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ECB WORKSHOP ON THE ANALYSIS OF THE MONEY MARKET

WORKING PAPER SERIES
NO 981 / DECEMBER 2008

WHY THE EFFECTIVE PRICE FOR MONEY EXCEEDS THE POLICY RATE IN THE ECB TENDERS?

by Tuomas Välimäki

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WHY THE EFFECTIVE PRICE FOR MONEY EXCEEDS THE POLICY RATE IN THE ECB TENDERS?[1]

Tuomas Välimäki[2]

In 2008 all ECB publications feature a motif taken from the €10 banknote.

This paper can be downloaded without charge from http://www.ecb.europa.eu or from the Social Science Research Network electronic library at http://ssrn.com/abstract_id=1310618.

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ECB WORKSHOP ON THE ANALYSIS OF THE MONEY MARKET

On 14 and 15 November 2007, Alain Durré, Huw Pill and Diego Rodriguez-Palenzuela of the ECB's Monetary Policy Stance Division organised a central bank workshop titled "The Analysis of the Money Market: Role, Challenges and Implications from the Monetary Policy Perspective". This workshop provided an opportunity for participating central bank experts to exchange views and foster debate, also in interaction with international organizations and academic institutions. The first day of the workshop addressed issues related to the macro-perspective of the money market, drawing on the experiences of a large number of countries. The second day adopted a micro-perspective on the money market, looking in particular at trading behaviour in the overnight money market and its implications for the evolution of spreads.

A first version of this paper was presented at this workshop. The papers presented at the time of the workshop did not consider the potential implications of the financial turmoil for the results of the paper, given that the tensions in money markets emerged in August 2007. The published version of these papers represents an update of the original paper, which incorporates the discussion which took place at the workshop and in most cases a discussion on the developments in the money markets since August 2007.

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CONTENTS

Abstract

The tender spread, i.e. the difference between the effective price for money in the ECB's main refinancing operations and the prevailing policy rate, is one of the main determinants behind the evolution of the EONIA with respect to the ECB's operational target. This study assesses the reasons for which the average tender spread did not reduce after the banks' demand for liquidity was isolated from their interest rate expectations in March 2004. The paper offers two potential explanations for the unexpected behavior. First, following the increased precision in the ECB's liquidity provision after the end-of- period fine tuning operations were added to the regularly applied tools, even a small bias in the liquidity supply could have resulted in a strictly positive tender spread. Second, banks' uncertainty over their individual allotments in the tender operations may have led to a strictly positive tender spread. Furthermore, the significant growth in the refinancing volumes may have intensified the allotment uncertainty.

Keywords: main refinancing operations, liquidity, EONIA, tenders

JEL Classification: D44, E58

Non-Technical Summary

The interbank overnight rate is the focal point of the money markets, as it is the starting point of the term structure of interest rates. The importance of the overnight market is further emphasized by the fact that the overnight rate is widely used as an operational target for the monetary policy implementation. To interpret correctly the information contained in the evolution of the overnight rate, one needs to understand all relevant determinants affecting this rate. This study analyzes the behavior of the difference between the effective price for money and the monetary policy steering rate (the tender spread) in the euro area. The tender spread is one of the key drivers behind the evolution of the EONIA with respect to the policy rate.

Previously, it has been shown that, banks' expectations on intra reserve maintenance period changes in the official interest rates result in a non-zero average tender spread. In March 2004, the timing of the reserve maintenance periods was adjusted so that possible rate changes now coincide with the change of the periods. This should have isolated banks' demand for central bank reserves form their interest rate expectations. Whereas the stability of the shortest rates was improved after the March 2004 reform, the tender spread did not vanish. Contrary to ex ante expectations, the mean difference between the effective price for money and the ECB policy rate was wider in 2005 and 2006 than in any single year after 2000, when the ECB switched from fixed to variable rate liquidity tenders.

This paper offers two explanations for the unexpected behavior of the effective tender rate. First, the interest rate elasticity of the demand for liquidity in the final central bank operation has decreased considerably after the ECB has de facto added final day fine tuning operations to its regularly used procedures. When this is combined with the ECB's quantity oriented liquidity policy, it is possible that even a small bias (genuine or perceived) in the liquidity supply may result in a strictly positive tender spread. Second, we argue that banks' risk aversion and money market inefficiencies may result in a strictly positive tender spread even, if the central bank liquidity supply was unbiased and the banks did not anticipate any intra period rate changes. Here, the driving force behind the tender spread would be uncertainty over the individual allotments in the ECB operations. Furthermore, we show that the maximum spread resulting from this kind of allotment uncertainty is positively related to the refinancing volumes that were doubled in the March 2004 reform.

1 Introduction

The Governing Council of the European Central Bank (ECB) sets the Eurosystem monetary policy by determining once a month the level for three official interest rates. Currently, *the minimum bid rate* is the key policy rate for signalling the monetary policy stance. This is the reserve price applied in the weekly tender operations (*main refinancing operations, MRO*) by which the ECB provides the money market with liquidity (*central bank reserves*). The other two rates determined by the Governing Council - marginal lending rate and the deposit rate - are applied to the standing facilities (*marginal lending and deposit facility*). Yet, the standing facility rates are not independent from the policy rate, as normally the interest rate corridor that results from these two rates has been set symmetrically around the minimum bid rate.[1] The purpose of this paper is to study the differences between the shortest market rates of interest and the key policy rate, and to analyze the reasons for which the effective price of liquidity (*marginal MRO rate*) in the central bank tender operations may differ from the key policy rate.

In addition to announcing the official rates, the central bank needs to conduct market operations (i.e. steer the market liquidity by buying and selling central bank reserves) to guide the market rates to the desired level. The operational target for the ECB's monetary policy implementation has never been expressed explicitly like e.g. the Fed Funds target rate in the US. However, it is quite clear that the aim of the ECB's liquidity policy has been to stabilize the shortest market rates to a level close to the key policy rate. Furthermore, the ECB has published the way it calculates its benchmark allotments in the main refinancing operations. This amount serves as the basis for decisions over the actual liquidity injections. Basically, this volume is calculated so that with it banks' use of the standing facilities is minimized, and they can fulfill their reserve requirements smoothly over the reserve maintenance period. Moreover, it can be shown that with the benchmark allotments the expected money market rate equals the policy rate, as long as the money market is efficient, the interest rate corridor is symmetric around the policy rate, the distribution of liquidity shocks is symmetric, and the interest rate is assumed to be constant over the remainder of the ongoing reserves maintenance period. Therefore, it should be possible to assess the precision of the ECB's monetary policy implementation directly by the size and especially by the stability of the spread between the shortest market rates and the key policy rate.

