have been lower bounds for short-term market rates, and to what extent increasing policy rates has been achieved without reliance on reductions in reserves held at the central bank.

Chart 8. Fed funds, Fed funds target and the rate of interest paid on reserves



The liquidity system in the euro area

In the euro area liquidity policy is operated within a corridor system. The European Central Bank (ECB) provides liquidity to the banking system, to ensure that the overnight money market rate (EONIA) stays close to the key policy rate. The most important liquidity provision is the main refinance operations (MRO), weekly allotments of liquidity with a normal maturity of one week. The operations are repo-transactions, where liquidity is allotted against collateral. The key policy rate is the “minimum-bid rate” (the main refinancing rate), the lowest rate at which banks may bid in the weekly liquidity allotments. The rates banks must pay to borrow liquidity from the central bank are determined through auctions, and are normally slightly higher than the minimum bid rate. In addition, liquidity is provided through longer-term refinancing operations, with monthly frequency and a normal maturity of three months. In addition, fine-tuning operations are executed on ad hoc basis, in particular on the last day of the maintenance period (c.f. the discussion of the need for fine-tuning in the discussion above).

Reserve requirements are imposed on banks, but they need to be met only on average over a maintenance period, lasting roughly from one monetary policy meeting to the next (around four weeks). They are (roughly) remunerated at the marginal rate determined in the weekly auctions, close to the overnight money market rate, meaning that reserve holdings are

virtually costless for banks.^{20,21} Regarding the purpose of reserve requirements, ...*The ... reserve system...primarily pursues the aims of stabilising money market interest rates and creating (or enlarging) a structural liquidity shortage...*²²

The ECB met the financial crises by increasing liquidity in the banking system substantially. On 8 October 2008 it was announced²³ ... *that MROs would henceforth be carried out through fixed rate tender procedures with full allotment, and that the width of the corridor formed by the two standing facilities (i.e. the marginal lending facility and the deposit facility) would be narrowed symmetrically from 200 to 100 basis points. Both of these measures will remain in place for as long as is necessary...* Moreover, on 15 October the ECB ... *decided to carry out all longer-term refinancing operations (LTROs) through fixed rate tender procedures with full allotment...* Furthermore, regarding longer-term operations, it was decided ...*to increase the frequency of such operations, with two three-month operations, one six-month operation and one operation with a maturity corresponding to the length of the relevant maintenance period...*

On three occasions, the last and final one in December 2009, ECB also provided longer-term liquidity with a maturity of one year. The first two had a fixed rate of one per cent, the refinancing rate at the time, while the rate of the last one was floating, linked to the average minimum bid rate in the main refinancing operations over the life of the operation.

Basically, the ECB has reacted to the financial crises by letting banks get whatever amount of liquidity they want (against collateral) at the refinancing rate of one per cent. Banks' demand for liquidity was strong, especially in some of the longer-term operations. The result of this was a high level of overall liquidity in the banking system and short-term money market rates below the main refinancing rate. Chart 9 shows the rates on the standing facilities, the overnight rate in the market (EONIA) and the key policy rate (the main refinancing rate). Until the end of 2008 the overnight rate hovered around the key policy rate. Since then,

²⁰ One should note, however, that only the required reserves are remunerated at this rate, excess reserves are not.

²¹ As mentioned earlier, there will be some costs for banks related to the fact that they must hold collateral to obtain the loans. Detailed information on the implementation of monetary policy in the euro area can be found in ECB (2008) and more regularly in the ECB's Monthly Bulletin (under Money Market Interest rates). Recent changes in the liquidity system are documented on ECB's web site, www.ecb.org.

²² See ECB (2008).

²³ The three following quotes are taken from Monthly Bulletin December 2008, box 3 on liquidity conditions, page 35.

