The Influence of a Heterogeneous Banking Sector on the Interbank Market Rate in the Euro Area

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1. Introduction

The interbank money market, and here especially the market for unsecured overnight loans, plays a crucial role in the conduct of monetary policy. It is the starting point for the transmission mechanism of monetary policy impulses, and in most industrialized countries, the rate on these overnight loans is the central bank's operating target. Hence, for the conduct of monetary policy it is important to know the functioning of this market and the determinants of the interbank money market rate.

The interbank money market reallocates the liquidity originally supplied by the central bank. One reason for this reallocation is the offset of anticipated and non-anticipated daily liquidity imbalances. Furthermore, banks are motivated to participate in the interbank market for speculative purposes. With a view on the euro area, however, we derive an additional reason for the reallocation: a heterogeneous banking sector. In the euro area, this heterogeneity results from different costs banks face when borrowing from the central bank. These cost differences occur because loans from the Eurosystem have to be based on adequate collateral and costs of holding eligible assets vary across banks within the euro area.

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Developing a model which captures this heterogeneity, we show that it induces intermediation. Banks with relatively low marginal costs act as intermediaries between the central bank and credit institutions with relatively high marginal costs.

Intermediation has important ramifications for the conduct of monetary policy as the following example shows. The main refinancing operations (MROs) are the Eurosystem's key instrument to provide liquidity for the banking sector in the euro area. They are executed weekly either through a fixed or variable rate tender.[1] In the past, several MROs were characterized by underbidding behaviour[2] which led to a sizeable increase in the interbank money market rate. This underbidding behaviour occurred when banks expected the central bank to lower interest rates within the maturity of the respective MRO. The extremely low demand for funds at the central bank can be attributed to speculation by the banks and to a reduced incentive to intermediate. The Eurosystem could have prevented the strong increase in the interbank market rate by providing the necessary additional liquidity. Typically, however, the Eurosystem refrained from offsetting the liquidity deficits in order to drive home the point that underbidding behaviour is a non-profit-making strategy for the banks (see, for example, ECB (2001a, p. 16)). This kind of "education" may work to prevent banks from speculating but it does not help to prevent a reduced incentive to intermediate. Therefore, if intermediation plays an important role in the interbank market, this kind of "education" will be fruitless.[3]

1 Some information on the MROs is given in section 2. It should be noted that the Eurosystem decided on some changes to its operational framework. These changes have been effective since March 2004. For details concerning these alterations see ECB (2003a) and ECB (2003b). For a detailed description of the MROs and the other monetary policy instruments of the Eurosystem before they were changed see, for example, ECB (2002c). A detailed description of the instruments including the alterations can be found in ECB (2004a) and ECB (2004b).

2 A MRO is characterized by underbidding behaviour if the aggregated bidding volume is significantly below the Eurosystem's benchmark allotment (for respective literature see page 397). The 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 (see ECB (2002b) for details).

3 It should be noted that due to the changes in the Eurosystem's operational framework (see footnote 1), the incentives for speculation and a reduced intermediation should not exist anymore since interest rate changes will not take place during the maturity of a MRO anymore implying that the underbidding problem should be solved. For a theoretical analysis concerning the incentives on behalf of the banks for speculation and a reduced intermediation under the old operational framework and the non-existing incentives under the new framework see Neyer (2003).

Our model shows that a consequence of the intermediation is a positive spread between the interbank market rate and the central bank rate. Using data for the euro area covering the period from January 1999 until December 2003, we test for a positive spread. The results of our empirical analysis support the outcome of our model. Furthermore, our theoretical analysis shows that an increase in the central bank rate leads to a likewise increase in the interbank market rate and that there is a positive relationship between the total liquidity needs of the banking sector and the interbank market rate. We test these implications of our model in a cointegration analysis using data for the euro area. Again we find empirical support for our model.

The bulk of the literature dealing with the interbank money market analyses the U. S. federal funds market. Developing a model in which individual banks compare the liquidity benefit of excess reserves with the federal funds rate, Ho and Saunders (1985) derive different federal funds demand functions and provide several explanations for specific features of the federal funds market. Clouse and Dow (2002) model the reserve management of a representative bank as a dynamic programming problem capturing main institutional features of the federal funds market to discuss the effects of various changes to the operating environment and monetary policy instruments. A large part of the literature which deals with the federal funds market analyses why the federal funds rate fails to follow a martingale within the reserve maintenance period, i. e. why banks obviously do not regard reserves held on different days of the maintenance period as perfect substitutes (Hamilton, 1996; Clouse and Dow, 1999; Furfine, 2000; Bartolini, Bertola and Prati, 2001; Bartolini, Bertola and Prati, 2002a).

However, the results of these papers for the U. S. federal funds market cannot be easily transferred to the respective markets in other countries because of country specific institutional aspects, as pointed out by Bartolini, Bertola and Prati (2003), for example. Consequently, papers dealing with liquidity demand and supply in the euro area consider typical features of the Eurosystem's operational framework. Capturing main characteristics of this framework, an extensive number of papers deals with the causes and consequences of the banks' under- and overbidding behaviour in the MROs (Ayuso and Repullo, 2001; Ayuso and Repullo, 2003; Bindseil, 2002; Ewerhart, 2002; Ewerhart, Cassola, Ejerskov and Valla, 2003; Nautz and Oechssler, 2003; Neyer, 2003). Pérez-Quirós and Rodríguez-Mendizábal (2001) construct a model in which the interest rates of the Eurosystem's two standing facilities play a crucial role in determining the behaviour of the interbank market rate. Välimäki (2001) presents an interbank market model to analyse the performance of alternative fixed rate tender procedures.

Our paper contributes to the existing literature by modelling an interbank money market which focusses on the following two institutional features in the euro area. First, contrary to the Federal Reserve System, which provides the liquidity to the banking sector mainly via outright purchases of securities, the Eurosystem provides the bulk of liquidity via loans to the banking sector.[4] Second, these loans have to be based on adequate collateral, whereas the costs of holding eligible assets vary across banks within the euro area.

A close reference to our work is the article by AYUSO and REPULLO (2003). Looking at the euro area, they also find a positive spread between the interbank market rate and the central bank rate. In their article, the positive spread 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. This would be consistent with the desire of a young central bank to gain credibility for its anti-inflationary monetary policy. AYUSO and REPULLO focus on the behaviour of the central bank and its relationship with the credit institutions. Our paper complements their work by focussing on the behaviour of the credit institutions and their interrelationship.

The remainder of this paper is structured as follows. Section 2 provides some institutional background on the money market in the euro area. In section 3 we present an interbank money market model with a heterogeneous banking sector. Section 4 empirically tests the implications of the model for the euro area, and section 5 summarizes the paper.

2. Institutional Background

Liquidity Demand

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. The Eurosystem's minimum reserve system requires credit institutions to hold a fixed amount of compulsory deposits on the accounts with the Eurosystem.

4 For a detailed comparison of the Eurosystem's and the Federal Reserve System's operational frameworks see, for example, RUCKRIEGEL and SEITZ (2002). BARTOLINI and PRATI (2003), also comparing the two central banks, focus on the different approaches to the execution of the monetary policy.

These holdings of required reserves are remunerated close to the market rate.[5] In order to fulfil reserve requirements, averaging provisions are allowed over a one-month reserve maintenance period. Until March 2004, the timing of the reserve maintenance period started on the 24th calendar day of each month and ended on the 23rd calendar day of the following month, i. e. it was independent of the dates of the Governing Council meetings at which interest rate changes were decided. Since March 2004, maintenance periods start on the settlement day of the first MRO following the Governing Council meetings at which interest rate changes are usually decided, and end on the day preceding the corresponding settlement day in the following month. The reason for this change in the timing of the maintenance period has been to avoid interest rate change speculation within a maintenance period which led to under- or overbidding behaviour in a couple of MROs.[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] The MROs, the key instrument of the Eurosystem to provide the banking sector with liquidity, are 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. With effect from March 2004, the maturity of the MROs has been reduced from two weeks to one week in order to avoid overlapping maturities which also induced under- or overbidding behaviour in the MROs in case of expected interest rate changes.[8] The

5 See ECB (2004a, pp. 58–59) for details.

6 For a detailed description of the current minimum reserve system we refer the reader to ECB (2004a), for a description of the reserve system before the changes were effective to ECB (2002c). For details concerning the reason why the Eurosystem has changed its minimum reserve system see ECB (2003a).