According to the evidence gathered between January 1999 and July 2007, the Eurosystem has been rather successful in achieving a small and stable spread. The average difference between EONIA and the minimum bid rate (henceforth, the EONIA spread) was 7 basis points (bps), and its standard deviation was

[1] That is, the Eurosystem has provided the banks with an opportunity to borrow overnight liquidity at the policy rate + 1%, as well as to deposit their excess liquidity with the Eurosystem at a policy rate - 1%. Therefore, these rates in practise constitute an effective ceiling and a floor to the 'corridor', in which the interbank overnight rate may fluctuate.

some 15 bps during the period in question.[2] As a comparison, the average spread between the Fed funds rate and the Fed funds target rate was 1 bps with a standard deviation of 10bps, while the standard deviation of the spread between SONIA and the base rate in UK was some 40bps.

There are several reasons for which the shortest market rate may deviate from the policy rate. Some of these relate to the different specifications applied in the market transactions and the policy operations.[3] These factors consist a 'natural spread', which is not relevant for policy making. Furthermore, as a constant spread between the policy rate and the market rates could be easily taken into account in the determination of the appropriate level for the key policy rate, the stability of the spread is likely to be more of interest to the policy marker. The clarity of the monetary policy signals conveyed by the operational framework increases with the stability of the spread. In this regard, the performance of the monetary policy implementation of the ECB has improved over time. Whereas, the standard deviation of the EONIA spread was some 15 bps between Jan 1999 and July 2007, the annual figures for this volatility measure reduced quite steadily from 23 bps in 2001 down to less than 5 bps in 2006.

The increase in the stability of the EONIA spread after 2003 may largely be attributed to the reform of the Eurosystem's operational framework in March 2004. On that occasion, banks' daily demand for liquidity was isolated from expectations over changes in the official central bank rates. This effect was achieved by synchronizing the timing of the reserve holding periods with the timing of changes to the official interest rates. Prior to the reform, banks' demand for liquidity increased (decreased) substantially when they expected the central bank rates to be raised (cut) during the rest of the reserve maintenance period. This effect should have vanished since March 2004 reform, as the central bank rates are now constant within a reserves maintenance period. Furthermore, it can be shown that the effect of the expected interest rate changes on the demand for liquidity results in asymmetric market rate reactions, when the banking sector operates in a liquidity deficit vis-a-vis the central bank. Whereas an expected rate hike increases the market rates, these rates do not reduce when the central bank rates are expected to be cut.[4] Therefore, the average spread

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[2] To calculate this difference, we used the mid point of the interest rate corridor to approximate the minimum bid rate for days at which the MROs were not conducted.

[3] For example, whereas EONIA is based on uncollateralized loans, the policy operations are conducted as reverse transactions, i.e. the central bank liquidity provision is fully collateralized. Therefore, the EONIA contains a credit premium compared to the policy rate. Furthermore, as the maturity of the policy operations (one week) is longer than overnight, the per annum level of the policy rate should be slightly higher than EONIA for these two rates to match effectively.

[4] It's quite easy to show that when a liquidity providing central bank follows a quantity oriented liquidity policy (like the ECB's benchmark allotments), the shortest market rate reacts asymmetrically to banks' expectations about interest rate cuts and hikes. When a rate hike is expected within the remainder of a reserve maintenance period, the shortest money market rate increases above the policy rate due to the increase in banks' demand for liquidity. Yet, the overnight rate does not fall below the policy rate in an anticipation of a rate cut. This results from the fact that, whereas the central bank's liquidity provision is immune to banks' increased demand before a rate hike, banks can reduce the injection of liquidity, when

between the shortest market rate and the policy rate should have reduced after the reform.

While the volatility of the spread fell after the March 2004 reform from 16bps (Jun 2000-Mar 2004) down to 7 bps (March 2004- July 2007), this does not (contrary to the ex ante expectations) seem to be the case for the level of the spread. The average spread was 6,9 bps between April 2004 and July 2007 compared to 7,2 bps between 23 June 2000 and March 2004. Furthermore, it can be shown that the unexpected development in the mean spread did not result from increases in the natural spread. It seems that the behavior of the EONIA spread accounts for the development in the difference between the effective price for liquidity and the key policy rate.[5]

This paper aims at explaining the reasons for this phenomenon - i.e. why the observed increase in stability of banks' demand for liquidity is not reflected in the average EONIA spread. We need to understand the determinants behind the behavior of the EONIA spread for two reasons. First, changes in the very short market rates do not have real effects when they are short lived and result from stochastic liquidity shocks. However, once the changes are longer lasting or reflect changes in the liquidity policy, they will be transmitted to interest rates with longer maturities, and consequently they start to interfere with the monetary policy stance. Second, the central bank needs to identify the underlying factors for the difference between the effective price for liquidity and its policy rate. Otherwise, it cannot use liquidity policy to correct any misalignments in the monetary policy transmission.

This study falls into the literature on the ECB monetary policy implementation, as it touches the neutrality of the ECB liquidity policy, and the bid behavior of the banks. The ECB liquidity policy is also analyzed e.g. in Ayuso and Repullo (2003), Bindseil (2002), and Välimäki (2003 a, b and c).[6] Ayuso and Repullo argue that the ECB prefers to see the market rates deviating upwards

they anticipate a rate cut. In such a case, banks merely hold back their bids in the liquidity providing tender operations, and consequently the equilibrium liquidity will correspond to the reduced demand for reserves. Furthermore, it can be shown that, if the policy operations are overlapping (as the ECB operations were until the March 2004 reform, when the ECB also cut the maturity of the weekly operations from two weeks down to one week), the equilibrium overnight rate will be above the prevailing policy rate also prior to an expected rate cut (see Välimäki, 2003c.