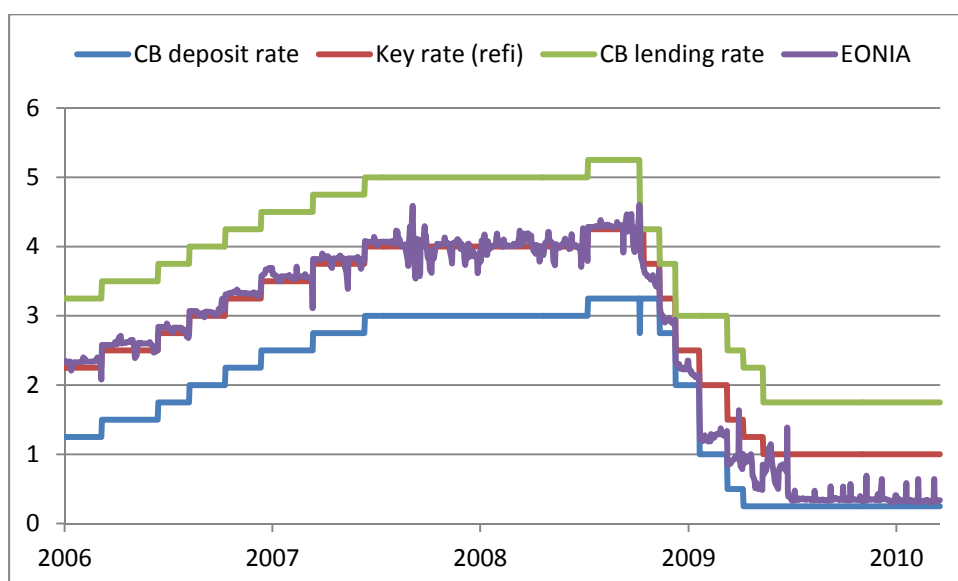
however, the overnight rate has fallen and approached the floor in the corridor, the interest rate at which banks' deposits at the ECB are remunerated. This is, of course, an intended policy from the ECB. In the Monthly Bulletin in January 2010 the ECB says:²⁴

...In these exceptional circumstances, the signaling of the monetary policy stance has become more complex. The close relationship that normally exists between the main refinancing rate and money market rates has taken on a different and more complex form. The decision to shift to a fixed rate tender procedure with full allotment in refinancing operations (rather than providing liquidity through competitive auctions) and the lengthening of the maximum maturity of operations to one year for a temporary – but extended – period have been necessary in order to mitigate the effects of the impaired functioning of the money market. Market participants' strong demand for liquidity, which has been fully accommodated by the Eurosystem, has caused overnight money market rates to fall significantly below the main refinancing rate and relatively close to the deposit rate. In this respect, the non-standard measures have temporarily led to a different relationship between monetary policy decisions and monetary policy operations. The new positioning of the overnight money market rate was considered acceptable in these exceptional circumstances as a means of helping to offset the impaired functioning of the money market and, in particular, the abnormally high level of spreads on the term money market rates. In this context, the deposit rate has played a more prominent role than in the past with respect to the EONIA and other very short-term money market interest rates...

A question that arises is why banks are willing to borrow liquidity from the ECB at a rate considerably higher than the rate in the overnight market. In principle, a bank could roll over overnight loans in the money market to a lower rate than what ECB charges for longer-term liquidity. However, as seen from the point of view of the banks, this difference can be interpreted as a kind of risk premium: The banks are willing to borrow from the ECB at a higher rate in order to obtain longer-term liquidity.

²⁴ See Monthly Bulletin January 2010, "The ECB's monetary policy stance during the financial crisis", page 63 (www.ecb.org).

Chart 9. ECB's lending and deposit rate, the refi rate and the EONIA



In sum, ECB has temporarily allowed the overnight rate to approach the floor of the corridor, as high supply of short- and long-term liquidity have been necessary to stabilise financial markets. As the ECB points out, the deposit rate at the ECB now plays a more prominent role than in the past. Then in some sense, the liquidity system has temporarily moved from a corridor system in the direction of a floor system.

The liquidity system in UK

In the UK the key policy rate is the Bank rate, the rate of interest at which banks' required reserves are remunerated. Open market operations (OMOs) are used to provide liquidity to the banking system. Describing the liquidity system,²⁵ *...banks will be able to commit to holding an average level of balances (reserves) at the Bank over a 'maintenance period', which will run from one MPC decision date to the next. In advance of each maintenance period, the banks will be free to choose a target level of reserves between zero and the larger of £1 billion or 2% of their eligible liabilities. Banks will not be obliged to meet their reserve targets precisely: provided average reserves over the maintenance period are within a range of $\pm 1\%$ around the reserve target, they will be remunerated at the MPC's official interest rate. However, banks will be penalised if their average reserves fall outside the range or if their accounts at the Bank are overdrawn on any day...*

²⁵ See Mac Gorain (2005)

...The Bank will also make unlimited overnight standing lending and deposit facilities available. The rates on these facilities will be 25 basis points above and below the official interest rate on the final day of the maintenance period, and 100 basis points above and below on other days. The Bank will also conduct open market operations each week, and on the final day of the maintenance period, in order to ensure that the supply of reserves is as close as possible to the level that will enable banks to meet their reserve targets...