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

8 For a detailed description of the current design of the MROs we refer the reader to ECB (2004a), for a description of the MROs before the changes were effective to ECB (2002c). For

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.

Reallocation of Liquidity

The liquidity supplied by the Eurosystem is reallocated via the interbank money market. This market can be divided into the cash market, the market for short-term securities and the market for derivatives.[10] The cash market consists of the unsecured market, the repo market and the foreign exchange swap market. In the unsecured market, activity is concentrated on the overnight maturity segment. The reference rate in this segment is the Eonia (Euro Overnight Index Average). It is a market index computed as the weighted average of overnight unsecured lending transactions undertaken by a representative panel of banks. The same panel banks contributing to the Eonia also quote for the Euribor (Euro Interbank Offered Rate). The Euribor is the rate at which euro interbank term deposits are offered by one prime bank to another prime bank. This is the reference rate for maturities of one, two and three weeks and for twelve maturities from one to twelve months.[11] The market for short term securities includes government securities (Treasury bills) and private securities (mainly commercial paper and bank certificates of deposits). In the market for derivatives, typically interest rate swaps and futures are traded.

As pointed out in the introduction, institutional features play an important role for the functioning of the interbank market and therefore for the determinants of the interbank market rate. The model presented in the following section focusses on two specific institutional features in the euro area: First,

details concerning the reason why the Eurosystem has changed the design of the MROs see ECB (2003a). A theoretical foundation for these alterations can be found in NEYER (2003).

9 Eligible assets have been defined by the Eurosystem. For details see ECB (2002c, pp. 38–50) and ECB (2004a, pp. 39–54.)

10 For more detailed information on the euro money market we refer the reader to ECB (2001b), ECB (2002a) and ECB (2003b).

11 For more information on these reference rates see www.euribor.org.

the Eurosystem provides the bulk of liquidity via loans to the banking sector. Second, these Eurosystem credit operations have to be based on adequate collateral, and the costs of holding eligible assets vary across banks within the euro area. We neglect other specific features such as the kind of the tender procedure the Eurosystem employs to provide the liquidity, the possibility of averaging provisions of required reserves or the remuneration of required reserves. Introducing these aspects to the analysis would not change the main results of our paper but would make the model unnecessarily complex.

3. A Simple Model of an Interbank Money Market

Liquidity Costs and Optimisation

We consider a continuum of measure one of risk-neutral, isolated, price taking banks. All banks have the same given liquidity needs summarized by the variable R.[12] To cover its liquidity needs, a single bank can borrow liquidity from the central bank or in the interbank market where it can also place excess liquidity.

The amount bank i borrows from the central bank at a given rate l is denoted with $K_i \geq 0$. This credit transaction with the central bank has to be based on adequate collateral. We assume that rate of return considerations induce a strict hierarchy of a bank's assets,[13] and that assets which can serve as collateral have a relatively low rate of return due to specific criteria they have to fulfil. Consequently, this collateralization incurs increasing marginal costs. These opportunity costs of holding collateral are given by

$$Q_i = q_i K_i + f(K_i), \tag{1}$$

where $f(K_i) \geq 0,\ f(0) = 0,\ f' \geq 0,\ f'' > 0$, and $f'(R) < \infty$. The bank specific parameter $q_i \geq 0$ represents different levels of marginal opportunity costs between banks (functions, variables, and parameters not indexed by i are the same for each

12 In our model, the interbank market function of balancing daily liquidity fluctuations could be considered by modelling liquidity needs R as a bank-specific random variable or by adding bank-specific shocks. However, this would make the analysis more complicated without changing the main results of this paper.

13 This 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.

bank). This heterogeneity in the banking sector is a key feature of our model. We motivate this heterogeneity by different opportunity costs of holding collateral. However, there may be other costs in which banks differ when borrowing liquidity from the central bank, for example, human capital costs.

In the interbank market, a bank can demand liquidity or place excess liquidity. Bank i's position in the interbank market is

$$B_i = R - K_i \lesseqgtr 0. \tag{2}$$

Trading in the interbank market, the bank faces transaction costs given by

$$Z_i = zh(B_i), \tag{3}$$

where $h(B_i) \geq 0$, $h(0) = 0$, $h'(B_i > 0) > 0$, $h'(B_i < 0) < 0$, $h'(0) = 0$, $h''(B_i) > 0$, $h'(R) < \infty$, and the parameter $z > 0$. Furthermore, we assume the cost function to be symmetric, i.e. $h(B_i) = h(-B_i)$. This approach of increasing marginal transaction costs can be compared with the common method of modelling the liquidity role of reserves which posits that banks incur increasing costs when liquidity deviates from a target level (CAMPBELL, 1987; BARTOLINI, BERTOLA and PRATI, 2001). The convex 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.

Defining l as the interest rate on the central bank credit, and e as the interbank market rate, bank i's total liquidity costs are

$$C_i = K_i l + B_i e + Q_i + Z_i. \tag{4}$$

The first term on the right hand side describes interest payments to the central bank, the second either interest payments or interest yield from transactions in the interbank market, and the last two terms represent opportunity costs of holding collateral and transaction costs. Focussing on prime banks, we neglect any credit risk in the interbank market. This is in line with the empirical analysis of our model results, where we use the Eonia and the Euribor as proxy variables for the interbank market rate. Both the Eonia and the Euribor are computed as the average of the offer rates of a representative panel of prime banks to other prime banks.

A bank minimizes its total liquidity costs by choosing the optimal level of K_i, subject to $K_i \geq 0$. The first order condition is given by

$$l + q_i + f' - e - zh' = 0. \tag{5}$$

Equation (5) reveals that if a bank covers its liquidity needs at the central bank and in the interbank market, marginal costs of central bank funds ($l + q_i + f'$) are equated to marginal costs of funds borrowed in the interbank market ($e + zh'$). If a bank places liquidity in the interbank market, the sum of marginal costs of central bank funds and marginal transaction costs in the interbank market ($l + q_i + f' - zh$) is equated to marginal revenues in the interbank market e. (Note, that in case the bank places liquidity in the interbank market $h' < 0$ holds.)

Equation (5) implicitly gives the optimal credit demand $K_i^{\text{opt}}(e,l,q_i,R,z)$. Using the implicit function theorem we find that $K_{i,K_i>0}^{\text{opt}}(\cdot)$ is decreasing in q_i:

$$\frac{\partial K_{i,K_i>0}^{\text{opt}}(\cdot)}{\partial q_i} = -\frac{1}{f'' + zh''} < 0. \tag{6}$$

The condition $K_i \geq 0$ introduces a non-differentiable point in the partial derivative $\partial K_i^{\text{opt}} / \partial q_i$. We find this point by setting K_i equal to zero and solving equation (5) for q_i. Denoting this upper threshold of q_i with $\overline{q}$ we obtain

$$\overline{q} = e - l - f'(0) + zh'(R). \tag{7}$$

If $q_i \geq \overline{q}$, bank i's opportunity costs of holding collateral will be so high that it prefers to cover its total liquidity needs in the interbank market, i. e. $K_i^{\text{opt}} = 0$ and $B_i = R$.

Evaluating equation (5) at $K_i = R$ and solving for q_i, we also find a lower threshold of q_i given by

$$\underline{q} = e - l - f'(R) + zh'(0) = e - l - f'(R). \tag{8}$$

If $q_i < \underline{q}$, bank i's opportunity costs of holding collateral will be so small that it will be advantageous to borrow from the central bank to place liquidity in the interbank market. In this case, the bank will demand more reserves at the central bank than it actually needs to cover its own requirements, i. e. $K_i^{\text{opt}} > R$ and $B_i < 0$. Due to its relatively low opportunity costs of holding collateral, this bank acts as an intermediary between the central bank and banks with relatively high opportunity costs.