[5] This can be evidenced e.g by splitting the EONIA spread in two parts: EONIA - Marginal MRO rate and Marginal MRO rate - minimum bid rate. The difference between EONIA and the Marginal MRO rate should contain all elements of the natural spread, while the difference between the effective price of liquidity and the policy rate (i.e. the spread between the marginal MRO rate and the minimum bid rate, henceforth, *tender spread*) reflects factors that are either linked to expectations on the liquidity policy or related to the design of the operations. EONIA exceeded the marginal MRO rate by 4.3bps on average prior to the March 2004 reform, while the average difference has been 4,6bps since then.

[6] In addition to these papers, questions related to the monetary policy framework of the Eurosystem, and the ECB's liquidity management style are analyzed e.g. in Ejerskov, Moss & Stracca (2003), Ewerhart (2003), Ewerhart et al (2004) and Moschitz (2004). Furthermore, Würtz (2003) presents a comprehensive EONIA model. Banks bidding in the ECB operation has been studied empirically e.g. in Scalia and Ordine (2005), Nyborg et al (2002) and Linzert et al (2004).

from the policy rate rather than downwards. Due to this claimed asymmetry, the ECB holds back its liquidity provision, which results in a positive spread between the market rate of interest and the policy rate. In addition to the central bank preferences, tight liquidity conditions may result from a combination of quantity oriented liquidity policy and banks interest rate expectations, as shown in Bindseil (2002) and Välimäki (2003a and b). Our paper will go one step further by showing that the liquidity conditions may appear tight even under static interest rate expectations, if the liquidity policy is quantity oriented and the money market is not perfect.

Taking into account the evidence that the liquidity supply of the ECB has not become tighter with regard to the liquidity demand stemming from the autonomous liquidity factors and reserve requirements, this paper presents two competing justifications for the continuation of the non-zero tender spread. First, even if the supply of liquidity has not reduced, the liquidity conditions could have become tighter due to changes in the interest rate elasticity of the demand for liquidity. We will show that changes in the second moment of the liquidity shock distribution (uncertainty over the forthcoming liquidity conditions) determine the elasticity of the demand for liquidity. Therefore, we argue that banks' demand for liquidity could have been affected by the changes in the liquidity uncertainty following first the lengthening of the period between the last MRO of a given reserve maintenance period and the final day of that period, and later as a result of the initiation of the policy to fine tune liquidity imbalances on the final day of each reserve maintenance period.[7]

Second, banks' demand for liquidity may have been affected by changes in the (un)certainty over the individual allotment volumes in the MROs at the marginal rate. That is, we will argue that paradoxically the ECB's increased control over the shortest market rates, which is reflected as lower volatility of the short market rates, may have increased banks' incentives to bid at rates that exceeding the expected marginal MRO rate. According to this argument, banks are ready to pay an insurance like premium for the liquidity provision in order to avoid uncertainty over the allotment volume. This may result in a situation where *banks' expectations over the behavior of the marginal MRO rate becomes the main factor driving the equilibrium rate.*

The rest of the paper is structured as follows. First, we present a brief introduction to the functioning of the operational framework of the Eurosystem. Section 3 presents some stylized facts on the evolution of the market rates as well as the tender rates in the euro area. The two competing motivations for the behavior of the tender spread will be developed in Section 4, while Section 5 makes the first assessment on the relevance of these factors explaining the

[7] Whereas the number of days between the allotment decision of the last MRO of a given reserve maintenance period and the end of the period varied between 2 and 8 days before the March 2004 reform, it has been 8 days for each period since the changes took place. However, the increase in uncertainty over the end-of-period liquidity conditions following this lengthening of the period was compensated by a more active attitude towards liquidity fine-tuning taken by the ECB. That is, a rather small expected end-of-period liquidty imbalance triggers nowadays a final day fine tuning operation. Hence, final day fine tuning operations is almost a regular feature of the current operational framework.

spread. Finally, conclusions will be presented in Section 6.

2 The monetary policy implementation framework

Recently, the central banks whose operational target is in the short-term money market rates have started widely to implement their monetary policy through frameworks in which banks' demand for liquidity is created or enlargened by reserve requirements, and the interbank overnight rate is steered by open market operations within an interest rate corridor set by two standing facilities. The Eurosystem was one of the first central banks to apply such a framework. We will next go briefly through the intuition behind the framework of the Eurosystem.

2.1 Reserve requirements, standing facilities and the determination of the overnight rate

In the euro area banks are required to hold reserve requirements with the Eurosystem. Whereas all deficiencies from the minimum reserve holdings are sanctioned by a penalty rate, the reserves banks hold in excess of their requirements will not be remunerated. Furthermore, the Eurosystem facilitates the banks' liquidity management by providing them with two standing facilities. First, banks can avoid reserve deficiencies by obtaining overnight reserves from the central bank's marginal lending facility. Although, the marginal lending rate (r^{ml}) is set above the policy rate, it is well below the penalty rate applied to the reserve deficiencies ($r^{policy} < r^{ml} < r^{penalty}$). Moreover, banks can avoid having unremunerated reserves, by placing their excess funds into the central bank's deposit facility, the rate of which (r^{d}) lies below the monetary policy steering rate ($0 < r^{d} < r^{policy}$). Due to the unlimited access to these two facilities,[8] banks do not have incentives to trade with each other at rates outside the corridor set by the marginal and deposit rates.