This operational framework, which is a corridor system, aims to dampen interest rate volatility, both during the maintenance period and on the final day. On the final day, the fine-tuning liquidity operations, the narrowing of the corridor and the fact that banks will not be obliged to meet their reserve targets precisely, will all contribute to keep the overnight rate close to the key policy rate. Moreover, the flexibility of reserve averaging over the maintenance period contributes to dampen interest rate volatility also during the whole period (c.f. the model discussion above).²⁶

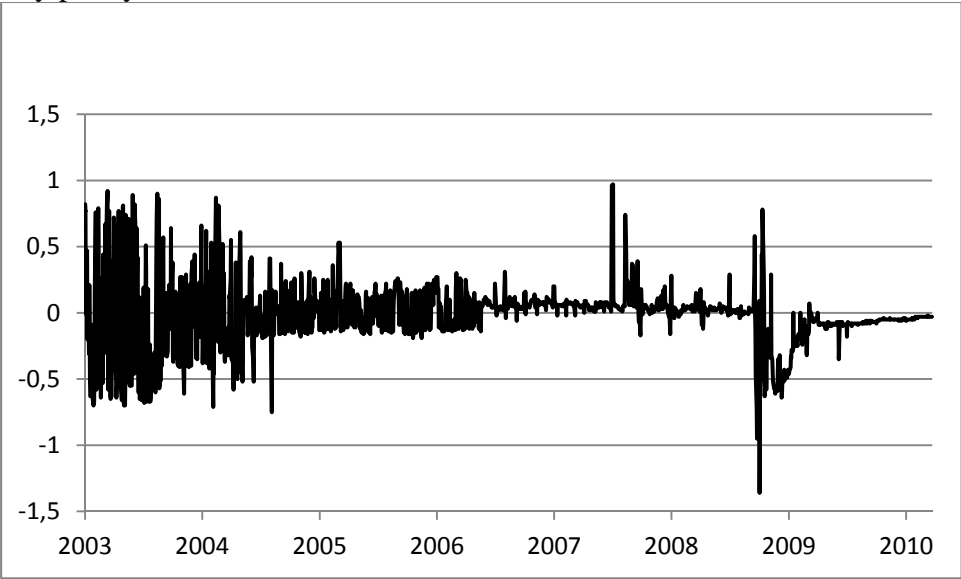
The operational procedure described above was introduced in May 2006, *...the primary reason [for the change was] that the Bank's current operations ... leave sterling overnight rates more volatile than is desirable...*²⁷ Interestingly, the change contributed substantially to reduce short-term interest rate volatility. Chart 10 shows the difference between the overnight money market rate and the key policy rate from 2003. Clearly, as from May 2006 volatility is substantially reduced, one reason being that prior to the change *...the settlements banks [had] to balance their accounts at the Bank each day...*²⁸ (and not on average over a maintenance period).

²⁶ A special issue for UK is that banks are free to choose the target level of reserves. To understand this, it is fruitful to ask the two questions, why do the banks not target a level of zero balances, and why do they not target a very high level, beyond what they need for clearing purposes? First, targeting a level of zero reserve balances would mean that all clearing balances would have to be deposited to BoE's deposit rate, below the rate at which the freely chosen reserve requirements are remunerated. This would be an unprofitable strategy for the banks. Second, one could argue that targeting a very high level of reserve balances would be costless for banks, as they would be remunerated roughly to the overnight market rate. Then, by targeting a very high level of reserves the banks would certainly avoid using the central bank's lending facility. However, as mentioned above, there is an upper limit for bank's reserve targets are upper limited, the larger of £1 billion or 2% of their eligible liabilities. In fact, it is because of this upper limit that the liquidity system can be characterized as a corridor system, and not a floor system. Moreover, the way reserve requirements are set up clearly shows that the purpose of the reserve requirements is to stabilize the short-term money market rates, and nothing else.

²⁷ See Mac Gorain (2005)