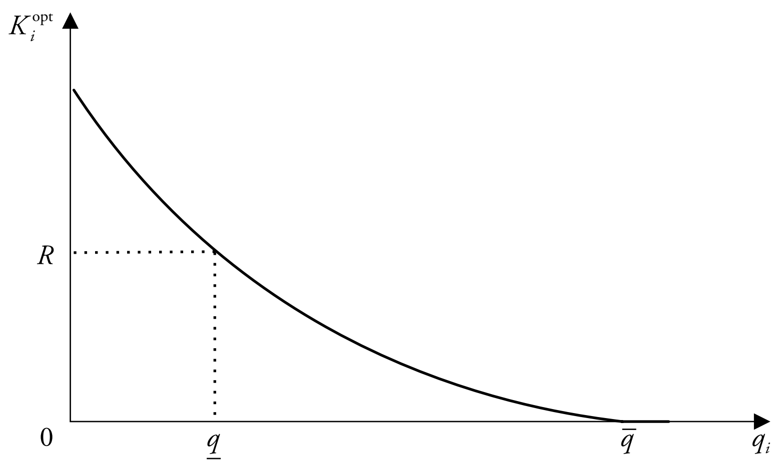
Since $q_i \geq 0$, equation (8) reveals that the interbank market rate must strictly be greater than the central bank rate ($e > l$). This result is obvious since otherwise no bank would be willing to borrow from the central bank to place the liquidity in the interbank market. Or to put it differently, no bank would be interested to act as an intermediary.

Thus, a bank's optimal credit demand $K_i^{\text{opt}}(\cdot)$ is described by the following function:

$$K_i^{opt}(e,l,q_i,R) = \begin{cases} K_{i,R \le K_i}^{\text{opt}}(\cdot) & \text{if } 0 \le q_i \le \underline{q} \\ K_{i,0<K_i<R}^{\text{opt}}(\cdot) & \text{if } \underline{q} < q_i < \overline{q} \\ 0 & \text{if } \overline{q} \le q_i. \end{cases} \quad (9)$$

If $0 \le q_i \le \underline{q}$, bank *i* will demand more reserves at the central bank than it needs to cover its own liquidity needs, i. e. $K_i^{\text{opt}} > R$. If $\underline{q} < q_i < \overline{q}$, bank *i* will cover its liquidity needs at the central bank and in the interbank market, i. e. $0 < K_i^{\text{opt}} < R$. Finally, if $\overline{q} \le q_i$, bank *i* will cover its liquidity needs exclusively in the interbank market. Figure 1 illustrates this result. It should be noted that the slope of the curve between 0 and $\overline{q}$ has been chosen arbitrarily. Its exact shape depends on the form of the cost functions $f(K_i)$ and $h(B_i)$.

Figure 1: Optimal Credit Demand at the Central Bank



Equilibrium Interbank Market Rate

At the equilibrium interbank market rate e^*, liquidity supply equals liquidity demand. Therefore, assuming that q_i is distributed in the interval $[0,q_{\max}]$ across banks according to the density function $g(q_i) = G'(q_i)$ with $G(0) = 0$, e^* is determined by

$$\begin{aligned}&\int_0^{\underline{q}^*}(K^{\text{opt}}_{i,0\le q_i\le \underline{q}^*}(\cdot)-R)g(q_i)dq_i\\ &=\int_{\underline{q}^*}^{\overline{q}^*}[R-K^{\text{opt}}_{i,\underline{q}^*<q_i<\overline{q}^*}(\cdot)]g(q_i)dq_i+\int_{\overline{q}^*}^{q_{\max}}Rg(q_i)dq_i,\end{aligned} \tag{10}$$

where $\underline{q}^* = e^* - l - f'(R)$ and $\overline{q}^* = e^* - l + zh'(R) - f'(0)$. The first line of equation (10) shows liquidity supply in the interbank market, the second liquidity demand. The demand for liquidity is divided into the demand by credit institutions covering their liquidity needs partially in the interbank market (first integral) and by banks covering their total liquidity needs in that market (second integral). Equation (10) gives us the determinants of e^* and therefore of the spread $(e^* - l)$: transaction costs in the interbank market, total liquidity needs of the banking sector, opportunity costs of holding collateral and the distribution of the latter across banks. Applying the implicit function theorem we obtain:

$$\frac{\partial e^*}{\partial l}=1 \tag{11}$$

$$\frac{\partial e^*}{\partial R}=\frac{1-\int_0^{\overline{q}^*}\frac{zh''g(q_i)}{f''+zh''}dq_i}{\int_0^{\overline{q}^*}\frac{g(q_i)}{f''+zh''}dq_i}>0 \tag{12}$$

$$\frac{\partial e^*}{\partial z}=\frac{-\int_0^{\overline{q}^*}\frac{zh'g(q_i)}{f''+zh''}dq_i}{\int_0^{\overline{q}^*}\frac{g(q_i)}{f''+zh''}dq_i}\gtreqless 0. \tag{13}$$

Equation (11) reveals that there is a positive relationship between the interbank market rate e^* and the central bank rate l. An increase in l results in increasing marginal costs of borrowing from the central bank implying that both, in the interbank market supplying and borrowing banks, reduce their demand for funds at the central bank. Consequently, supply in the interbank market decreases and demand increases inducing the interbank market rate to rise. Furthermore, equation (11) shows that a rising l leads to a *likewise* increase in e^*. The reason is that an increase in e has the same absolute effect on total marginal liquidity costs as an increase in l, but in the opposite direction (see the first order condition given by equation (5)). This means that no wedge is driven between marginal interest payments to the central bank and marginal interest payments/revenues in the interbank market.

Equation (12) shows that there is also a positive relationship between the interbank market rate e^* and total liquidity needs R.[14] This result is driven by the cost functions $f(K_i)$ and $h(B_i)$. If both cost functions are convex, as assumed, it is obvious that the liquidity supplying banks will cover their additional liquidity needs by reducing their supply in the interbank market *and* by demanding more funds at the central bank, while the banks on the demand side in the interbank market will cover their additional needs by demanding more funds in the interbank market *and* at the central bank.[15] Consequently, in the interbank market, the supply decreases and the demand increases implying a rising interbank market rate.

However, it should be noted that the convexity of both cost functions, f and h, is not a necessary condition for the result $\partial e^*/\partial R > 0$. This result also holds if only one cost function is convex and the other is linear, and it may also hold if one is convex and the other is concave. In the latter case, we additionally have to assume that the second order condition for a cost minimum, $f'' + zh'' > 0$, is fulfilled. In the following, we briefly describe the effects of a rising R on e^* in case one cost function is assumed to be concave.

If $f'' < 0$ and $h'' > 0$ assuming $|f''| < zh''$, then $\partial e^*/\partial R \gtreqless 0$, i. e. in case of decreasing marginal costs of borrowing from the central bank, the interbank market rate may decrease as a result of rising liquidity needs. The reason is that it may be advantageous to the supplying banks to demand more funds at the central bank to place even more liquidity in the interbank market and to the demanding banks to cover a higher portion of their liquidity needs at the central bank.

14 The cost functions $h(B_i)$ and $f(K_i)$ are assumed to be strictly convex, i. e. $0 < zh''/(f'' + zh'') < 1$. This implies that $\int_0^{\bar{q}^*} zh'' g(q_i)/(f'' + zh'')dqi < 1$.

15 Formally, one obtains this result by using equation (5) and employing the implicit function theorem which reveals that $\partial K_i^{opt}/\partial R < 1$.

This would lead to a decreasing demand and an increasing supply in the interbank market implying the interbank market rate to fall. Whether this case occurs depends on the increase of the marginal cost curve h' relative to the decrease of the marginal cost curve f' as well as the density function $g(q_i)$.

If $h'' < 0$ and $f'' > 0$ assuming that $|zh''| < f''$, then $\partial e^*/\partial R > 0$, i. e. the effect of a rising R on e^* is unambiguously positive. The intuition behind this result is that it is advantageous to the demanding banks to cover an even higher portion of their liquidity needs in the interbank market. For the supplying banks marginal costs of placing liquidity in the interbank market increase since they must demand more funds at the central bank if they want to maintain their supply in the interbank market due to their own increased liquidity needs. But borrowing more funds at the central bank implies increasing marginal costs. As a consequence, banks will reduce their supply in the interbank market. Therefore, there is an increasing demand and a decreasing supply leading to a rise in e^*.