The Eurosystem provides banks with an averaging scheme for the holding of the required reserves. That is, compliance with the reserve requirement is judged by banks' average end-of-day reserves balances over a reserves maintenance period (RMP). In case of the Eurosystem this period is nowadays normally 4 or 5 weeks depending the frequency of the Governing Council meetings. Due to the averaging provision, reserve holdings on one day of a RMP are substitutes for holdings on other days within the same period. Yet, on the final day of each period the remaining requirement (i.e. the unfulfilled amount) naturally becomes binding. On this day banks (on aggregate terms) need either to use the marginal lending or deposit facility depending on whether the aggregate liquidity exceeds or is below the remaining requirement. As long as there is uncertainty over the development of the liquidity situation during the rest of the day, the

[8] Note however that the borrowing from the marginal lending facility is based on adequate collateral. Otherwise, banks may use these facilities on their own initiative and without limits.

interbank rate is a probability weighted average of the standing facility rates. So, the final day (T) overnight rate (r_T) is a decreasing function of liquidity, and its expected value depends on expected liquidity conditions and standing facility rates prevailing on that day.

$$\begin{aligned} r_T &= p_T r_T^{ml} + (1 - p_T)\, r_T^d, \qquad (1) \\ &\text{where } p \text{ is the probability reserve deficiency} \end{aligned}$$

On other days of a *RMP*, the demand for liquidity is more elastic due to the averaging provision. However, the averaging provision is limited by the fact that the Eurosystem does not allow negative end-of-day balances on any day. Therefore, overdrafts must always be covered by marginal lending. Furthermore, a bank may use the deposit facility prior to the final day of the *RMP* to obtain some remuneration on its central bank balances in case it has already fulfilled the reserve requirement for the entire maintenance period. So, the overnight rate for days prior to the final day is a function of the current marginal lending and deposit rates and the expected overnight rate during the remaining period, as well as the probabilities at which banks will be overdrawn during that day, possess reserves exceeding the remaining requirement for the whole period or merely use their funds to fulfill the reserve requirement (which consequently reduces the need to hold balances on the following days). Let's denote the probability at which the banks need to use the marginal lending facility on day t by p_t, and the probability of using the deposit facility by k_t. The overnight rate can be determined as a probability weighted average of these rates, as follows:

$$r_t = p_t r_t^{ml} + k_t r_t^d + (1 - p_t - k_t)\, \mathrm{E}\left[r_T\right].$$

The benchmark liquidity provision is determined so that with the benchmark allotment the final day use of the standing facilities is minimized (hence, $p_T = 0.5$ assuming symmetric liquidity shock distribution). Therefore, the expected overnight rate for the final day equals the mid-point of the interest rate corridor, i.e. $\mathrm{E}[r_T] = 0.5(r_T^{ml} + r_T^d) \equiv r^{mid}$. Moreover, in Eurosystem framework the minimum reserve holdings have been manyfold compared to the standard deviation of the liquidity shocks. So, it is likely that both p_t and k_t are negligible as long as the benchmark liquidity policy is followed, and $t < T$. In such a case, the overnight rate on any day of the *RMP* should equal the rate expected for the final day ($r_t = \mathrm{E}[r_T]\,, \forall t = 1, ..., T$). In literature this behavior is often been referred to as *martingale hypothesis*. Empirical evidence supporting the martingale hypothesis for the euro area can be found e.g. in Würtz (2003) and Moschitz (2004).

2.2 Supply of liquidity and banks behavior in ECB tender operations

The euro area banking sector operates in a liquidity deficit vis-a-vis the Eurosystem.[9] This liquidity need is satisfied mainly by two types of open market operations. By longer term reverse operations (LTRO) the ECB provides the market with central bank reserves for the period of three months. These operations do not serve any monetary policy purposes. Therefore, they are conducted as pure variable rate tenders with pre-announced allotment volumes, so that the ECB is a rate taker in the operations. The function of signalling the monetary policy stance is left to the main refinancing operations (MRO) by which the ECB covers the bulk of banks' liquidity needs. MROs were conducted as fixed rate tenders[10] until June 2000, when the tender format was changed to variable rate tenders.[11] The ECB has applied a pre-announced reserve price for liquidity (*minimum bid rate*) in the MROs conducted as variable rate tenders. This rate replaced the fixed tender rate as the key policy rate to the current monetary policy stance of the ECB (ECB, 2000b).

The minimum bid rate has always been set to the mid-point of the interest rate corridor created by the standing facilities. This used to be the case also for the fixed tender rate since April 1999. We will call the situation in which the standing facility rates are merely set so that the mid-point of the corridor equals the key policy rate (i.e. they do not have as independent signalling function) a symmetric corridor.

The ECB's liquidity provision in the last MRO of a *RMP* is based on the benchmark allotment, which aims at precisely covering the banks' remaining need for reserve balances (ECB, 2002). As long as the liquidity shock distribution is symmetric, this means that the expected probability of using the marginal lending facility equals that of the deposit facility, and the expected overnight rates between the last allotment and the end of the *RMP* equal the mid-point of the corridor. Consequently, if the minimum bid rate exceeded the mid-point in the last MRO, banks would not be willing to bid for the whole benchmark amount. Therefore, the mid-point of the corridor is the maximum value for the policy rate in the last operation of a *RMP*. In contrast, the ECB could set the minimum bid rate below the mid-point of the corridor and still allot according to the benchmark rule. Yet, in such a case banks' competition over the benchmark allotment volume would result in the effective price of liquidity increasing above the minimum bid rate. Thus, the minimum bid rate can fulfil its function as the key policy rate only when the interest rate corridor is set symmetrically

[9] Basically this means that the liquidity supplied by foreign exchange reserves and other financial assets does not cover the demand created by the banksnotes in circulation and minimum reserve requirements.

[10] In a fixed rate tender, each bank tells the central bank how much liquidity it is willing to borrow at the pre defined tender rate. When the cumulative bid amount exceeds the allotment volume, the central bank allots each bank only a proportion of its bid (i.e. pro-rata rationing is applied).

[11] Multiple rate auction procedure (also known as discriminatory price or american auction) is applied in the ECB's main refinancing operations conducted as variable rate tenders.

