

Flexibility of Monetary Policy in the Euro Area and the Remuneration of Required Reserves

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Abstract

The governing council of the ECB has committed itself to take interest rate decisions only during the first of its bi-monthly meetings to avoid speculation on interest rate changes every two weeks. Presenting a model of a bank's liquidity demand and reserve management, we show that this self-commitment would not be necessary, i.e. that monetary policy could be conducted more flexible, if the remuneration of required reserves were changed. Then, interest rate changes would not influence a bank's net marginal costs of holding reserves implying that speculation on interest rate changes would not occur.

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1 Introduction

In November 2001, the governing council of the European Central Bank (ECB) decided that it would - as a rule - take interest rate decisions only during the first of its bi-monthly meetings in order to avoid speculation on interest rate changes every two weeks (Duisenberg, 2001). The background was that speculation on interest rate changes led to under- and overbidding behaviour in several main refinancing operations (MROs), i.e. in the tender procedures with which the Eurosystem provides the bulk of liquidity to the banking system in the euro area. A MRO is characterized by overbidding (underbidding) if the aggregated bidding volume exceeds (remains under) significantly the Eurosystem's benchmark allotment. This benchmark allotment is the Eurosystem's assessment of actual liquidity needs of the banking sector in the euro area, providing smooth provisions of required reserves.¹ The Eurosystem's reaction to the bidding problems was threefold. In June 2000, the governing council decided to switch from fixed rate tenders to variable rate tenders as a response to the severe overbidding behaviour in the first half of the year 2000.² However, this switch solved the overbidding problem but underbidding behaviour could not be avoided. Therefore, in November 2001, the governing council decided to make interest rate decisions during its first meeting of a month only. This commitment did not solve the underbidding problem either, so that, with effect from March 2004, the Eurosystem changed two of its key monetary policy instruments.³ Since then, the under- and overbidding problem seems to be solved. However, the self-commitment still applies, i.e. the governing council does not change interest rates within the reserve maintenance period because expectations of interest rate changes shall not influence the banks' bidding behaviour within that period.

The *aim of this paper* is to show that this self-commitment would not be necessary if the Eurosystem changed the remuneration of required reserves. Presenting a theoretical model of a bank's liquidity demand and management of required reserves we show that the rate at which required reserves are remunerated decides whether a bank's net marginal costs of holding reserves and therefore their liquidity demand at

¹For more information on the Eurosystem's benchmark allotment see ECB (2002).

²For details concerning this switch, see ECB (2000).

³These changes to the monetary policy instruments are described briefly in section 2.

the central bank will be affected by an interest rate change. Transferring our model results to the euro area reveals that if required reserves were remunerated at the current MRO-rate instead of at the average of the rates on the MROs conducted in the cause of a maintenance period, as it is presently the case, under- and overbidding would not occur even in case the governing council decided to change interest rates within the reserve maintenance period. Therefore, we suggest a small change to the Eurosystem's operational framework which is to remunerate required reserves at the current MRO-rate. Then, the self-commitment would not be necessary, the governing council could take interest rate decisions whenever the assessment of available information requires this, i.e. monetary policy could be conducted more flexible.

One may argue that monetary policy could be conducted flexible enough if the governing council decided once a month on interest rates, and Duisenberg (2001) argues that an additional advantage of making interest rate decisions once a month only was that the governing council would have more time for other important tasks and responsibilities, such as payment systems or supervision. However, the point made in this paper is that there is no convincing reason to restrict the flexibility of monetary policy decisions. We argue that if there is information which requires to change interest rates, the governing council should have the possibility to do so without breaking a commitment.

A great part of *related literature* analyses the banks' liquidity demand and their reserve management in the U.S., using models which capture main elements of the Federal Reserve System's operational framework and institutional aspects of the U.S. federal funds market.⁴ However, since country specific institutional aspects play an important role for banks' liquidity demand and their reserve management, the results of these papers cannot be easily transferred to the euro area. Consequently, articles analyzing banks' behaviour in the euro area consider specific institutional features of the euro area. In this context, an extensive number of papers analyzes the consequences and causes of the under- and overbidding behaviour in several MROs. Ewerhart (2002) shows that when banks expect the central bank to cut interest rates, they will strategically reduce demand for funds prior to the date of the

⁴See, for example, Ho and Saunders (1985), Hamilton (1996), Clouse and Dow (1999, 2002), Furfine (2000), and Bartolini, Bertola and Prati (2001, 2002).

policy decision, which may unbalance the dynamic system of bidding volumes, tender conditions, and money market rates. Neyer (2004) shows that the overlapping maturities of the MROs lead to under- and overbidding behaviour in case the central bank is going to change its interest rates. According to Ayuso and Repullo (2001, 2003) the overbidding behaviour was due to the liquidity allotment decisions of the Eurosystem which implied a contemporaneous restriction in the supply of liquidity. In their 2003-article they argue that the Eurosystem had an asymmetric objective function in the sense that the Eurosystem, which wants to steer the interbank rate towards a target rate, would be more concerned about letting the interbank rate fall below the target. Bindseil (2002), on the other hand, argues that the overbidding phenomenon is solely due to interest rate expectation effects. The empirical analysis in Breitung and Nautz (2001) strongly confirms interest rate expectation effects on the banks' overbidding behaviour. However, as pointed out in Nautz and Oechssler (2003), these effects cannot explain why the overbidding increased over time. To explain this phenomenon, Nautz and Oechssler develop a stylized game among banks with adaptive expectations which reveals the weakness of the fixed rate tender method. Experimental evidence in favour of that model can be found in Ehrhart (2001).