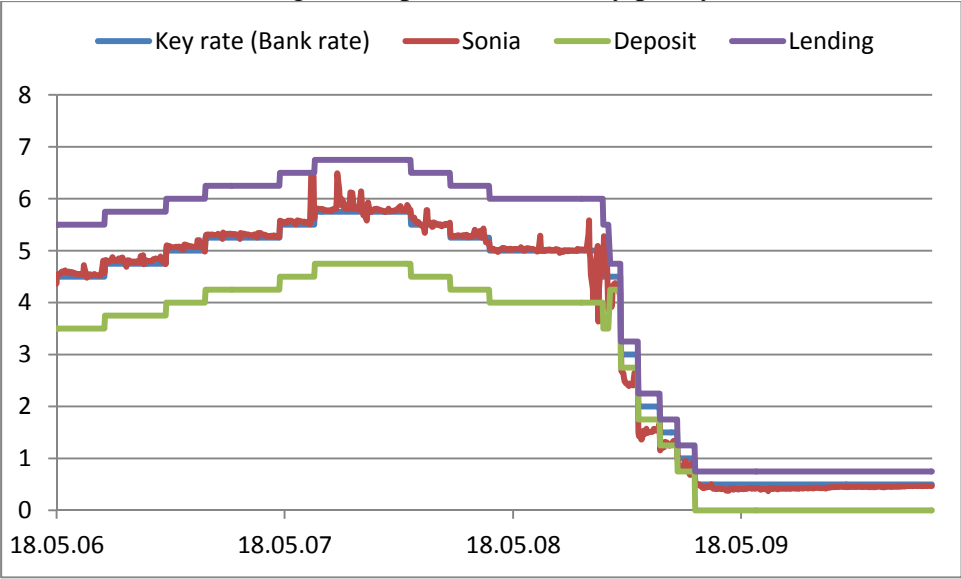
²⁸ See Mac Gorain (2005)

Chart 10. UK: The difference between the overnight money market rate and the key policy rate



Turning to the developments of interest rates during the financial crisis, chart 11 shows the lending and the deposit rate, the key policy rate (the Bank rate) and the overnight money market rate (SONIA). Until the turmoil started in August 2007 the overnight rate was close to the key rate, after which it was more volatile for some months. Then followed a relatively stable period, before volatility increased again substantially in the last quarter of 2008 after the failure of Lehman Brothers.

Chart 11. BoE’s lending and deposit rate, the key policy rate and the SONIA



To encounter the financial crisis, BoE, among other things, ...*increased the size and frequency of the OMOs and further widened the collateral...* Moreover, as reserve balances at longer-term maturity were provided, the Bank ...*expanded the range within which reserves were remunerated in order to accommodate the extra reserves...* Furthermore, BoE ...*held ad hoc fine-tuning scheduled operations to drain the reserves injected through larger extended collateral long-term repo operations...*²⁹ These operations have a correspondence to our model. When the central bank increases the supply of long-term liquidity, the banks will at the same time need to deposit more reserve balances overnight. Then, if the central bank does not drain liquidity overnight, the overnight money market rate will fall. Hence in terms of our model, higher supply of long-term liquidity moves the supply curve to the right, and to stabilize short-term money market rates, the central bank must move the supply curve back to its origin by draining liquidity overnight (or over some other short period, say a week). This is exactly what BoE did, as ...*The draining of reserves ... served to offset the impact of a much larger stock of extended-collateral long-term repo OMOs on the Bank's balance sheet...*³⁰

On 5 March 2009 BoE announced additional measures. The Bank Rate was reduced by 0.5 percentage points to 0.5 per cent. An earlier established Asset Purchase Facility (APF) would be used to purchase assets, financed by the issuance of central bank reserves (the majority of purchases being UK gilts). As a consequence of the decision to finance asset purchases through the issuance of central bank reserves, it was decided to remunerate *all* reserves balances held by commercial banks at Bank Rate. Moreover, the usual system, in which banks choose monthly reserves targets, subject to an upper limit, to achieve on average over a maintenance period, was suspended. Reserves subsequently increased in line with the amount injected by asset purchases.

Describing the consequences of this,...*The decision to remunerate any positive level of reserves balances at Bank Rate removed the interest rate incentive for banks to lend funds in the overnight market at rates below Bank Rate... ...as an increasing amount of reserves was*

²⁹ See Bank of England, Quarterly Bulletin 2008Q4, page 376, www.bankofengland.co.uk

³⁰ See Bank of England, Quarterly Bulletin 2008Q4, page 376, www.bankofengland.co.uk

supplied through the asset purchase programme, the secured overnight rate fell and traded close to Bank rate...³¹

In sum, after the change in March 2009 the Bank rate has constituted a floor for the overnight money market rate. Prior to the change, BoE had to drain liquidity to keep the overnight rate in line with the key rate. After the change however, any supply of liquidity is in line with the overnight rate being kept close to the key rate. In terms of our model, after the decision was made to remunerate all reserve balances at the key rate, the operational set up has some characteristics of a floor system.