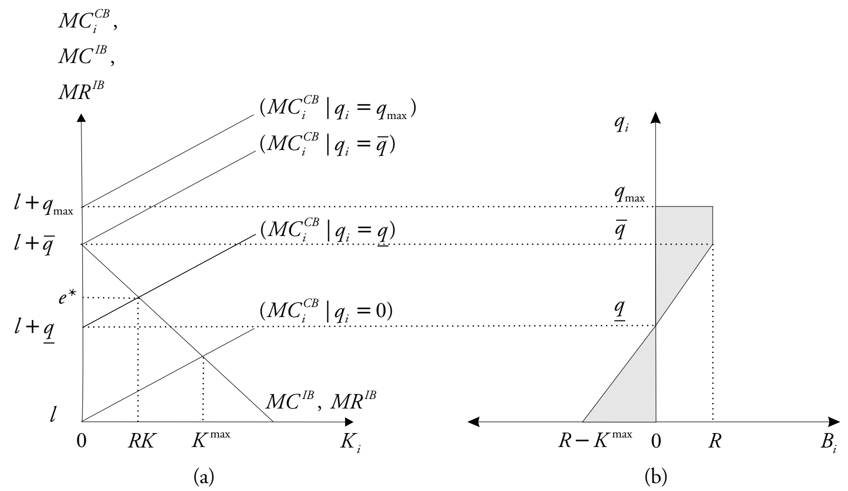
The effect of transaction costs on the interbank market rate is ambiguous (see equation (13)).[16] Rising transaction costs in the interbank market imply increasing marginal costs for both, in the interbank market borrowing and supplying banks. Consequently, demand as well as supply will fall. It depends on the shape of the cost functions $f(K_i)$ and $h(B_i)$ and on the density function $g(p_i)$ which effect outweighs the other and thus whether there is a decrease or increase in e.

The main findings of this section are summarized by the following result:

Result: *If opportunity costs of collateral, which banks need to hold to obtain funds from the central bank, differ between banks, an interbank market will emerge. Banks with relatively low opportunity costs will act as intermediaries between the central bank and banks with relatively high costs. The interbank market rate will be higher than the central bank rate, with the difference being determined by total liquidity needs of the banking sector, transaction costs in the interbank market, opportunity costs of holding collateral, and the distribution of the latter across banks.*

16 Note that for $0 \le q_i < \underline{q}^*$, $h' < 0$ and for $\underline{q}^* < q_i < \overline{q}^*$, $h' > 0$.

Figure 2: Interbank Market Equilibrium



Illustration

In order to illustrate our results graphically, we postulate the cost functions to be quadratic:

$$Q_i = q_i K_i + \frac{s}{2} K_i^2 \tag{14}$$

and

$$Z_i = \frac{z}{2} B_i^2 \tag{15}$$

with the parameters $s,z > 0$. Furthermore, we assume a uniform distribution of q_i, with $g(q_i) = 1$. Under these assumptions, Figure 2 shows the interbank market equilibrium.

In panel (a), the upwards sloping curves represent marginal costs of borrowing from the central bank given by

$$MC_i^{CB} = l + q_i + sK_i. \tag{16}$$

Since there is a continuum of banks differing in q_i, which is distributed in the interval $[0,q_{max}]$, there is a continuum of marginal cost curves between l and

$(l + q_{\max})$. The downwards sloping curve represents marginal costs of borrowing in the interbank market. For banks placing liquidity in that market this curve depicts net marginal revenues (interest yield on interbank loans minus transaction costs). These marginal costs and revenues are given by

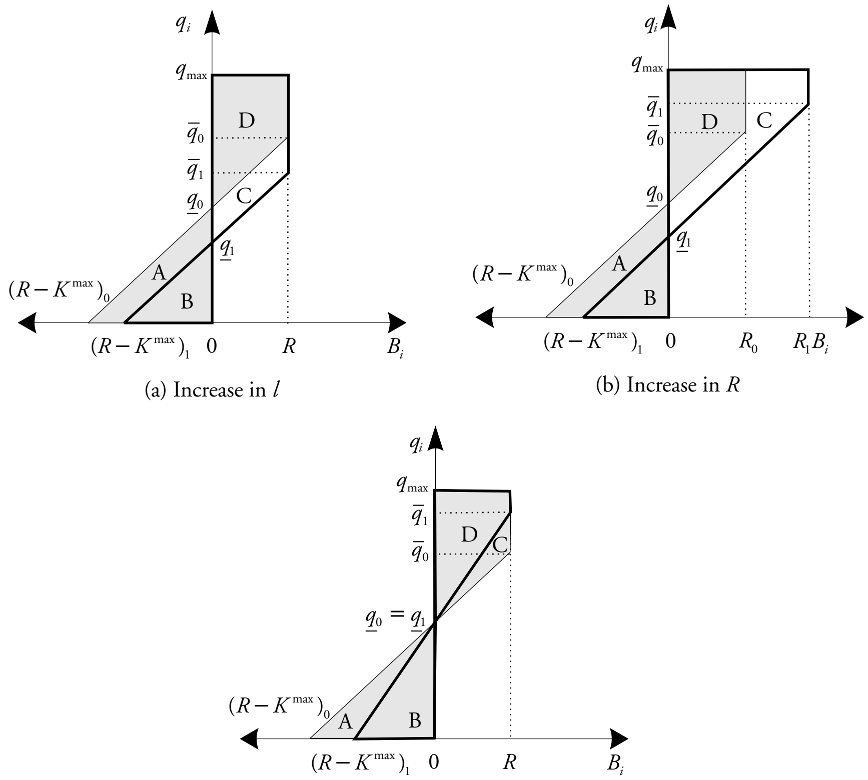
$$MC^{IB} = MR^{IB} = e + z(R - K_i). \tag{17}$$

Looking at panel (a) and comparing marginal costs of borrowing from the central bank with those of borrowing in the interbank market and with marginal revenues from placing liquidity in the interbank market respectively, leads to the following results: For banks with $q_i > \overline{q}$ marginal costs of borrowing from the central bank are always higher than those of borrowing in the interbank market. Consequently, $K^{\text{opt}}_{i,q_i \geq \overline{q}} = 0$ (we break ties in favour of borrowing in the interbank market). Banks with $\overline{q} > q_i > \underline{q}$ partially cover their liquidity requirements at the central bank and in the interbank market, i.e. $0 < K^{\text{opt}}_{i,\overline{q}>q_i>\underline{q}} < R$. The bank-specific amount $K^{\text{opt}}_{i,\overline{q}>q_i>\underline{q}}$ is found at the point where the bank-specific marginal cost curve $(MC_i^{CB} \mid \overline{q} > q_i > \underline{q})$ and the marginal cost curve MC^{IB} intersect. Credit institutions with $q_i < \underline{q}$ borrow more reserves than they need to cover their own liquidity needs to place the excess liquidity in the interbank market, i.e. $K^{\text{opt}}_{i,q_i<\underline{q}} > R$. The bank-specific amount $K^{\text{opt}}_{i,q_i<\underline{q}}$ is determined by the intersection of the bank-specific marginal cost curve $(MC_i^{CB} \mid q_i < \underline{q})$ and the marginal revenue curve MR^{IB}. $K^{\max}$ denotes the central bank credit amount of the bank with the lowest level of marginal opportunity costs of holding collateral, i.e. with $q_i = 0$.

Panel (b) in Figure 2 represents aggregate demand and supply in the interbank market. The shaded area to the left of the vertical q_i-axis represents aggregate supply, the respective area to the right aggregate demand. In equilibrium, both areas have to be of the same size. The equilibrium interbank rate e^* is determined by the intersection of the specific marginal cost curve $(MC_i^{CB} \mid q_i = \underline{q})$ and the marginal cost/revenue curve $(MC^{IB} = MR^{IB})$, i.e. where $K_i^{\text{opt}} = R$ (see equation (17) and replace K_i by R).

Figure 3 illustrates the consequences of an increase in the central bank rate l, liquidity needs R, and transaction costs z on liquidity demand and supply in the interbank market. The index 0 (1) marks variables before (after) the increase in l, R and z.

Figure 3: Comparative Static Analysis



(a) Increase in l

(b) Increase in R

(c) Increase in z

An increase in l implies that in Figure 2 the continuum of the marginal cost curves MC_i^{CB} shifts parallel upwards. The consequent decrease in $K^{\max}$, $\underline{q}$ and $\bar{q}$ implies that in Figure 3, panel (a) aggregate supply shrinks from the area (A + B) to the triangle B. Aggregate demand, on the other hand, increases from the area D to the area (C + D). Consequently, there will be a rise in e to restore market equilibrium. Graphically, this rise in e shifts the marginal cost/revenue curve ($MC^{IB} = MR^{IB}$) upwards, implying $K^{\max}$, $\underline{q}$ and $\bar{q}$ to increase again, until the areas to both sides of the vertical q_i-axis are of the same size again.