This paper contributes to this literature by showing that under the current operational framework the Eurosystem's self-commitment to take interest rate decisions only at its first meeting of a month is necessary to avoid under- and overbidding problems in the MROs, but that only a small change to the operational framework would make this self-commitment unnecessary, so that monetary policy could be conducted more flexible.

The remainder of this paper is structured as follows. Section 2 provides some for this paper relevant background information on the institutional framework. Section 3 presents a model of a bank's liquidity demand and its management of required reserves first, by assuming that reserves are remunerated at a current rate and second, by assuming that they are remunerated at an average rate. Section 4 discusses the conclusions for the Eurosystem's operational framework, and the last section gives a short summary.

2 Institutional Background

Liquidity Needs of the Banking Sector

In the euro area, liquidity needs of the banking sector mainly arise from two factors: the so-called autonomous factors - as banknotes in circulation and government deposits with the Eurosystem - and minimum reserve requirements. In order to fulfil the reserve requirements, averaging provisions over a reserve maintenance period are allowed. Due to the bidding problems in the MROs, which have been briefly described in the introduction, the timing of the maintenance periods has been changed with effect from March 2004. Since then it depends on the dates the governing council meets: Maintenance periods start on the settlement day of the MRO following the first meeting in a month, and end on the day preceding the corresponding settlement day in the following month.⁵ This timing implies that - if the governing council keeps to its self-commitment to take interest rate decisions only during the first meeting - there will be no interest rate changes during a maintenance period. A further important institutional feature is that in the euro area, holdings of minimum reserves are remunerated. They are remunerated at the end of a maintenance period at the average of the rates on the MROs conducted in the cause of the maintenance period.⁶

Liquidity Supply

The bulk of the liquidity needs of the banking sector (about 74 %) is satisfied by the Eurosystem through its MROs. About 26 % of the liquidity needs are met through longer-term refinancing operations, and less than 1 % through fine-tuning operations. Finally, residual liquidity needs (only about 0.4 %) are balanced by the banks' recourse to the marginal lending facilities.⁷ In what follows, we focus on the MROs, the Eurosystem's key monetary policy instrument. The MROs are

⁵Until March 2004, the timing of the maintenance periods was independent of the dates the governing council met. They started on the 24th of each month and ended on the 23rd of the following month. For details concerning the change in the minimum reserve system see ECB (2003).

⁶For a detailed description of the current minimum reserve system we refer the reader to ECB (2004a, 2004b), for a description of the reserve system before the changes were effective to ECB (2002b).

⁷For a detailed description of the supply of liquidity in the euro area see ECB (2002a). The data given in this paragraph are averages over the period from January 1999 until December 2001. Source: ECB (2002a).

credit transactions which are executed weekly either as a fixed rate or a variable rate tender. From the launch of the euro in January 1999 until June 2000, tenders were conducted exclusively as fixed rate tenders. Since then, only variable rate tenders with a minimum bid rate have been used, all conducted as “American” auctions. The Eurosystem’s benchmark allotment, i.e. the amount of liquidity it aims to provide, is its assessment of actual liquidity needs of the banking sector, providing smooth provisions of required reserves. A smooth fulfilment of required reserves is preferred since it enhances the buffer function of reserve holdings against unexpected liquidity shocks (ECB, 2002a). Due to the bidding problems in the MROs, their maturity has been changed with effect from March 2004. It has been reduced from two weeks to one week so that the maturities of two subsequent MROs do not overlap anymore.⁸ The MROs have to be based on adequate collateral, and although differences in the financial structure across Member States of the EMU have been considered when defining the list of eligible assets,⁹ marginal costs of collateral vary across countries within the euro area (Hämäläinen 2000). Banks also face different costs of holding collateral because they tend to focus on different business segments. The reason is that as a consequence of this specialization their asset structures will be distinct from one another, implying that banks have different marginal opportunity costs of holding eligible collateral.¹⁰

Interbank Money Market

For the Eurosystem, the interbank money market for unsecured overnight loans plays an important role. It is the starting point for the transmission mechanism of monetary policy impulses and the Eurosystem aims to steer the EONIA, the reference rate in this market segment.¹¹ Empirical studies find a positive spread between the EONIA and the MRO-rate.¹² In Ayuso and Repullo (2003), the positive spread

⁸For details concerning the change in the MROs see ECB (2003). For a theoretical foundation for this measurement see Neyer (2004).

⁹Eligible assets have been defined by the Eurosystem. For details see ECB (2002b, p. 38-50; 2004a, p. 39-54.)

¹⁰For a detailed description of the current design of the MROs we refer the reader to ECB (2004a, 2004b), for a description of the MROs before the changes were effective to ECB (2002b). For details concerning the reason why the Eurosystem has changed the design of the MROs see ECB (2003).

¹¹The EONIA (Euro Overnight Index Average) is a market index computed as the weighted average of overnight unsecured lending transactions undertaken by a representative panel of banks. For more information on this reference rate see www.euribor.org.

¹²See, for example, Ayuso and Repullo (2003), Ejerskov, Moss, and Stracca (2003), Nyborg,

supports the hypothesis of an asymmetric objective function of the Eurosystem in the sense that the Eurosystem, which wants to steer the interbank rate towards a target rate, is more concerned about letting the interbank rate fall below the target. In the model presented by Neyer and Wiemers (2004) a positive spread between the interbank market rate and the central bank rate is the result of a heterogeneous banking sector. Banks differ in marginal costs of obtaining funds from the central bank which implies intermediation by banks with relatively low marginal costs.