The liquidity system in Sweden

In Sweden the objective of monetary policy ... *is to keep inflation around 2 per cent per...*³²

The liquidity system is a corridor system. With the repo rate ...*the Riksbank indicates what the overnight rate will be one week ahead... If there is a liquidity deficit in the banking system, the Riksbank supplies funds by buying securities through weekly repos. In the event of a liquidity surplus the Riksbank issues Riksbank certificates...The Riksbank conducts fine-tuning operations on a daily basis with the aim of stabilising the overnight rate.*

In July 2009 the repo rate was cut to 0.25 per cent. The lending rate and the deposit rate were cut to 0.75 and -0.25 per cent, respectively. This means that the deposit rate is negative. However, this negative rate of interest does not play an important role. Every day the Riksbank conducts fine-tuning operations so that banks can deposit or borrow liquidity to the repo rate plus/minus 10 basis points. Hence in practice, with a repo rate equal to 25 basis points banks can deposit liquidity at the central bank at the rate of 15 basis points. Only if banks fail to deposit liquidity at this rate of interest, they will need to use the deposit facility at the negative rate.³³ Chart 12 shows the central bank's deposit and lending rate, the repo rate

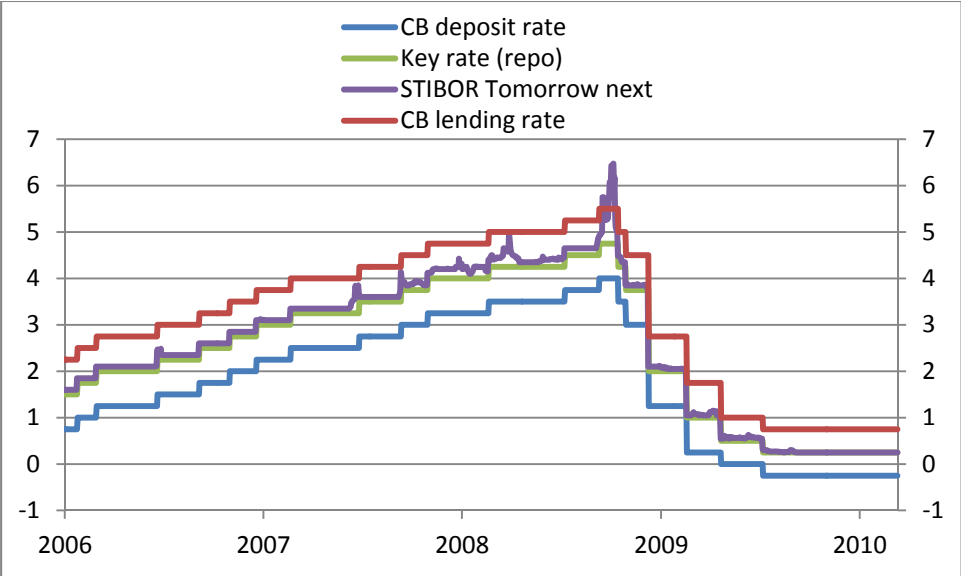
³¹ See Bank of England, Quarterly Bulletin 2009Q2, page 71-72, www.bankofengland.co.uk

³² See www.riksbank.com.

³³ To illustrate the minor importance of the negative deposit rate, the Riksbank gives the following example, ... *on 23 August [2009] the Riksbank drew in SEK 130 billion from the issue of Riksbank certificates at an interest rate of 0.25 per cent, while the banking system deposited SEK 167 billion in fine-tuning transactions at an interest rate of 0.15 per cent. On the same day, the banking system deposited only SEK 34 million at the negative deposit rate (-0.25 per cent). The negative deposit rate has not affected how much money the banks have deposited with the Riksbank at the deposit rate. The control system has thus continued to work in exactly the same way as previously...*

(the key policy rate) and the tomorrow-next money market rate. Evidently, the Riksbank has managed to keep the short-term money market rate very close to the key policy rate.

Chart 12. The Riksbank’s lending and deposit rate, the repo rate and tomorrow next



Whether this is a corridor or a floor system is a matter of definition. Sure, the system is a corridor system with a corridor of plus/minus 10 basis points. However, with such a narrow corridor, one could perhaps argue that the most important feature of a corridor system has been removed, namely the incentive to avoid using the central bank’s standing facilities. With a very narrow corridor the hot potato problem disappears. In this sense, the Swedish liquidity system more looks like a floor system with a floor equal to the repo rate minus 10 basis points.