In Figure 2, an increase in R leads to a parallel upward shift of the marginal cost/revenue curve ($MC^{IB} = MR^{IB}$). Furthermore, on the horizontal axis, R moves to the right. The shift of the marginal cost/revenue curve implies $K^{\max}$ to increase, but since this increase must be smaller than the rise in R ($\partial K_i^{\text{opt}} / \partial R < 1$) the distance $\overline{RK^{\max}}$ becomes smaller which implies that $\underline{q}$ decreases. The upper threshold $\overline{q}$, on the other hand, increases. Therefore, as Figure 3, panel (b) illustrates, aggregate supply shrinks from the area (A + B) to B, whereas aggregate demand increases from the area D to (D + C). Hence, the interbank market rate e will rise to restore the market equilibrium.

In Figure 2, an increase in z implies the marginal cost/revenue curve ($MC^{IB} = MR^{IB}$) to turn clockwise in that point where it intersects with the marginal cost curve ($MC_i^{CB} \,|\, q_i = \underline{q}$) (a change in z does not imply a change in $\underline{q}$ as long as e has not changed yet, see equation (8)). Therefore, the marginal cost/revenue curve becomes steeper implying $\overline{q}$ to rise and $K^{\max}$ to fall. Consequently, as Figure 3 shows, aggregate demand and supply shrink such that the effect on e^* is ambiguous.

4. Empirical Analysis

Money Market Rate and ECB Rate: Test of the Spread

The purpose of our paper is to show that intermediation occurs due to cost differences between banks in obtaining funds from the central bank. Looking at the euro area, one obtains the most obvious indication of intermediation when considering that only a small fraction of all banks actually takes part in the MROs.[17] A further indication would be an on average positive spread between the interbank market rate and the rate banks have to pay at the central bank. The following empirical analysis shows that the spread is significantly positive.

The spread between the interbank market rate and the central bank rate has been examined in a number of recent publications (Ayuso and Repullo, 2003; Ejerskov, Moss and Stracca, 2003; Nyborg, Bindseil and Strebulaev, 2002). While the positive sign of the spread is not explicitly tested in the latter two publications, Ayuso and Repullo do find a significantly positive spread.

17 At the end of 2000 (June 2003), the criteria for participating in the MROs were fulfilled by 2542 (2242) credit institutions (ECB, 2001c, p. 63; ECB, 2004b, p. 75). But in 1999 and 2000 the total number of institutions which actually took part in these operations fluctuated between 400 and 600. Also in 2001 and 2002 the number of banks taking part in the MROs was relatively small: it fluctuated between 175 and 658, on average 357 banks took part in the MROs. In the first half of 2003, the total number of counterparties participating in the MROs averaged 253 institutions.

Our test differs from AYUSO and REPULLO's in the interest rates used to approximate the interbank market rate and the central bank rate as well as in the samples used for the analysis. Testing for a positive spread, AYUSO and REPULLO use two alternative measures of the interbank market rate, namely the Eonia and the one-week Euribor. As a proxy for the central bank rate, they employ the fixed rate applied to the fixed rate tenders and the minimum bid rate of the variable rate tenders. Additionally, we test for a positive spread between the two-week Euribor (which has not been available for the sample period used by AYUSO and REPULLO) and the weighted average rate of the variable rate tenders. The advantage of testing for a positive spread between these two rates is that the maturities of the underlying credit transactions are identical. Furthermore, the weighted average rate of the variable rate tenders is a more appropriate rate for comparing the actual liquidity costs when borrowing in the interbank market with those when borrowing from the central bank which is a key issue of our model.

We start our analysis by comparing the key central bank rate in the euro area, i. e. the fixed rate applied to the fixed rate tenders and the minimum bid rate of the variable rate tenders, with the key interbank money market rate, i. e. the Eonia. Our sample of daily observations ranges from 7 January 1999 to 23 December 2003. The data are drawn from ECB sources[18]. Figure 4 shows the Eonia and the respective MRO-rate. The spread between those series is displayed in Figure 5. Both figures already indicate a positive spread between the Eonia and the key ECB interest rate.

Obviously, the Eonia has usually been close to the MRO-rate, except for some infrequent spikes which coincide with some special episodes and effects during the sample period. These are:

- Underbidding episodes in February, April and October 2001, December 2002 and March 2003. More underbidding episodes occurred (April 1999, November 2001 and June 2003), but they did not lead to tight conditions in the interbank market and thus had no significant effect on the Eonia.
- Anomalous allotment on 18 September 2001, i. e. in the week following the terrorist attack in the US.
- End of year and cash changeover effects.
- End of reserve maintenance periods effects. The allowance of averaging provisions of required reserves over a reserve maintenance period typically results in strong activities in the interbank market on the last days of the maintenance period and therefore in strong fluctuations in the Eonia during these days.

18 The time series are available on the ECB website www.ecb.int.

Figure 4: Eonia and MRO-rate, i. e. the rate applied to the fixed rate tenders and the minimum bid rate of the variable rate tenders (in percentages)

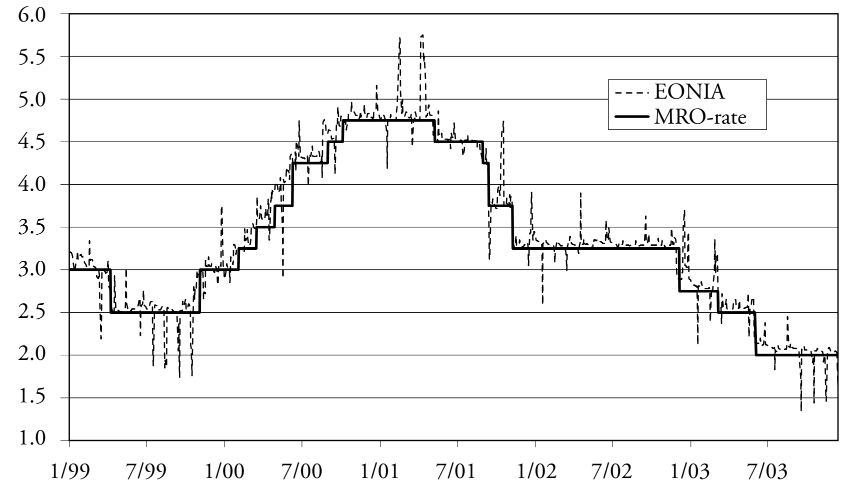
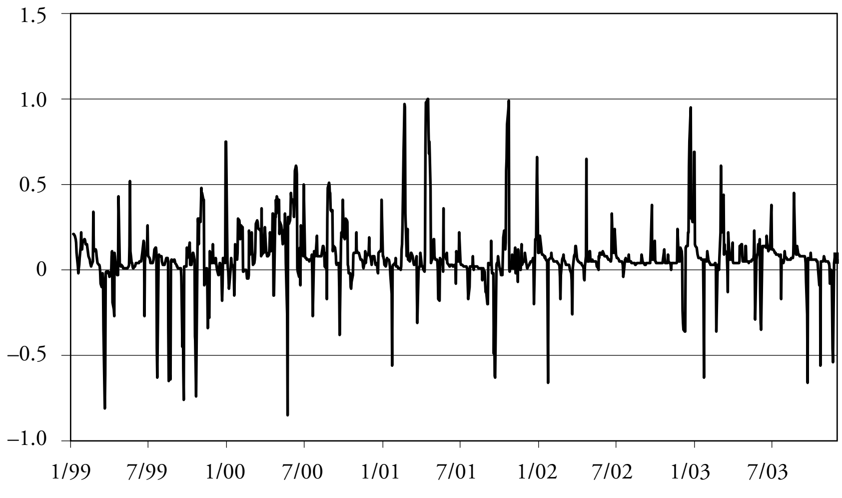


Figure 5: Spread between the Eonia and the MRO-rate, i. e. the rate applied to the fixed rate tenders and the minimum bid rate of the variable rate tenders (in percentage points)



– Periods between the governing council's announcement of an interest rate change and its implementation.

In order to test for a positive spread, we exclude these periods from the sample because we aim to test the positive sign of the spread under "normal" conditions. Furthermore, since we use weekly data for the tests of the Euribor spreads below, we also use weekly data for the Eonia spread to make results comparable.[19] The first column of Table 1 reports the one-sided test of the null hypothesis of a non-positive spread against the alternative of a positive spread between the Eonia and the MRO-rate. The average spread was 10.5 basis points during the fixed tender period and fell to 6.1 basis points during the variable tender period. The null hypothesis of a non-positive spread can be rejected on a confidence level of 1%.