As pointed out in the introduction, institutional features play an important role for a bank's liquidity demand and reserve management. The model presented in the next section focusses on the following specific institutional features in the euro area: First, the bulk of liquidity to the banking sector is provided via loans, contrary to the US, for example, where the banking sector is mainly provided with liquidity via outright purchases of securities. Second, these credit operations have to be based on adequate collateral. Third, for fulfilling reserve requirements averaging provisions over a reserve maintenance period are allowed. Fourth, holdings of required reserves are remunerated. And last, there is a positive spread between the interbank market rate and the MRO-rate. Considering these features we analyze a bank's liquidity demand and reserve management distinguishing two cases: first, reserves are remunerated at a current rate and second, they are remunerated at an average rate.

3 A Model of a Bank's Liquidity Demand and its Management of Required Reserves

3.1 Remuneration of Reserves at a Current Rate

Liquidity Needs

In our model, there are two time periods, $t = 1, 2$, which cover a reserve maintenance period. An isolated, price taking bank is considered which needs liquidity for covering given autonomous factors A and given reserve requirements RR imposed by a central bank. Concerning required reserves, the bank can make use of averaging

Bindseil, and Strebulaev (2002), and Neyer and Wiemers (2004).

provisions. The reserve requirement is fulfilled if

$$RR = \frac{R_1 + R_2}{2}, \quad (1)$$

with R_t being the reserve holdings of the bank in period t .

To cover its liquidity needs, the bank can borrow from the central bank or in the interbank market where it can also place liquidity.

Borrowing from the Central Bank

The loan borrowed from the monetary authority in period t is denoted by K_t where $K_t \geq 0$. On this loan the bank has to pay the interest rate l_t which is set by the monetary authority. The bank receives exactly the amount of liquidity it demands.¹³ The loan K_t has to be based on adequate collateral. We assume that rate of return considerations induce a strict hierarchy of the bank's assets,¹⁴ and that assets which can serve as collateral have a relatively low rate of return due to specific criteria they have to fulfil. Consequently, there are increasing marginal opportunity costs of holding collateral: The more liquidity the bank borrows from the central bank, the more collateral it must hold at the expense of other assets. This is combined with increasing marginal costs due to the assumed hierarchical order of the bank's assets. Postulating a tractable quadratic form for these opportunity costs, the relevant cost function is given by

$$Q(K_t) = qK_t + \frac{p}{2}K_t^2, \quad (2)$$

with the parameters $q \geq 0$ and $p > 0$. As we will show, the parameter q , which reflects the level of marginal opportunity costs of holding collateral, plays a key role for the banks' optimal liquidity demand at the central bank.

¹³We will comment on this assumption below, when discussing the relation between the central bank rate and the interbank market rate.

¹⁴This approach can be compared with the one by Blum and Hellwig (1995). They consider a bank with deposits and equity. The bank can put these funds into loans to firms, government bonds or reserves of high powered money. Blum and Hellwig assume that rate of return considerations induce a strict preference for loans over bonds and for bonds over reserves.

Transactions in the Interbank Market

If the bank borrows more funds from the central bank than it needs to cover its own liquidity needs, it will place the excess liquidity at the rate e_t in the interbank market. If, on the other hand, the loan from the central bank is too small to cover the bank's total liquidity needs, it will borrow at the rate e_t in the interbank market. The bank's position in the interbank market is given by

$$B_t = A + R_t - K_t \begin{matrix} \leq \\ \geq \end{matrix} 0. \quad (3)$$

Trading in the interbank market, the bank faces transaction costs which are

$$Z(B_t) = \frac{z}{2} (B_t)^2, \quad (4)$$

with the parameter $z > 0$. This approach can be compared with the common approach of modelling the liquidity role of reserves which posits that banks incur increasing costs when liquidity deviates from a target level (see, for example, Campbell (1987) and Bartolini et al. (2001)). The quadratic form reflects increasing marginal costs of searching for banks with matching liquidity needs and those resulting from the need to split large transactions into many small ones to work around credit lines.

Total Liquidity Costs

Bringing together interest payments to the central bank, interest payments or interest yields resulting from transactions in the interbank market, collateral's opportunity costs, transaction costs, and the remuneration of required reserves, one obtains for total liquidity costs in period t :

$$C_t(K_t, R_t) = K_t l_t + B_t e_t + Q(K_t) + Z(B_t) - R_t l_t. \quad (5)$$

Note that required reserves are remunerated at the current central bank rate.

Central Bank Rate and Interbank Market Rate

We assume that there is a positive spread between the interbank market rate e_t and the central bank rate l_t given by

$$u = e_t - l_t. \quad (6)$$

This positive spread is motivated by a heterogeneous banking sector as in Neyer and Wiemers (2004)? Banks differ in marginal costs of obtaining funds from the central bank. This implies intermediation by banks with relatively low marginal costs and a positive spread between the interbank market rate. Therefore, in our model the existence of an interbank money market is the result of this heterogeneity. We neglect that banks enter the interbank market to balance liquidity fluctuations resulting from bank-specific shocks to reserves. This can be considered by modelling the autonomous factors A as a bank-specific random variable or by adding bank-specific shocks. However, this would make the analysis more complex without changing the main results.