The liquidity system in Canada

In Canada monetary policy ...is designed to achieve an inflation target of 2 per cent within a range of 1-3 per cent, and the proximate target (or instrument) of monetary policy is the overnight rate of interest...The Bank of Canada’s framework can be broadly characterized as one with zero reserves and which has a target for the overnight interest rate at the midpoint of a 50-basis-point operating band...³⁴ The government has an account at the central bank and

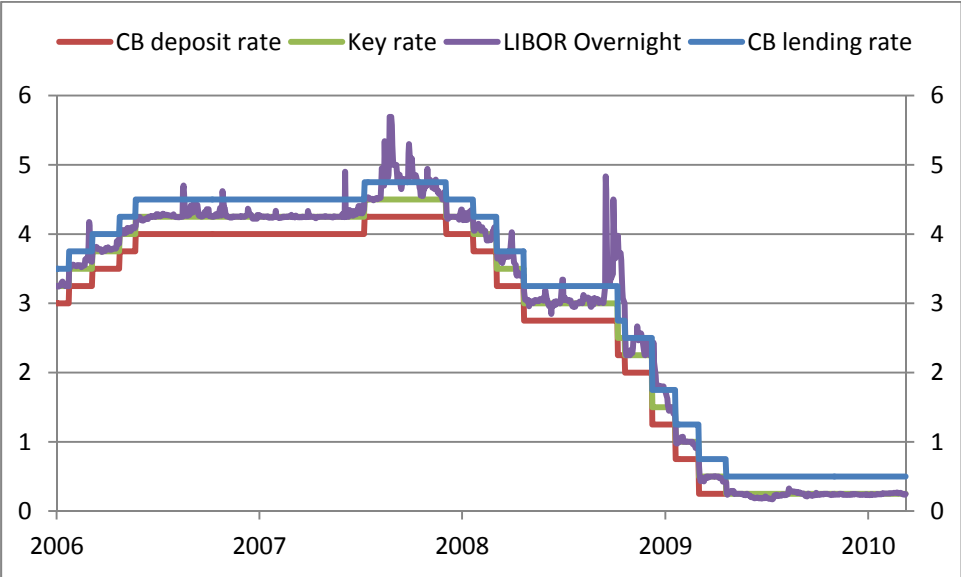
³⁴ See Engert et. al. (2008)

the central bank needs to undertake fine tuning operations to steer the amount of liquidity, to achieve the goal of keeping the overnight interest rate close to the mid-point of the corridor.

On 21 April 2009 the Bank of Canada announced that the operating band would be narrowed, from 50 basis points to 25 basis points and that the target for the overnight rate would be the bottom of the new interval of ¼-½ per cent rather than the midpoint of the band. BoC communicated that *...the Bank will provide excess settlement balances to create the incentives for the overnight rate to trade at the bottom of the operating band, i.e., the target rate. By providing significantly more aggregate balances than required by participants..., overnight funds are expected to trade at ¼ per cent – the rate that the Bank of Canada pays on deposits...*³⁵

With these changes BoC increased the supply of liquidity, beyond the need for settlement purposes, while at the same time, the overnight interest rate approached the floor of the corridor, see chart 13. Hence it seems that BoC moved in the direction of a floor system, at least temporarily.

Chart 13. BoC’s lending and deposit rate, the key rate and the overnight rate



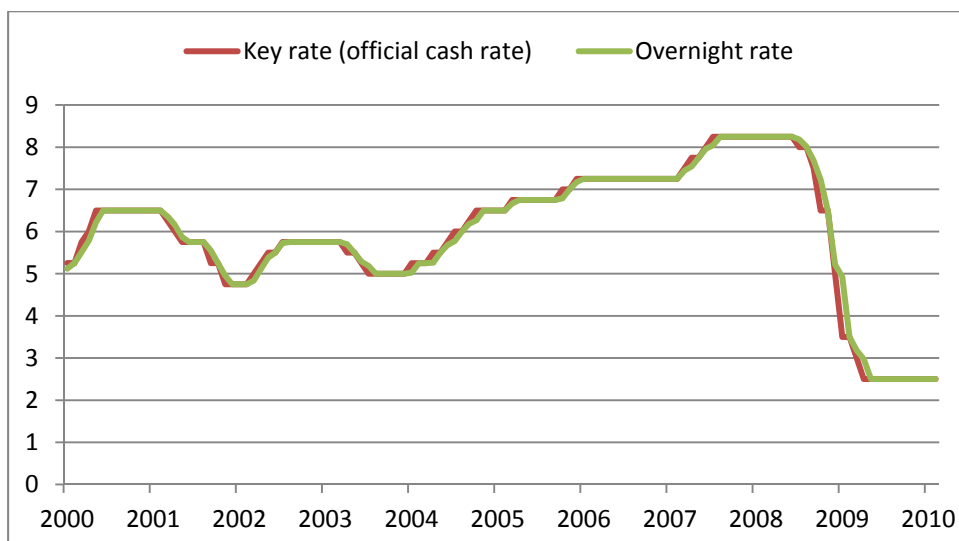
³⁵ See press release 21 April 2009, www.bankofcanada.ca.