However, this test involves two potential biases that might affect the spread. First, the MROs have a two-week maturity[20] which implies that the MRO-rate has a positive term premium when compared to the Eonia which in turn refers to overnight transactions. This should bias the spread downwards. Second, differences in credit risk may bias the spread upwards since the MROs are collateralized while the Eonia refers to unsecured interbank market transactions.[21] In order to reduce the first bias, we use the two-week Euribor for testing whether the spread is positive. The two-week Euribor has the same maturity as the MROs, thus the term premiums should be equal. Due to the fact that the two-week Euribor is available only since 15 October 2001, we also use the one-week Euribor, which is already available since January 1999, providing us with a much larger sample while the difference in maturity is only one week.[22] The second bias should generally be small since the Eonia and the Euribor are only offered to banks of first class credit standing. Additionally, we do not compare the respective Euribor with the minimum bid rate but with the weighted average rate during the variable rate tender period. The reason is that the latter is a more appropriate rate when comparing the actual liquidity costs in the interbank market with those at the central bank. Figures 6 and 7 show daily data on the one-week and two-week Euribor spreads. Both figures already indicate an on average positive spread between the respective interbank market rate and the respective central bank rate.

19 We use weekly data for testing the Euribor spreads to ensure that the maturity of the respective interbank term deposits is as long as the maturity of the respective MRO.

20 Note, that since March 2004, which is outside our sample period, the MROs have a maturity of one week.

21 Concerning a discussion of these two potential biases see also AYUSO and REPULLO (2003).

22 The data on the one-week and two-week Euribor is available on www.euribor.org.

Figure 6: Spread between the one-week Euribor and the MRO-rate, i. e. the rate applied to the fixed rate tenders and the weighted average rate of the variable rate tenders (in percentage points)

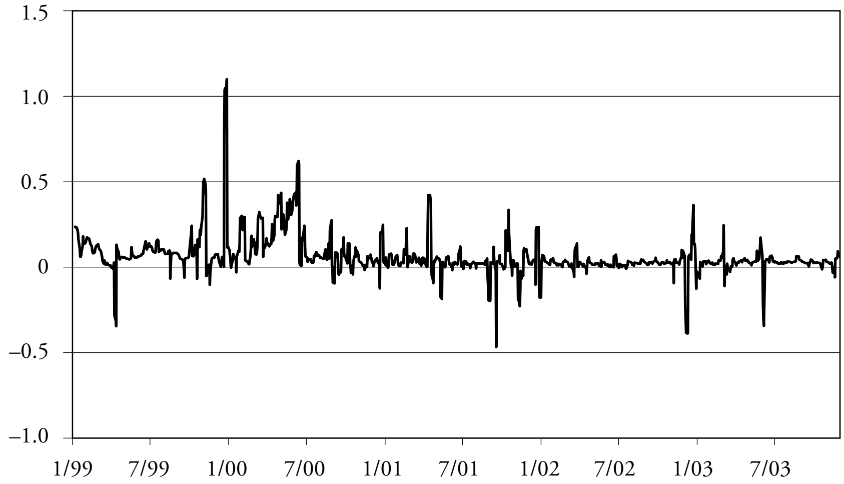
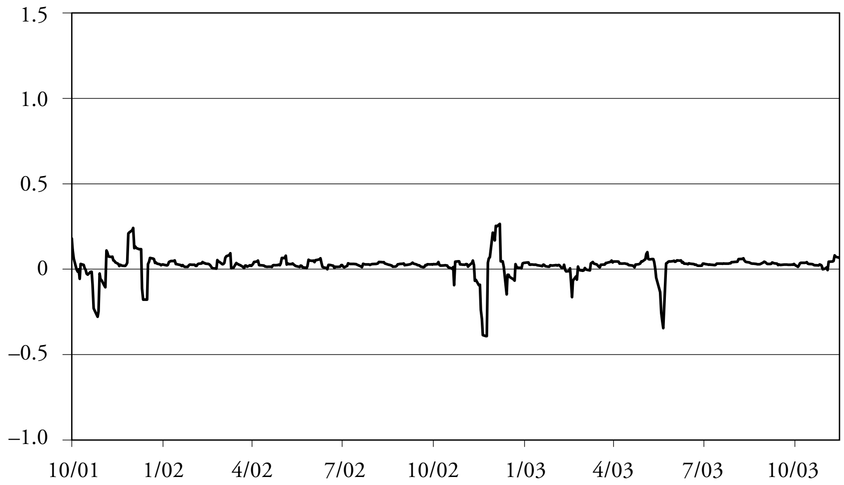


Figure 7: Spread between the two-week Euribor and the MRO-rate, i. e. the rate applied to the fixed rate tenders and the weighted average rate of the variable rate tenders (in percentage points)



As noted above, for testing the Euribor spreads we restrict the sample to the days of settlement of the MROs. Furthermore, we exclude the same special episodes as for the test of the Eonia spread. The second and third column of Table 1 report the one-sided tests of the null hypothesis of a non-positive spread against the alternative of a positive spread. The average one-week Euribor spread was 13.1 basis points during the fixed rate tender period and fell to 3.1 basis points during the variable rate tender period. The average two-week Euribor spread was 2.2 basis points. For all cases the null hypothesis of a non-positive spread can be rejected on a confidence level of 1%.

Table 1: Tests of a Positive Interest Rate Spread (Days of Settlement, Special Events Exluded)

	Eonia			1-week Euribor			2-week Euribor
	FT	VT	F+V	FT	VT	F+V	VT
Mean	0.105	0.061	0.074	0.131	0.031	0.062	0.022
(t-stat)	(−6.807)	(−11.336)	(−12.031)	(−8.901)	(−8.448)	(−10.126)	(−4.394)
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N	61	138	199	61	138	199	87

The interest rate data in the first block correspond to the Eonia spread while the second and third block show the one-week and two-week Euribor spread. Tests are reported for the fixed rate tender period (FT), the variable rate tender period (VT) and for both periods combined (F + V). Two-week Euribor data is only available for part of the variable rate tender period. Each column reports the sample mean, its t-statistic, the p-value of the one-sided test of the null hypothesis $mean \leq 0$ against the alternative $mean > 0$ and the sample size N. During the fixed rate tender period the interbank market rate is compared with the fixed rate of the MROs, whereas in the variable rate tender period the Eonia is compared with the minimum bid rate while the respective Euribor is compared with the weighted average rate. All spreads are given in percentage points.

To check for robustness of the spreads, we also tested the Eonia spread and the two Euribor spreads using daily data, with and without the exclusion of special events. Results are presented in the appendix. We can also reject the null hypothesis of a zero spread for all cases on a 1% level.

A Test of the Results of the Comparative Static Analysis

Apart from predicting a positive spread between the interbank market rate and the central bank rate, the comparative static analysis of the last section shows that our model also implies qualitative and quantitative relations between the interbank market rate *e* and some of its determining variables. Therefore, we also test the result of our theoretical model that $\partial e^*/\partial l = 1$ and $\partial e^*/\partial R > 0$. The effect of transaction costs, collateral opportunity costs and the distribution of the latter across banks on the equilibrium interbank market rate are captured by a constant and, if their effect changes over time, by including a trend in the following cointegration analysis.

According to standard unit root tests, the one-week Euribor (our proxy for *e*) and the MRO rate, i. e. the rate applied to the fixed rate tenders and the weighted average rate of the variable rate tenders (used for l) are I(1) variables for the whole sample period ranging from 7 January 1999 to 23 December 2003. Again, all series are observed on the days of settlement of the tender, which results in a sample size of $T = 259$. Figure 8 displays both interest rates. The series of banks' total liquidity needs R is the sum of autonomous factors and required reserves.[23] Figure 9 shows a distinct double trend break in R which is mainly due to a large decrease in banknotes in circulation before the introduction of the Euro money in January 2002 and the strong rebound since April 2002 (ECB 2004b, p. 89). Allowing for a piecewise linear trend in the ADF test using bootstrapped critical values, we can reject the unit root for R on a 10% level.

Since the I(1) hypothesis cannot be rejected for the interest rate variables, we test for cointegration (Johansen, 1988; Johansen, 1996). A complication arises from the inclusion of the double trend break present in R in the cointegration analysis since the critical values of the rank tests depend on the number and location of break points and the trend specification. Johansen, Mosconi and Nielsen (2000) propose a modification of the standard Johansen model which allows for a piecewise linear trend with known break points. They estimate response surface functions which allow for computing critical values of the rank statistics, and they develop tests for changes in the slope parameters of the deterministic trends. These techniques are implemented in MALCOM (Mosconi, 1998) for RATS[24], which has been used for this study.