Requiring that the central bank knows the spread u as well as aggregate liquidity demand the assumption that the bank receives exactly the amount of liquidity it demands implies that the central bank can steer the interbank market rate e_t perfectly by setting l_t .

Optimal Liquidity Demand and Reserve Management

The bank minimizes total liquidity costs across the maintenance period, while keeping average reserves over the maintenance period to the required level RR by choosing the optimal intertemporal allocation of required reserves and optimal borrowing from the monetary authority. Disregarding discounting, whose impact is negligible over this short horizon, the bank's objective function becomes

$$\min_{K_t, R_t} \left\{ \sum_{t=1}^2 C_t \right\}. \quad (7)$$

Defining V_t as the associated value function, the Bellman equation for the intra-maintenance period problem is given by

$$V_1 = \min_{K_1, R_1} \{C_1(K_1, R_1) + V_2(K_2, R_1) | K_t \geq 0\}. \quad (8)$$

Solving this optimization problem one obtains the following results for the bank's optimal intertemporal allocation of required reserves and its optimal liquidity demand at the central bank:

$$R_1 = R_2 = RR \quad (9)$$

and

$$K_1 = K_2 = \begin{cases} \frac{u+z(A+RR)-q}{p+z} & \text{if } q < \bar{q} \\ 0 & \text{if } q \geq \bar{q} \end{cases} \quad (10)$$

where

$$\bar{q} = u + z(A + RR). \quad (11)$$

The most important result is that interest rate changes within the reserve maintenance period do neither influence the bank's optimal allocation of required reserves nor its liquidity demand at the central bank. Even in case the monetary authority changes its rate during the maintenance period, the bank does not frontload or postpone required reserves but provides them smoothly across the maintenance period. What drives this result is that required reserves are remunerated at the current central bank rate and that procuring liquidity for fulfilling required reserves involves increasing marginal costs. The former implies that holding reserves is neutral with regard to interest costs and yields, so that interest payments do not influence the optimal allocation of required reserves at all. However, the latter implies that the bank is not indifferent concerning the intertemporal allocation of required reserves but it is optimal to hold in both periods the same amount of reserves.

Optimal borrowing from the central bank reflects the smooth provisions of required reserves: K_1 is equal to K_2 . Equation (10) reveals that the parameter q , the level of marginal opportunity costs of holding collateral, plays a key role for the bank's liquidity demand at the central bank. It decides whether a bank actually borrows from the central bank and if how much. The threshold \bar{q} defines the level of marginal opportunity costs of holding collateral at which the bank borrows no liquidity from the central bank. If $q \geq \bar{q}$, the bank covers its total liquidity needs in the interbank market. For all K_t marginal costs of borrowing from the central bank are higher than of borrowing in the interbank market, i.e. $l_t + q + pK_t > e_t + z(A + RR - K_t)$.

A further threshold for q is

$$\underline{q} = u - p(A + RR). \quad (12)$$

This threshold defines the level of q at which the bank borrows more liquidity from the central bank than it needs to cover its own liquidity needs. If $q < \underline{q}$, marginal costs of placing liquidity in the interbank market are smaller than the benefits, i.e. $l_t + q + pK_t - z(A + RR - K_t) < e_t$ (note that if $q < \underline{q}$, the expression in brackets is negative since $K_t > A + RR$). Equations (11) and (12) show that the thresholds \bar{q} and \underline{q} are the same in both periods. Let us assume for a moment that there is a continuum of banks which differ in q . Then, in both periods, independently of a possible interest rate change, the same banks cover their total liquidity needs solely the interbank market and the same banks place excess liquidity in the interbank market. In the sense of the interbank market model presented in Neyer and Wiemers (2004)? this means that in both periods the same banks act as intermediaries between the central bank and banks which face relatively high costs of obtaining funds from the monetary authority.

Figure 1 illustrates the bank's borrowing from the central bank. If $q < \underline{q}_t$, the bank's costs of obtaining funds at the central bank are that low that it covers its total liquidity needs at the monetary authority and places liquidity in the interbank market. Obviously, the amount it places in the interbank market and therefore its loan from the central bank depends negatively on q . If $\underline{q}_t < q < \bar{q}_t$, the bank covers its liquidity needs at the central bank and in the interbank market. Again, it is obvious that the share the bank covers at the central bank depends negatively on q . If $q \geq \bar{q}_t$, the bank's costs of procuring funds from the central bank are that high that it prefers to satisfy its total liquidity needs in the interbank market. Summing up, if required reserves are remunerated at the current central bank rate, the bank's optimal intertemporal allocation of required reserves and its liquidity demand at the central bank are not influenced by a change in the central bank rate within the reserve maintenance period. Independently of an interest rate change there is a smooth provision of required reserves. Generally, this smooth provisions of required reserves is reflected by the bank's liquidity demand at the central bank which is the same in both periods.