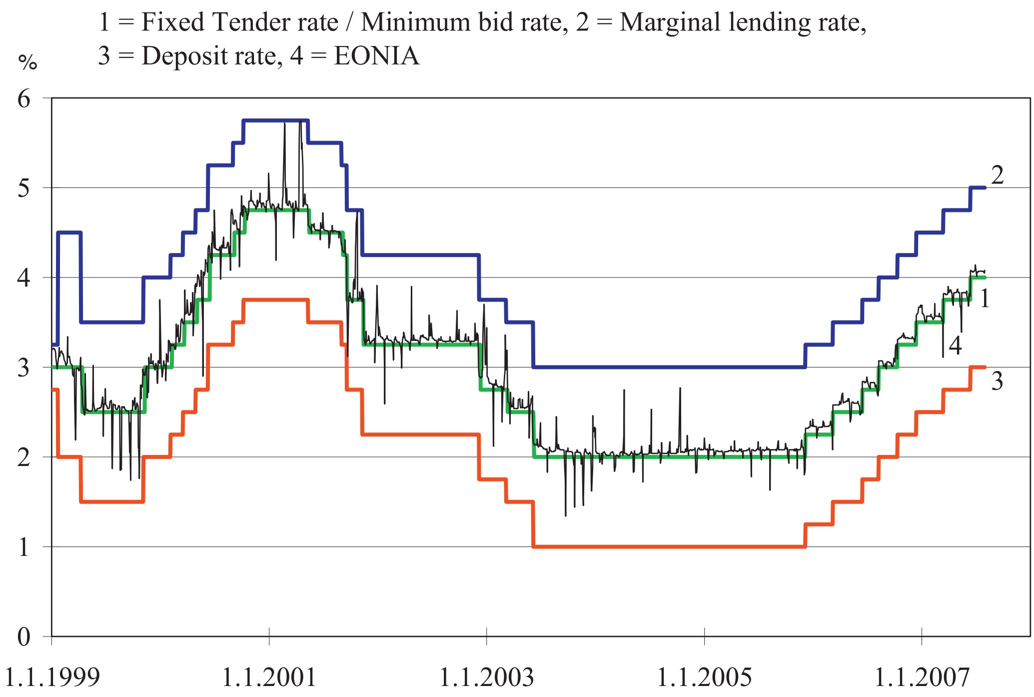
around it in the final MRO of a *RMP*. In such a case, the marginal MRO rate (i.e. the effective tender rate) should equal the minimum bid rate, as long as the banks are risk neutral and the money market is efficient.

In the earlier MROs, the symmetry of the corridor around the policy rate is not a sufficient condition for shortest money market rates to be tied to the level of the prevailing key policy rate. Due to the martingale property of the overnight rates, it is the mid-point expected to prevail at the final day of the period that gives the expected value for the all overnight rates within the same period, if the benchmark liquidity policy is followed. Therefore, the expected market rate of interest exceeds the current minimum bid rate, if the official rates (i.e. the standing facility rates and the key policy rate) are expected to be raised within the *RMP*. In such a case, banks raise their bid rates in the tender operations (up to the level of the expected market rate), so that the there is no opportunity to make excess profits from the central bank liquidity provision. In contrast, the current minimum bid rate exceeds the expected end-of-period mid-point of the corridor, if the official rates are expected to be cut during the remaining *RMP*. Banks would not be willing to borrow from the central bank, if the expected price of liquidity was lower at the interbank market. Hence, the central bank would not be able to allot according to the benchmark rule, when banks expected the official rates to be cut. In such a case, banks would 'underbid' the central bank operation. That is, the liquidity provision would drop to a level at which the expected market rate equals the current minimum bid rate. Furthermore, it can be shown that, if the policy operations are overlapping (as they were in the ECB operations until the maturity of the weekly operations was cut from two weeks to one week in the March 2004 reform), the equilibrium overnight rate exceeds the minimum bid rate also prior to an expected rate cut (Välimäki, 2003c).

To sum up, with the quantity oriented benchmark allotment rule used by the ECB, the expected overnight rate equals the key policy rate only when the official rates are expected to be kept constant in the near future. However, a quantity oriented liquidity policy results in an asymmetric development of the market rates, if the demand for liquidity is affected by the very short term expectations on changes in the central bank rates. Whereas the expected overnight rate exceeds the policy rate whenever the rates are expected to be raised within a *RMP*, it does not fall below the policy rate when a rate cut is anticipated. The March 2004 reform in the operational framework of the Eurosystem aimed precisely at stabilizing banks demand for liquidity, which would naturally stabilize the overnight rate as well as remove the asymmetry.

In the next section, we take a brief look at the stylized facts on the Euro area experience. We will see, whether or not the shortest market rates have stabilized and has the spread between the effective and official price for liquidity narrowed after the March 2004 reform.

Figure 1: The EONIA and the official ECB rates



Source: Bank of Finland

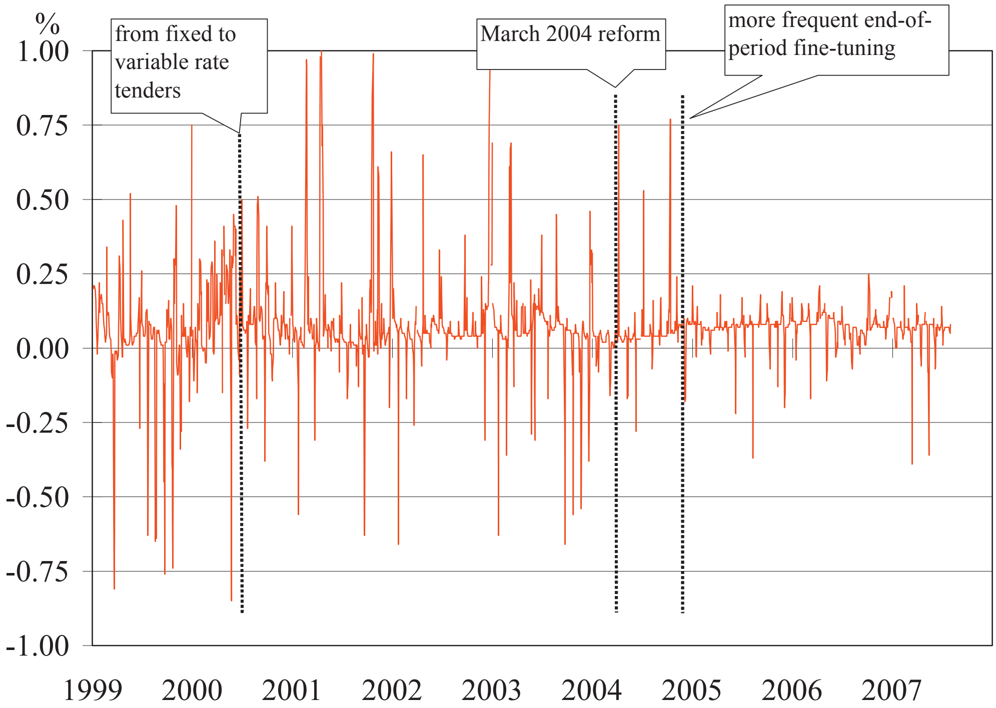
3 Stylized facts on euro short-term interest rates