The liquidity system in New Zealand

In New Zealand the objective of monetary policy is *...to keep inflation between 1 and 3 percent on average over the medium term. The Bank implements monetary policy by setting the Official Cash Rate (OCR)...³⁶...The standing liquidity facilities are designed to ensure that domestic overnight interbank borrowing/lending rates stay close to the OCR...³⁷*

In New Zealand settlement account balances are remunerated. Each account holder at the central bank has an individual assigned tier, and *...The Reserve Bank remunerates account balances at or below the assigned tier at the OCR. For balances in excess of the assigned tier, the remuneration rate is the OCR less 100 basis points...* Based on a certain method, demand for settlement balances are calculated, and the amount of liquidity allocated to a bank *...should satisfy its cash requirements for all but the most extreme circumstances...* The interpretation is that the central bank provides sufficient liquidity to the banking sector, and, as reserves for settlement purposes are remunerated at the OCR rate, the overnight money market rate stays close to it. Hence the liquidity system in New Zealand has characteristics of a floor system, even though it in principle is a corridor system. Chart 14 shows the official cash rate and the overnight money market rate. The overnight money market rate has been kept close the OCR during the whole financial crisis.

Chart 14. The key rate and the overnight rate in New Zealand



³⁶ See www.rbnz.govt.nz.

³⁷ This and the two other quotations below are taken from Nield (2008).

The liquidity system in Switzerland

In Switzerland ...*the monetary policy strategy consists of the following three elements: a definition of price stability³⁸, a medium-term inflation forecast and – at operational level – a target range for a reference interest rate, the three-month Libor for Swiss francs...*³⁹

Hence the Swiss National Bank (SNB) sets a target range for the three-month Swiss franc Libor. ...*As a rule, this target range extends over one percentage point, and the SNB generally aims to keep the Libor in the middle of the range. It steers the three-month Libor indirectly, influencing the situation in the short-term money market by means of open market operations...*

Repo transactions are the central bank's major monetary policy instrument and repo auctions are normally held daily. Moreover, ...*Repo transactions are generally concluded with a one-week maturity. In special circumstances, the maturity may vary from one day (overnight) to one year. The National Bank sets the maturity of repo transactions in such a way that it is able to influence money market rates on a daily basis. Due to the maturity structure of the repo transactions, the commercial banks have to request liquidity almost every day to ensure they have the sight deposits required to meet minimum reserve requirements...*

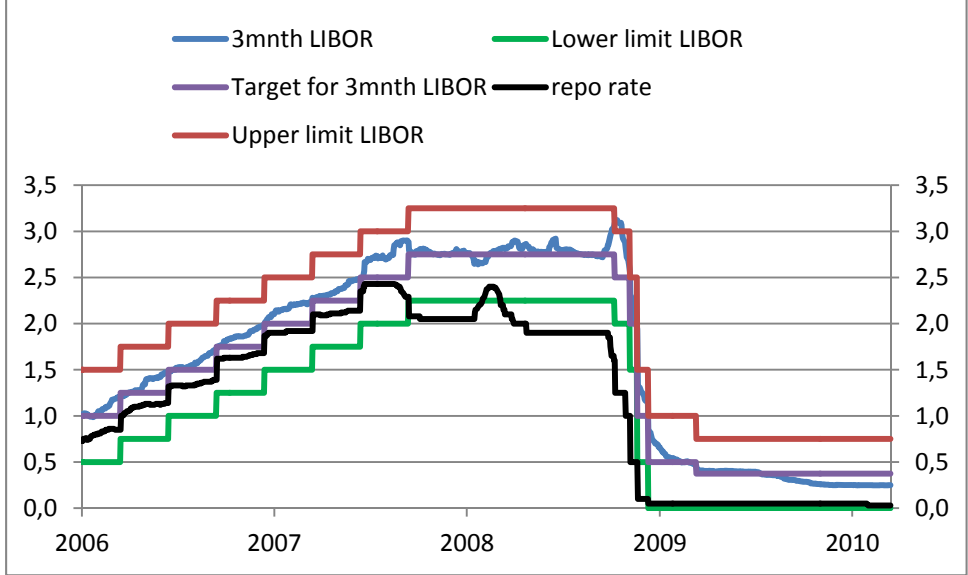
Chart 15 shows the target for the three-month LIBOR (mid-point of the interval), the target band for the LIBOR, the three-month LIBOR, and the repo rate. In March 2009 the target for the three-month LIBOR was reduced to 0-0.75 per cent, and from June 2009 the central bank decided to bring the LIBOR down to around 25 basis points (hence as from June 2009 the target is somewhat lower than the mid-point of the interval). The repo rate is low, just a few basis points higher than zero. By using market operations the Swiss National Bank seems to keep the three-month LIBOR close to the target. Hence the liquidity system of the SNB has characteristics of a corridor system.