It is worth noting that in our model, the bank knows in the first period the central bank rate l_2 with certainty, i.e. we assume that there are no shocks and that the bank forms rational expectations. However, introducing uncertainty by incorporating a

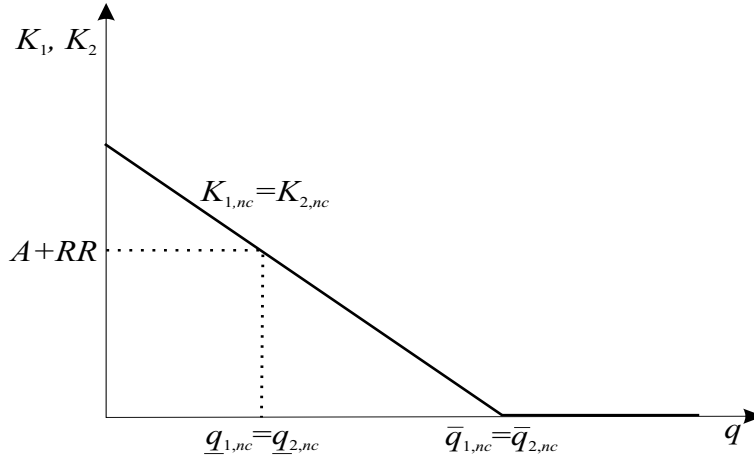


Figure 1: **No Interest Rate Change: Optimal Credit Demand at the Central Bank**

monetary policy shock into our model would not change our results as long as the bank is assumed to be risk-neutral.

3.2 Remuneration of Reserves at an Average Rate

This subsection shows that interest rate changes during the maintenance period do influence the bank's optimal allocation of required reserves and its optimal liquidity demand if reserves are remunerated at an average rate.

If required reserves are remunerated at the average of the central bank rates, liquidity costs in period t are given by

$$C_t(K_t, R_t) = K_t l_t + B_t e_t + Q(K_t) + Z(B_t) - 2RR \left(\frac{l_t + l_{t-1}}{2} \right) I_{[t=2]}. \quad (13)$$

The only difference to equation 5 is the last term which shows that required reserves are remunerated at the average of the central bank's rate on its credit operations. The indicator function $I_{[\cdot]}$ takes a value of 1 when $t = 2$, and 0 otherwise, reflecting that interests are paid at the end of the maintenance period.

As in the previous subsection, the bank minimizes total liquidity costs across the maintenance period, while keeping average reserves over the maintenance period to

the required level RR by choosing the optimal intertemporal allocation of required reserves and optimal borrowing from the monetary authority.

Interest Rate Decrease

In case the central bank cuts its interest rate in the second period ($l_1 > l_2$), one obtains the following results for optimal intertemporal allocation of required reserves and optimal borrowing from the central bank (the index c stands for *cut*):

$$R_{1,c} = \begin{cases} RR - \frac{(p+z)(l_1-l_2)}{2pz} & \text{if } q < \bar{q}_{1,c} \\ RR - \frac{u+z(A+RR)-q}{2p+z} - \frac{(p+z)(l_1-l_2)}{z(2p+z)} & \text{if } \bar{q}_{1,c} \leq q < \bar{q}_{2,c} \\ RR - \frac{l_1-l_2}{2z} & \text{if } \bar{q}_{2,c} \leq q, \end{cases} \quad (14)$$

$$R_{2,c} = \begin{cases} RR + \frac{(l_1-l_2)(p+z)}{2pz} & \text{if } q < \bar{q}_{1,c} \\ RR + \frac{u+z(A+RR)-q}{2p+z} + \frac{(l_1-l_2)(p+z)}{z(2p+z)} & \text{if } \bar{q}_{1,c} \leq q < \bar{q}_{2,c} \\ RR + \frac{l_1-l_2}{2z} & \text{if } \bar{q}_{2,c} \leq q, \end{cases} \quad (15)$$

$$K_{1,c} = \begin{cases} \frac{u+z(A+RR)-q}{p+z} - \frac{l_1-l_2}{2p} & \text{if } q < \bar{q}_{1,c} \\ 0 & \text{if } \bar{q}_{1,c} \leq q, \end{cases} \quad (16)$$

and

$$K_{2,c} = \begin{cases} \frac{u+z(A+RR)-q}{p+z} + \frac{l_1-l_2}{2p} & \text{if } q < \bar{q}_{1,c} \\ \frac{2(u+z(A+RR)-q)}{2p+z} + \frac{l_1-l_2}{2p+z} & \text{if } \bar{q}_{1,c} \leq q < \bar{q}_{2,c} \\ 0 & \text{if } \bar{q}_{2,c} \leq q, \end{cases} \quad (17)$$

where

$$\bar{q}_{1,c} = u + z(A + RR) - \frac{(p+z)(l_1-l_2)}{2p} \quad (18)$$

and

$$\bar{q}_{2,c} = u + z(A + RR) + \frac{l_1-l_2}{2}. \quad (19)$$

For the lower threshold \underline{q}_t one obtains

$$\underline{q}_{1,c} = u - p(A + RR) + \frac{(p + z)(l_1 - l_2)}{2z} \quad (20)$$

and

$$\underline{q}_{2,c} = u - p(A + RR) - \frac{(l_1 - l_2)(p + z)}{2z}. \quad (21)$$

Equations (14) and (15) show that independently of its individual level of marginal costs q , the bank holds more reserves in the second period, i.e. $R_2 > R_1$ for all q . Required reserves are not provided smoothly across the maintenance period. The reason is that due to the remuneration of required reserves at the average rate, holding reserves is not neutral with regard to interest costs and yields if the central bank changes its rate, so that interest payments do influence the optimal allocation of required reserves. Due to the remuneration of the reserves at the average rate, marginal benefits of holding reserves decrease in both periods, marginal costs of holding reserves decrease in period 2 only. Therefore, intertemporal optimality requires to hold more reserves in $t = 2$. We describe equations (14) and (15) in