This section recalls some stylized facts from the shortest money market rates for the euro. The official ECB rates (i.e. the minimum bid rate/fixed tender rate, marginal lending rate and the deposit rate) are shown in Figure 1 together with the EONIA. It's easy to see that the interest rate corridor has been effective in containing the volatility of the interbank overnight rate, as the EONIA has never exceeded the marginal lending rate or fallen below the deposit rate. Furthermore, the EONIA has quite closely followed the key policy rate (either the fixed tender rate or the minimum bid rate), except at the end of each reserve maintenance period, when there seems to be a considerable spike (either positive or negative) in the EONIA spread. Yet, the existence of the end of maintenance period spikes is merely a built in feature in monetary policy implementation frameworks in which the averaging provision is applied to the holding of reserves.

3.1 EONIA spread

To have a clearer view on the development of the EONIA, we divide the total period (January 1999-July 2007) in three sub-periods that reflect the two most

Figure 2: The EONIA spread: EONIA - key policy rate



significant adjustments in the operational framework of the ECB (see Figure 2). The first period (January 1999-June 2000) covers the period at which the MROs were conducted as fixed rate tenders. The second period starts from the switch to the variable rate tender procedure, and it continues until the March 2004 reform. During both of these first two subperiods, all changes to the official rates were made within the reserve maintenance periods. This is not the case for the third period (March 2004- July 2007) that starts from the reform that adjusted the reserve maintenance periods to be in line with the monthly interest rate decisions of the Governing Council.[12]

As stated already in the introduction, the volatility of the EONIA spread has reduced since the changes to the operational framework, but the average EONIA spread does not differ significantly between any of the three subperiods in question (Table 1). The standard deviation of the EONIA spread was 19 bps when the MROs were conducted as fixed rate tenders. It decreased slightly (to 16 bps) on the second subperiod, and more than halved between the second and the third subperiods (standard deviation was 7 bps between March 2004 and July 2007). Meanwhile, the average EONIA spread was recorded at 6, 7 and 7 bps.

Table 1: EONIA spread and its volatility in basis points

[12]Note that also the maturity of the MROs was shortened from fortnight to one week on this occasion.

	All observations		Omitting last weeks		During last weeks	
	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Period 1	5.7	18.9	9.9	11.5	-8.4	29.9
Period 2	7.3	16.2*	7.9*	10.2*	5.3*	28.1
Period 3	6.8	7.1*	7.3	2.8*	5.2	13.8*

A statistically significant change between consecutive periods is indicated by an asterisk.

The considerable reduction in the volatility of the EONIA spread after the March 2004 reform may be resulting from two (partly) independent factors. First, banks' demand for liquidity should have stabilized between the second and the third periods due to the alignment of the changes of the reserve maintenance periods with the changes in the official interest rates. So, speculation over the Governing Council interest rate decisions should not have affected the shortest money market rates any longer after March 2004. Second, the stochastic end of the reserve maintenance period interest rate spikes should have become smaller after the accuracy of liquidity supply was improved by the ECB activating its end-of-period fine-tuning policy.

One may estimate the weight these two factors have on the reduction in the volatility of the EONIA spread by studying the evolution of the spread separately for the final weeks of the reserve maintenance periods on one hand, and for the time series where the final week observations are omitted on the other hand. Whereas banks' expectations over the official central bank rate changes will affect the demand for liquidity before the final MRO allotment (i.e. approximately only before the last week of a reserve maintenance period), the accuracy of the liquidity supply should affect only the volatility of the overnight rate after this operation. Therefore, we take a reduction in the final week's EONIA volatility as an indication of an effect stemming from the increased accuracy of the liquidity supply. Similarly, a reduction in the volatility during the earlier part of the period is seen to be a result of increased stability of the demand for liquidity.

When we drop the last weeks of the maintenance periods from the samples, the standard deviation of the EONIA spread is 11, 10 and 3 bps for the three subperiods respectively, while the standard deviations for final weeks' EONIA spread are 30, 28 and 14 bps.[13] So, the reduction in the volatility of the EONIA spread following the March 2004 reform seems to reflect both a considerable stabilization in the banks' demand for liquidity and a significant improvement in the accuracy of the end-of-period liquidity supply.

[13] Note that, the March 2004 reform did not initially reduce the end-of-period volatility. On the contrary, the growth in the number of days between the last MRO allotment and the end of the period deteriorated the accuracy of liquidity supply at first. However, the change in the fine tuning policy that followed quite soon after the reform seemingly reduced the final day EONIA spreads. This can be evidenced by studying the average absolute EONIA spread from the final banking day of each reserve maintenance period. The figure was 32 bps before March 2004, while it has been 16 bps since the reform, and merely 11 bps since the start of the more active fine-tuning policy.

Turning to the average EONIA spread, one may observe that the average spread during the three subperiods were 9.9, 7.9 and 7.3 bps, when the final week of each reserve maintenance period is not taken into account, and -8.4, 5.3 and 5.2 bps during the final weeks. The difference in the mean spread between the second and the third subperiods is not statistically different for the final weeks nor for the earlier days in the *RMP*. The significant changes in the mean spread after the switch to the variable rate tender procedure (i.e. between 1st and 2nd subperiods) probably reflect the fact that during a large part of this period interest rate hike expectations were prevailing, and the increased demand probably affected also the supply of liquidity.[14]

As the evidence on the development of the volatility of the EONIA spread meets our ex ante expectations, we turn our focus now to the unanticipated development in the mean spread. The fact that the average EONIA spread has not decreased after the March 2004 reform could be a result of an increase in the natural part of the spread, it may be a caused by tighter liquidity supply (compared to the demand), or it can be related to specifications of the operational framework. In the next section, the EONIA spread from the period with variable rate tenders will be split in two components to demonstrate that it is indeed the policy part of the spread that has behaved contrary to the ex ante expectations.