³⁸ The SNB equates price stability with a rise in the national consumer price index (CPI) of less than 2% per annum.

³⁹ This quotation and the quotations below are taken from http://www.snb.ch/en/mmr/reference/snb_legal_geldpol_instr/source and http://www.snb.ch/en/iabout/monpol/id/monpol_instr

To our knowledge, the Swiss National Bank is the only central bank which targets the three-month LIBOR directly. Until late summer 2007 the repo rate was around 25 basis points lower than the three-month LIBOR, the latter being roughly in line with the target. Then, as in other countries, money market risk premium rose, creating a larger deviation between money market rates and expected overnight rates. For Switzerland, this is mirrored in the greater deviation between the repo rate and the LIBOR rate as from late summer 2007. To keep the three-month LIBOR at target, liquidity had to be provided at a lower rate of interest, that is, the repo rate (the black line) was reduced. This corresponds to what other central banks also faced, as policy rates needed to be cut more, in line with higher money market risk premium, in order to keep the money market rates at the desired level.

Chart 15. SNB’s lending and deposit rate, the three-month LIBOR, target for three-month LIBOR and the repo rate



5. Final remarks

Developments during the financial crisis of 2008 and 2009 have, at least temporarily, changed the way monetary policy is implemented in many countries. Before the crisis, most countries implemented policy through some form of a corridor system. The key feature of a corridor system is that it is costly for banks to use the central bank’s standing facilities for deposits and lending. Provided that this cost is sufficiently large, the system will encourage interbank trading. However, for given values of the central bank’s rate, the system also implies a tight link between the quantity of central bank reserves and the overnight interest rate: The central bank cannot control the two independently. In contrast, a floor system has almost the opposite

features: there are limited incentives for interbank trading, but the central bank can control the overnight rate and the level of excess reserve balances independently. 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.

In our discussion, we compare the *pure forms* of corridor and floor systems. However, one could in principle see these two as extremes, with a continuum of systems in between. For instance, a corridor system with a very narrow corridor (say of +/- 10 basis points) will in practice not be much different from a floor system. The same can be said about a corridor system that remunerates only required reserves at the key policy rate, but sets the reserve requirement at a very high level relative to what is needed for settlement purposes. Such adjustments to a pure corridor system will dampen the incentives for interbank trading, but at the same time limit the potential deviation between the overnight rate and the key policy rate if there is a need to increase the quantity of reserve balances. Within the framework of our discussion, any change that makes it less costly or less likely for banks to use the central bank's standing facilities can be seen as a move away from the pure version of a corridor system towards a floor system.

Norges Bank implements monetary policy through a relatively pure version of a floor system. In this sense, the Norwegian system represents a corner solution in an international comparison. During the unusual conditions that prevailed during 2008 and 2009 the floor system in Norway worked well. Norges Bank was able to supply ample amounts of liquidity to banks, both short-term and long-term, without risking any ambiguity about the stance of monetary policy. That being said, we have no foundation that enables us to claim that a floor system is the optimal system over time, both under normal and stressed conditions. It may well be the case that a corridor system is superior to a floor system in normal times, as it creates more incentives for interbank activity. Though the evidence is unclear, more interbank activity may be sound for financial stability. Furthermore, with a structural liquidity shortage in the banking system, banks' collateral costs are lower in a corridor system than in a floor system.

One interesting question is whether the financial crisis has taught central banks around the world any lessons about the implementation of monetary policy. Do the experiences of the

crisis suggest that any permanent changes are warranted? We do not have the answer to this question. One way to proceed could be to look for an optimal point on the scale between the pure versions of corridor and floor systems. The criterion for optimality would be whether it works well both under normal and stressed conditions, taking into account the relative frequency of the two states. Another line of thinking would be to build some ex-ante flexibility into the systems, for instance by practicing an adjustable width of the corridor: wide 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 market rates. A third way would be to return to the systems that were in place before the crisis, and to adapt them again (on a discretionary basis) should a new crisis emerge in the future. All in all, it is too early to say whether the systems for implementing monetary policy around the world will change permanently following the financial crisis of 2008/09.

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