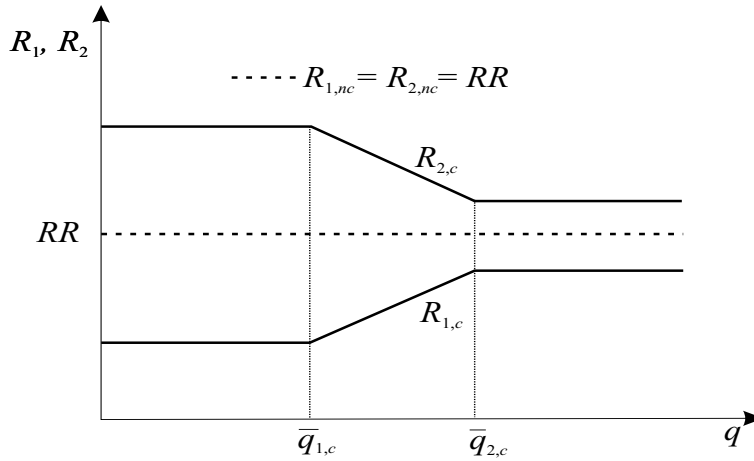


Figure 2: **Interest Rate Decrease: Optimal Holding of Required Reserves**

more detail by the help of figure 2. It illustrates that for all q $R_2 > R_1$. If the bank borrows from the central bank in both periods, i.e. if $q \leq \bar{q}_{1,c}$ (we will comment on

the thresholds $\bar{q}_{t,c}$ in the next paragraph), the level of marginal opportunity costs of holding collateral q has no influence on the optimal intertemporal allocation because these opportunity costs arise in both periods. Obviously, q does not influence the optimal allocation either if the bank covers its total liquidity needs in the interbank market in both periods, i.e. if $q \geq \bar{q}_{2,c}$. However, if the bank borrows from the central bank in the second period only ($\bar{q}_{1,c} < q < \bar{q}_{2,c}$), the optimal intertemporal allocation of reserve holdings depends on q because opportunity costs of holding collateral arise in the second period only. In this case, the cost advantage of fulfilling required reserves unevenly will be the higher the lower the costs of obtaining funds at the central are. Consequently, the difference between R_2 and R_1 is the higher the lower q . Since $R_{1,c} < R_{2,c}$, liquidity needs are smaller in the first than in the

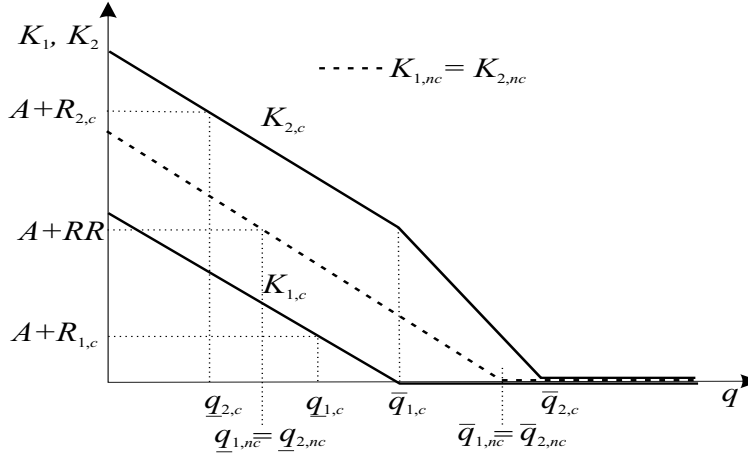


Figure 3: **Interest Rate Decrease: Optimal Borrowing from the Central Bank**

second period. Basically, this implies that $K_{1,c} < K_{2,c}$ as equations (16) and (17) show and as figure 3 illustrates. The reduced liquidity needs in the first and the increased liquidity needs in the second period also imply that the thresholds fall apart: Depending on q , the bank may borrow from the central bank in the second period although it does not so in the first, i.e. $\bar{q}_{2,c} > \bar{q}_{1,c}$; and, again depending on q , the bank may place liquidity in the interbank market in the first period but it does not so in the second, i.e. $\underline{q}_{2,c} < \underline{q}_{1,c}$. The negative relationship between R_2 and q in case $\bar{q}_{1,c} < q < \bar{q}_{2,c}$ is also reflected by the credit demand curve: The slope of $K_2(q)$ becomes steeper within this interval, i.e. the decrease in the credit demand

depending on q becomes stronger.

Interest Rate Increase

In case the central bank raises its interest rate in the second period ($l_2 > l_1$), the results for optimal intertemporal allocation of required reserves and optimal borrowing from the central bank become (the index r stands for *raise*):¹⁵

$$R_{1,r} = \begin{cases} RR - \frac{(l_1-l_2)(p+z)}{2pz} & \text{if } q < \bar{q}_{2,r} \\ RR + \frac{u+z(A+RR)-q}{2p+z} - \frac{(l_1-l_2)(p+z)}{z(2p+z)} & \text{if } \bar{q}_{2,r} \leq q < \bar{q}_{1,r} \\ RR - \frac{l_1-l_2}{2z} & \text{if } q \geq \bar{q}_{1,r}, \end{cases} \quad (22)$$