3.2 Tender spread

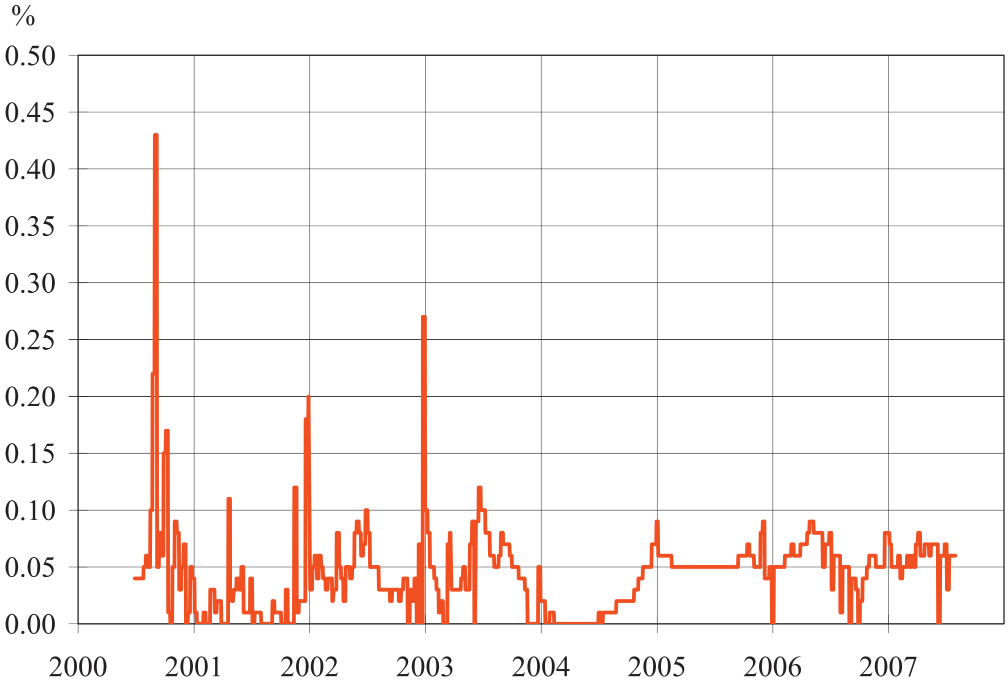
By *tender spread* we henceforth refer to the difference between the marginal MRO rate and the minimum bid rate. This spread can never be negative, and a non-zero spread means that the effective price of central bank reserves is higher than the price indicated by the key policy rate. Furthermore, a strictly positive tender spread indicates that there could be policy related factors behind the tender spread, as the equilibrium spread is zero, if the interest rate expectations are static within a reserve maintenance period, benchmark liquidity is allotted, money markets are efficient and banks are risk neutral.

As the marginal MRO rate is the lowest price at which banks may receive funds from the ECB, the tender spread is naturally transmitted directly to the EONIA spread. The rest of the EONIA spread (EONIA - marginal MRO rate) is related to the 'natural' causes for the spread (e.g. differences in maturities, collateralization, etc.), or - especially after the last central bank operation for a given reserve maintenance period - to liquidity shocks (i.e. unexpected developments in the autonomous liquidity factors) that may change the aggregate liquidity conditions.

The tender spread from the ECB's main refinancing operations carried out as variable rate tenders is shown in Figure 3. The spread has stabilized significantly after the March 2004 reform: the standard deviation of the spread was 5.0 bps before the changes and 2.4 bps after it. This confirms that the increased stability of the EONIA spread indeed is at least partly stemming from lower intraperiod

[14] Note that, the benchmark allotment rule was published only in May 2002.

Figure 3: The tender spread, i.e. marginal MRO rate - Minimum bid rate



Source: Bank of Finland

variability in banks' demand for liquidity.

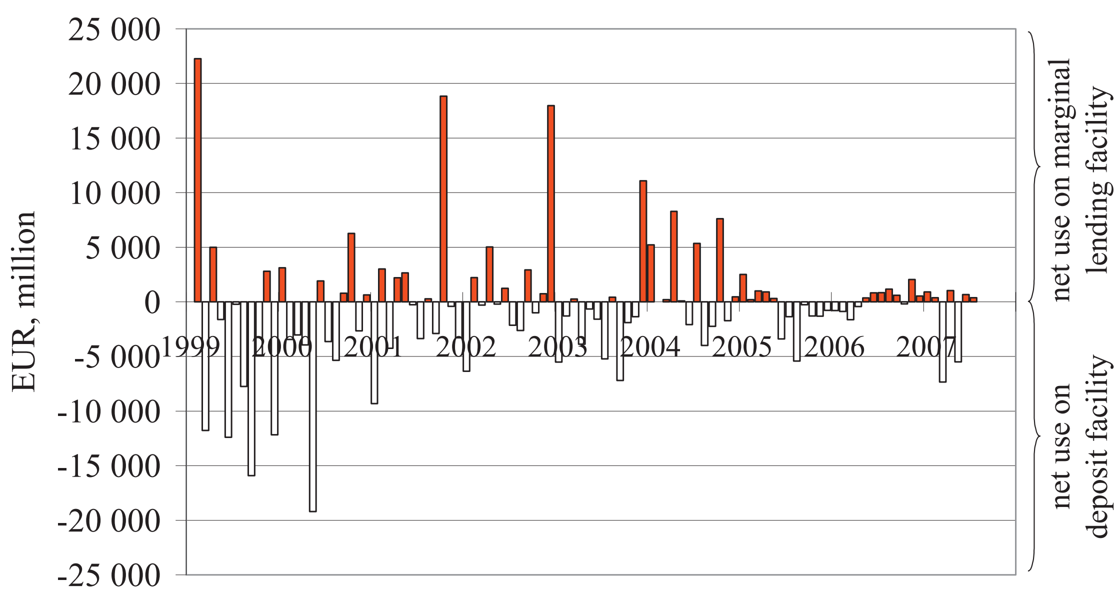
However, even if the reform was a success in reducing the volatility of the demand for liquidity, and consequently the volatility of the shortest market rates, the behavior of the average spread remains a puzzle. The analysis on the development of the tender spread indicates that it indeed is the policy part of the EONIA spread that has behaved contrary to the ex ante expectations. Whereas the average tender spread was 4.3 bps before the reform, it has been 4.8 bps between March 2004 and the end of July 2007. Although this increase in the average tender spread is not statistically significant, it confirms that the spread has not decreased with the stabilization of the intraperiod demand for liquidity.