23 The respective time series are available on the ECB website www.ecb.int.
24 www.estima.com

Figure 8: One-week Euribor and the MRO-rate, i. e. the rate applied to the fixed rate tenders and the weighted average rate of the variable rate tenders (in percentages)

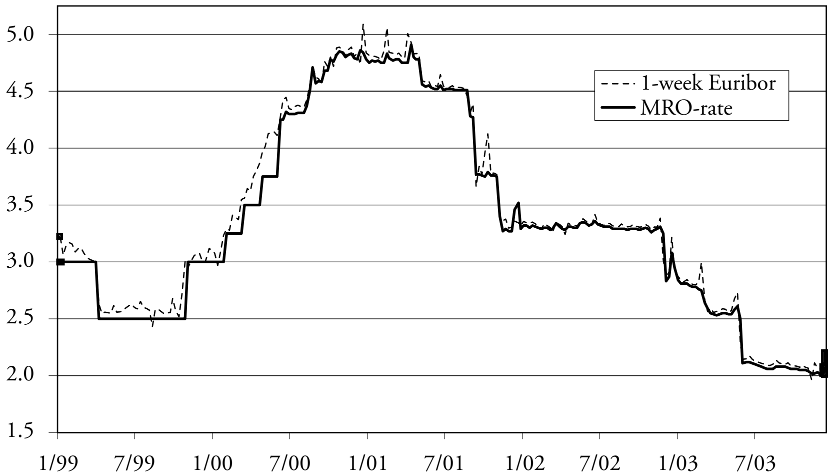
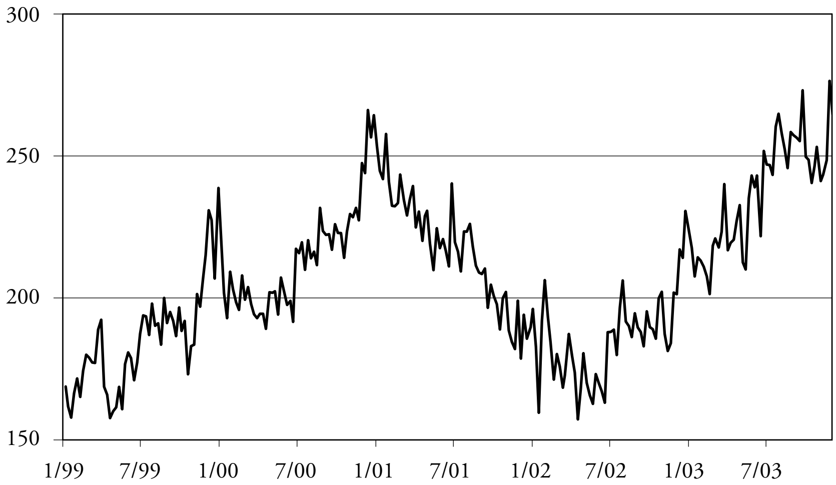


Figure 9: Banks total liquidity needs, i. e. the sum of autonomous factors and required reserves (billion Euro)



Following this approach, we divide our sample into three periods $j = 1, 2, 3$ with length $T_j - T_{j-1}$ $(0 = T_0 < T_1 < T_2 < T_3 = T)$, so that T_1 and T_2 denote the respective breakpoints in December 2000 and April 2002, and estimate the model

$$\Delta X_t = \left(\Pi, \Pi_j\right)\begin{pmatrix} X_{t-1} \\ t \end{pmatrix} + \mu_j + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t \tag{18}$$

for $j = 1, 2, 3$ conditionally on the first k observations of each subsample, where Δ is the difference operator, $X = (e, l, \ln(R))'$ is the vector of the endogenous variables and Π, Π_j, Γ_i, μ_j are coefficient matrices and vectors. The innovations ε_t are assumed to be independently, identically normally distributed with mean zero and variance Ω. Defining appropriate dummy variables, equations (18) can be written as one equation, which facilitates estimation with standard econometric software (Johansen, Mosconi and Nielsen, 2000, p. 29).

Table 2: Maximum Lag Analysis: Information Criteria and p-value for the Modified Godfrey Portmanteau Test

k	Akaike	Hannan-Quinn	Schwartz	Godfrey χ^2_{ar5}
1	−16.244	−16.059	−15.784	0.055
2	−16.165	−15.896	−15.497	0.041
3	−16.088	−15.735	−15.211	0.161
4	−16.064	−15.627	−14.977	0.389
5	−16.016	−15.495	−14.721	0.517

As a first step, we determine the maximum lag k of the vector autoregressive model (VAR). Table 2 reports information criteria for different values of k and the modified Godfrey portmanteau test (Sims, 1980).

The information criteria unanimously suggest a lag length of one. Therefore, $k = 1$ has been selected, since it is also the first lag which gives approximately white noise, as the Godfrey portmanteau test shows. Conventional diagnostic tests do not suggest the presence of serial correlation, heteroscedasticity and ARCH effects in the residuals of the VAR, but the Jarque-Bera tests in Table 3 show that the normality assumption is strongly violated in our model. Residuals for the interest rates are skewed and also leptokurtic which is a typical feature of high frequency financial market data. However, in a comparison of systems cointegration tests, HUBRICH, LÜTKEPOHL and SAIKKONEN (2001) argue that in the case of a non Gaussian data generating process the Johansen approach amounts to computing a pseudo likelihood ratio test which still may have better properties than many competitors.

Table 3: Jarque-Bera Normality Tests (p-values)

Equation	Skewness	Kurtosis	Sk+Kur
One-week Euribor	0.000	0.000	0.000
MRO-rate (avg)	0.000	0.000	0.000
Liquidity requirements	0.048	0.887	0.141

Cointegration appears if (Π, Π_j) in equation (18) has reduced rank so that it can be written as $(\Pi, \Pi_j) = \alpha(\beta', \gamma')$, where α and β are $(p \times r)$ matrices and γ is $(1 \times r)$ with $p = 3$. As can be seen from equation (18), we restrict the linear trend to the cointegration space and thus exclude a quadratic trend in the levels of X_t. The trace test to determine the cointegration rank is reported in Table 4. The test suggests a rank of $r = 2$, which is therefore chosen for the following analysis. Table 5 shows the characteristic roots of the I(0) model ($r = 3$) and the I(1) model ($r = 2$), which corroborate the assumption $r = 2$. In addition, tests for the stability of the cointegration rank and the cointegration space (HANSEN and JOHANSEN, 1992) give satisfactory results.

Table 4: Trace Tests for the Cointegration Rank r

H(0)	Test	p-value
r = 0	230.44	0.00000
r ≤ 1	84.08	0.00000
r ≤ 2	18.63	0.26148

Table 5: Characteristic Roots of the Unrestricted ($r = 3$) and the Restricted ($r = 2$) Models

Root	r = 3	r = 2
1	0.930	1.000
2	0.590	0.590
3	0.165	0.162

Since our model contains two cointegration vectors, we have to impose and test restrictions on the cointegration space in order to identify the cointegration vectors. Therefore, we propose the following normalised (trend-) stationary cointegration relations:

$$e_t = l_t + \beta_{1,3} \ln(R_t) + \beta_{1,4} t + ec_t^e \tag{19}$$

and

$$\ln(R_t) = \beta_{2,4} I_1 t + \beta_{2,5} I_2 t + \beta_{2,6} I_3 t + ec_t^R, \tag{20}$$