$$R_{2,r} = \begin{cases} RR + \frac{(p+z)(l_1-l_2)}{2pz} & \text{if } q < \bar{q}_{2,r} \\ RR - \frac{u+z(A+RR)-q}{2p+z} + \frac{(p+z)(l_1-l_2)}{z(2p+z)} & \text{if } \bar{q}_{2,r} \leq q < \bar{q}_{1,r} \\ RR + \frac{l_1-l_2}{2z} & \text{if } q \geq \bar{q}_{1,r}, \end{cases} \quad (23)$$

$$K_{1,r} = \begin{cases} \frac{u+z(A+RR)-q}{p+z} - \frac{l_1-l_2}{2p} & \text{if } q < \bar{q}_{2,r} \\ \frac{2(u+z(A+RR)-q)}{2p+z} - \frac{l_2-l_1}{2p+z} & \text{if } \bar{q}_{2,r} \leq q < \bar{q}_{1,r} \\ 0 & \text{if } q \geq \bar{q}_{1,r}, \end{cases} \quad (24)$$

and

$$K_{2,r} = \begin{cases} \frac{u+z(A+RR)-q}{p+z} + \frac{l_1-l_2}{2p} & \text{if } q < \bar{q}_{2,r} \\ 0 & \text{if } q \geq \bar{q}_{2,r}, \end{cases} \quad (25)$$

where

$$\bar{q}_{1,r} = u + z(A + RR) - \frac{(l_1 - l_2)}{2} \quad (26)$$

and

$$\bar{q}_{2,r} = u + z(A + RR) + \frac{(p + z)(l_1 - l_2)}{2p}. \quad (27)$$

¹⁵It is not possible to interpret the results given by the equations (9) to (12) simply by assuming that $l_2 > l_1$ since the thresholds \bar{q}_t are different. The reason is that if the central bank raises its interest rate the bank may - depending on q - demand liquidity at the central bank in the first but not in the second period.

For the lower threshold \underline{q}_t , one obtains

$$\underline{q}_{1,r} = u - p(A + RR) + \frac{(p + z)(l_1 - l_2)}{2z} \quad (28)$$

and

$$\underline{q}_{2,r} = u - p(A + RR) - \frac{(p + z)(l_1 - l_2)}{2z}. \quad (29)$$

Equations (22) and (23) show that also an interest rate increase influences the optimal allocation of required reserves. If the monetary authority raises the interest rate, it is advantageous for the bank to hold more reserves in the first than in the second period. The reason is that marginal costs of holding reserves increase in the second period only, while marginal benefits increase in both periods due to the remuneration of reserves at the average rate. Consequently, liquidity needs are higher in the first period so that the bank basically borrows more funds from the monetary authority in $t = 1$, i.e. $K_{1,r} > K_{2,r}$. Furthermore, analogously to the case in which the central bank decreases its interest rate, the thresholds $\bar{q}_{t,r}$ as well as $\underline{q}_{t,r}$ fall apart. Since the bank may borrow in the first but not in the second period, $\bar{q}_{1,r} > \bar{q}_{2,r}$, and due to the increased liquidity needs in $t = 1$ it may place liquidity in the interbank market in the second period only, i.e. $\underline{q}_{1,r} < \underline{q}_{2,r}$. Figures 4 and 5 illustrate these results. They can be interpreted analogously to figures 2 and 3; the R_t -curves, and the K_t -curves as well as the thresholds \bar{q}_t and \underline{q}_t are simply swapped for the two periods. Summing up, if required reserves are remunerated at the end of a maintenance period at the average of the rates of the credit transactions conducted with the central bank during the maintenance period, the bank's optimal intertemporal allocation of required reserves and its liquidity needs at the central bank are influenced by interest rate changes within a maintenance period. If the central bank raises (cuts) its interest rate, the bank holds more (less) reserves in the second period than in the first period, i.e. required reserves are not provided smoothly. Generally, this fulfilling of required reserves is reflected by a bank's demand for reserves at the central bank which is higher (lower) in the second period.

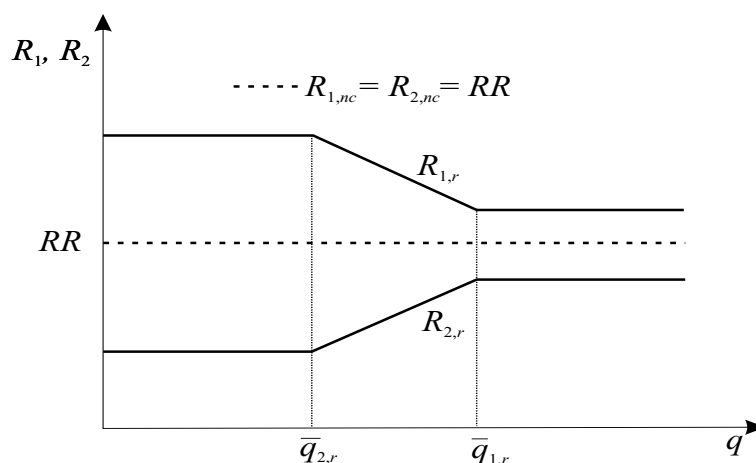


Figure 4: **Interest Rate Increase: Optimal Holding of Required Reserves**

4 Conclusions for the Eurosystem's Operational Framework

Let us assume that - as in Neyer and Wiemers (2004) - there is a continuum of banks differing in q , i.e. in the level of marginal opportunity costs of holding collateral.¹⁶ Then, aggregating required reserve holdings reveals that uneven provisions of individual banks will not be balanced but that also aggregate reserves will be provided unevenly if the central bank changes its interest rate and if reserves are remunerated at the average rate. Obviously, these uneven provisions are reflected by an aggregate liquidity demand at the central bank exceeding or remaining under that level which allows for smooth provisions. If, on the other hand, reserves are remunerated at the current rate, aggregate reserves will be provided smoothly and consequently, aggregate liquidity demand at the central bank will equal the amount which allows for this smooth fulfilment of required reserves independently of an interest rate change.

Transferring these results to the euro area means that under the current operational framework of the Eurosystem - where reserves are remunerated at an average rate - aggregate reserves would be provided unevenly if the ECB changed its interest rates within the reserve maintenance period, i.e. the buffer function of reserve holdings would be reduced. Furthermore, the interest rate change would lead to

¹⁶The reason for this assumption has been given in section 2.

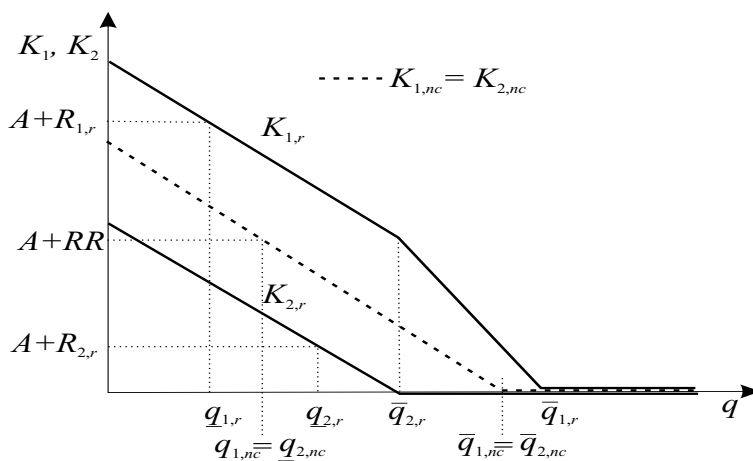


Figure 5: **Interest Rate Increase: Optimal Borrowing from the Central Bank**

over-/underbidding behaviour: Aggregate bids would exceed/remain under the Eurosystem's benchmark allotment. Consequently, the governing council must keep to its self-commitment if it wants to avoid this bidding behaviour and the uneven provisions of required reserves. However, if the Eurosystem's operational framework would be changed so that reserves were remunerated at the current MRO-rate, interest rate changes would neither influence the banks' management of required reserves nor their bidding behaviour since interest rate changes would not affect their net costs of holding reserves. Speculation on interest rate changes could not occur. This means that the Eurosystem's self-commitment - which has been made to avoid speculation on interest rate changes - would be unnecessary. The commitment could be given up, monetary policy could be conducted more flexible. The governing council could take interest rate decisions whenever the assessment of available information requires this.

Finally, we want to comment on an ostensible advantage of the reserve remuneration at an average rate which is that the interbank market rate may adjust smoothly over time rather than jumping on the date the central bank rate is changed. The idea behind this argument is as follows. If the ECB cut its interest rates within a reserve maintenance period, banks would postpone required reserve holdings due to the remuneration at the average rate (see our model). Consequently, in the interbank

market liquidity demand would decrease before the interest rate cut which would imply that also the interbank market rate declines already before the cut, i.e. there would be a smooth change of the interbank market rate. However, this line of reasoning is wrong. It does not consider that in the interbank market, there would not only be a decrease in demand but also in supply since banks would demand for less liquidity in the MRO prior to the interest rate cut (underbidding).¹⁷

Therefore, as far as we know, there is no convincing advantage of remunerating reserves at the average of the rate on the MROs conducted in the course of the maintenance period. Contrary, the remuneration at the average rate has the disadvantage of the necessary self-commitment to prevent uneven provisions of required reserves and undesired bidding behaviour. Consequently we suggest to change the Eurosystem's operational framework in such a way that holdings of required reserves are remunerated at the current MRO-rate.

5 Summary

We have presented a model of a bank's liquidity demand and reserve management capturing main elements of the Eurosystem's current operational framework to analyze the influence of the remuneration of required reserves on the flexibility of monetary policy. The model shows that if reserves are remunerated at the average of the rates on credit transactions between the monetary authority and banks conducted in the cause of a maintenance period, and if the central bank changes its interest rate within that period, there will be uneven provisions of required reserves and liquidity demand at the central bank will deviate from the level allowing for smooth provisions of required reserves. If, on the other hand, reserves are remunerated at the current rate of a credit transaction, required reserves will be provided smoothly and liquidity demand at the central bank will correspond to the level allowing for this smooth fulfilment.

Transferring these results to the euro area means that under the current operational

¹⁷Furthermore, it should be noted that even if the remuneration of required reserves had an interest rate smoothing effect, this effect would only occur if the Eurosystem gave up its commitment not to change interest rates within a reserve maintenance period.

framework - where reserves are remunerated at the average of the rates on the MROs conducted in the course of a maintenance period - the governing council of the ECB must keep to its self-commitment to take interest rate decisions only during the first of its bi-monthly meetings in order to avoid speculation on interest rate changes which would lead to uneven provisions of reserves and under- and overbidding behaviour in the MROs.

Therefore, we suggest a slight change to the Eurosystem's operational framework which is to remunerate reserves at the current MRO-rate. Then, there would be no convincing reason anymore for the Eurosystem's self-commitment. It could be given up so that monetary policy could be conducted more flexible. The governing council could take interest rate decisions whenever the assessment of available information requires this without breaking a commitment.

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