where I_j are indicator functions with

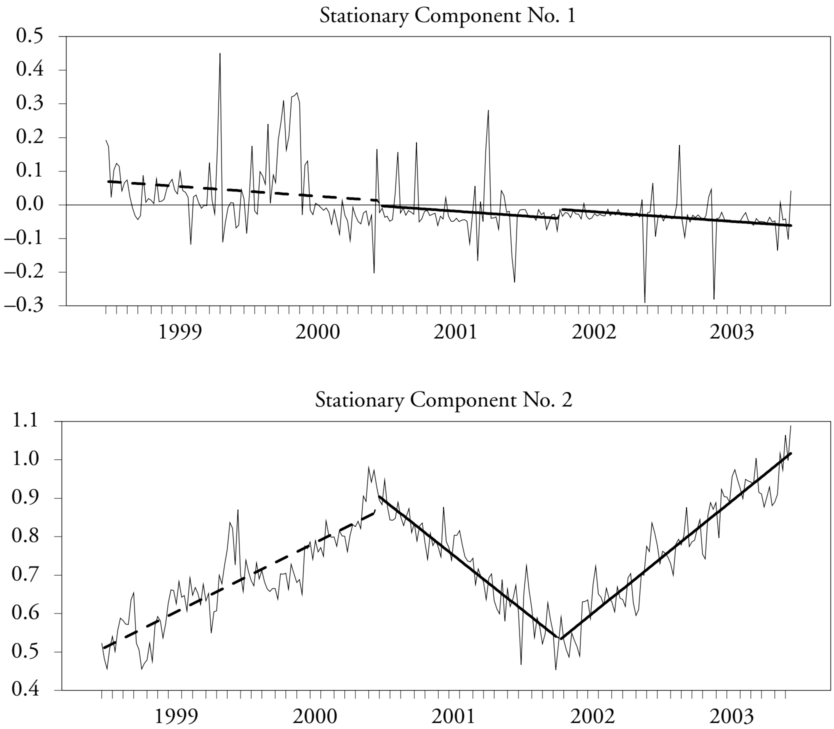
$$I_j = \begin{cases} 1 & \text{for } t = T_{j-1}+1, \dots, T_j, \\ 0 & \text{otherwise,} \end{cases}$$

and ec_t^e, ec_t^R are equilibrium errors. Equation (19) can be interpreted as determining the equilibrium interbank market rate e_t, where we have restricted the coefficient of the central bank rate l_t to be $\beta_{1,2} = 1$ and the linear trend to be constant in all three subsamples, $\beta_{1,4} = \beta_{1,5} = \beta_{1,6}$, while equation (20) restricts R_t to be trend stationary with a piecewise linear trend. The likelihood ratio test for the restrictions embodied in (19) and (20), which is asymptotically $\chi^2(3)$ distributed, is equal to 1.73968 (p-value = 0.62815). Therefore, the restrictions cannot be rejected. The restricted estimates for equation (19) are given by

$$e_t = l_t + \underset{(0.0202)}{0.0846} \ln(R_t) - \underset{(5.5391 \cdot 10^{-4})}{1.0026 \cdot 10^{-4}} t + ec_t^e \tag{21}$$

(standard errors in brackets) and the (undetrended) stationary components along with the piecewise linear trends are given in Figure 10. Thus, the empirical analysis supports the comparative static analysis for the central bank rate and the liquidity needs in equations (11) and (12).

Figure 10: Residuals of the Cointegration Relationships (Undetrended) Along with the Piecewise Linear Trends



Stationary component 1 pertains to the interbank market equation (19) while stationary component 2 pertains to the liquidity requirement equation (20).

5. Summary

For the conduct of monetary policy it is important to know the functioning of the interbank money market and the determinants of the interbank money market rate. In this context, institutional arrangements play an important role. Looking at the euro area, we focus on two specific institutional features. First, the Eurosystem provides the bulk of liquidity via loans to the banking sector. Second, these loans have to be based on adequate collateral, and the costs of holding eligible assets differ across banks.

Developing a simple interbank money market model capturing these aspects, we show that this heterogeneity in the banking sector establishes a further reason for banks to participate in the interbank market, besides the traditional motives which are balancing daily liquidity fluctuations and speculation. The banks' different costs imply that, via the interbank market, banks with relatively low costs act as intermediaries between the central bank and credit institutions with relatively high costs. It should be noted that we focus on different opportunity costs of holding collateral. However, the crucial point is that banks differ in costs of obtaining funds from the central bank, which can also be human capital costs, for example.

Our model shows that a consequence of this intermediation is a positive spread between the interbank market rate and the central bank rate. Our empirical analysis strongly supports a positive spread for the euro area.

With the help of our interbank market model, we derive the following determinants of the interbank market rate: the central bank rate, transaction costs in the interbank market, total liquidity needs of the banking sector, collateral's opportunity costs, and the distribution of the latter across banks. In order to test the comparative static results of our model we perform a cointegration analysis. We identify a long-run relationship between the interbank market rate, the central bank rate and the total liquidity needs of the banking sector. The estimated equation supports our comparative static results.

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Appendix: Testing Eonia and Euribor Spreads for Different Samples

Tables 6 to 8 report one-sided tests of the null hypothesis of a non-positive spread against the alternative of a positive spread using different samples.

Table 6: Tests of a Positive Interest Rate Spread (Daily Data, Special Events Exluded)

	Eonia			1-week Euribor			2-week Euribor
	FT	VT	F+V	FT	VT	F+V	VT
Mean	0.095	0.068	0.076	0.134	0.032	0.062	0.024
(t-stat)	(−14.854)	(−24.926)	(−27.882)	(−16.483)	(−19.331)	(−20.319)	(−11.105)
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N	292	692	984	292	692	984	437

The interest rate data in the first block correspond to the Eonia spread while the second and third block show the one-week and two-week Euribor spread using daily data respectively. Tests are reported for the fixed rate tender period (FT), the variable rate tender period (VT) and for both periods combined (F + V). Two-week Euribor data is only available for part of the variable rate tender period. Each column reports the sample mean, its t-statistic, the p-value of the one-sided test of the null hypothesis $mean \leq 0$ against the alternative $mean > 0$ and the sample size N. During the variable rate tender period the Eonia is compared with the minimum bid rate at the MROs while the Euribor rates are compared with the weighted average MRO rate. All spreads are given in percentage points. Special episodes are excluded for all spreads.

Table 7: Tests of a Positive Interest Rate Spread (Days of Settlement, Special Events Included)

	Eonia			1-week Euribor			2-week Euribor
	FT	VT	F+V	FT	VT	F+V	VT
Mean	0.083	0.080	0.080	0.122	0.034	0.062	0.026
(t-stat)	(−3.907)	(−6.673)	(−7.706)	(−9.514)	(−7.449)	(−20.319)	(−5.430)
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N	76	183	259	76	183	984	115

Table 8: Tests of a Positive Interest Rate Spread (Daily Data, Special Events Included)

	Eonia			1-week Euribor			2-week Euribor
	FT	VT	F+V	FT	VT	F+V	VT
Mean	0.071	0.074	0.073	0.140	0.032	0.064	0.023
(t-stat)	(6.727)	(12.910)	(14.331)	(17.076)	(14.493)	(19.670)	(8.240)
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
N	384	910	1294	384	910	1294	572

SUMMARY

This paper presents an interbank market model with a heterogeneous banking sector. We show that banks participate in the interbank market because they differ in marginal costs of obtaining funds from the European Central Bank. Our model shows that this heterogeneity implies intermediation by banks with relatively low marginal costs. The resulting positive spread between the interbank market rate and the central bank rate is determined by transaction costs in the interbank market, total liquidity needs of the banking sector, costs of obtaining funds from the central bank, and the distribution of the latter across banks.

ZUSAMMENFASSUNG

In diesem Beitrag wird ein Modell des Interbankenmarkts mit heterogenem Geschäftsbankensektor entwickelt. Es wird gezeigt, dass ein Interbankenmarkt entsteht, wenn sich die Grenzkosten der Kreditbesicherung bei der Europäischen Zentralbank zwischen den Geschäftsbanken unterscheiden. Die Heterogenität im Bankensektor impliziert, dass Banken mit relativ niedrigen marginalen Besicherungskosten als Intermediäre fungieren. Die dafür notwendige positive Differenz zwischen dem Interbankenmarktzins und dem Zentralbankzins wird durch die Transaktionskosten im Interbankenmarkt, den aggregierten Liquiditätsbedarf des Bankensektors, die Besicherungskosten sowie deren Verteilung über die Banken bestimmt.

RÉSUMÉ

Cet article développe un modèle d'un marché interbancaire dans le cadre d'un secteur bancaire hétérogène. Ce modèle démontre qu'un marché interbancaire se développe lorsque les coûts marginaux inhérents à l'obtention de fonds de la Banque Centrale Européenne diffèrent d'une banque à l'autre. Cette hétérogénéité conduit à ce que les banques dont les coûts marginaux sont relativement bas fassent fonction d'intermédiaire. La hauteur de la différence positive nécessaire pour ce entre le taux d'intérêt du marché interbancaire et le taux d'intérêt de la banque centrale est déterminée par les coûts de transaction sur le marché interbancaire, la totalité des besoins en liquidité du secteur bancaire, les coûts inhérents à la réception de fonds de la banque centrale ainsi que par la distribution de ces derniers entre les banques.