We next study the ECB's liquidity supply, in order to see whether the reason for the continuation of a significantly positive average tender spread could be a change in the volumes supplied by the ECB.

3.3 Liquidity supply

Deviations of the ECB's liquidity supply from the demand created by the autonomous liquidity factors and the reserve requirements result in banks using the standing facilities on the final day of a *RMP*. That is, whereas excess liquidity supply will be deposited into the deposit facility, a lack of liquidity will be covered from the marginal lending facility. Therefore, the net use of the stand-

Figure 4: Net aggregate use of standing facilities



ing facilities on the final day of each maintenance period reflects the tightness of the actual liquidity provision. Tight liquidity conditions is associated with banks' aggregate marginal borrowing exceeding the use of deposit facility, while loose liquidity appears as larger use of the deposit facility. The banking sector's net use of the standing facilities is illustrated in figure 4, where positive values indicate tight liquidity conditions.

Judging by the final day net aggregate use of the standing facilities, the average end-of period liquidity conditions were quite loose during the time of the fixed rate tenders, but they have been close to neutral during the period with variable rate tenders. Furthermore, the average liquidity supply does not seem to have changed significantly after the March 2004 reform. The average net use of the standing facilities during the three subperiods analyzed were EUR -3.3, 0.1 and -0.1 bn.

Yet, even if the average liquidity supply seems to be unchanged after March 2004 reform, the accuracy of the liquidity supply has increased. Whereas the standard deviation of the final day net use of the standing facilities was EUR 5.5 bn during the second subperiod, it was only EUR 2.9 bn during the third period. The increased precision in the liquidity supply naturally accounts for the increase in the fine-tuning frequency. The standard deviation of the net standing facility use has been only 2.1 bn since November 2004, when the new policy was initiated. During the period with fixed rate tenders, this figure was recorded at EUR 9.9 bn. That is, both the mean and the volatility of liquidity supply indicate that the benchmark liquidity policy was not closely followed by the ECB during the period of fixed rate tenders.

Based on the evidence presented in this section, it seems quite clear that the ECB's actual liquidity supply over the maintenance periods has not been reduced since the March 2004 reform. Therefore, the explanation for the positive tender spread should be searched elsewhere.

4 Potential explanations for the tender spread

This section outlines two different rational explanations for the unexpected development of the EONIA and the tender spreads during the last three years. First, we analyze potential effects stemming from changes in the accuracy of the liquidity provision. After that, we study the allotment uncertainty the individual banks face while preparing their bids, and potential effects of the increased interest rate stability on this uncertainty.

4.1 Decrease in interest rate elasticity

We may present the overnight rate of the last day of a reserve maintenance period as a function of the cumulative liquidity shock distribution $F(\cdot)$[15] by rewriting equation (1) as follows:

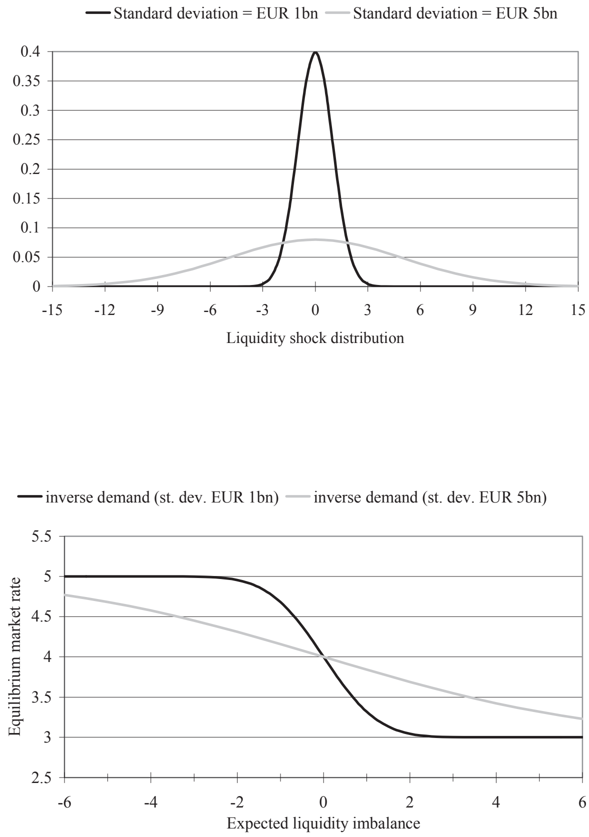
$$r_T = F(rr_T - l_T)r_T^{ml} + (1 - F(rr_T - l_T))\, r_T^d, \tag{2}$$

rr_T and l_T denote respectively the remaining unfulfilled reserve requirement and the liquidity on the final day of a *RMP*. Based on equation (2), it is quite clear that the overnight rate is a decreasing function of liquidity, but also the interest rate elasticity of the demand for liquidity increases with the liquidity uncertainty. That is, the wider the liquidity shock distribution, the less certain one can be which standing facility will be used more intensively. Figure 5 illustrates this by presenting two liquidity shock distributions and the inverse demand curves matching them. The inverse demand curves map the expected liquidity imbalances (deviations from the liquidity that would precisely comply with the requirement) with the expected overnight rate. In both cases the liquidity shocks are assumed to be distributed normally, the difference between them is that the standard deviations is either EUR 1 or 5 billion.

Henceforth, we call the liquidity at which the final day overnight rate equals the key policy rate (and also the mid-point of the corridor) *neutral liquidity* (l^n). If the benchmark liquidity (l^{bm}) was not neutral, the expected overnight rate during the last central bank liquidity injection for a *RMP* would not only depend on the volume injected, but also on the remaining liquidity uncertainty. We illustrate this possibility by an example. Assume that the benchmark liquidity is slightly tight ($l^{bm} < l^n$). In such a case, banks would not be able to get all the refinancing they were willing to borrow from the central bank at the key policy

[15] $F(x) = \int_{-\infty}^{x} f(\varepsilon)\, d\varepsilon$, where $f(\varepsilon)$ is the liquidity shock distribution.

Figure 5: Liquidity shock distribution and derived inverse demand curve

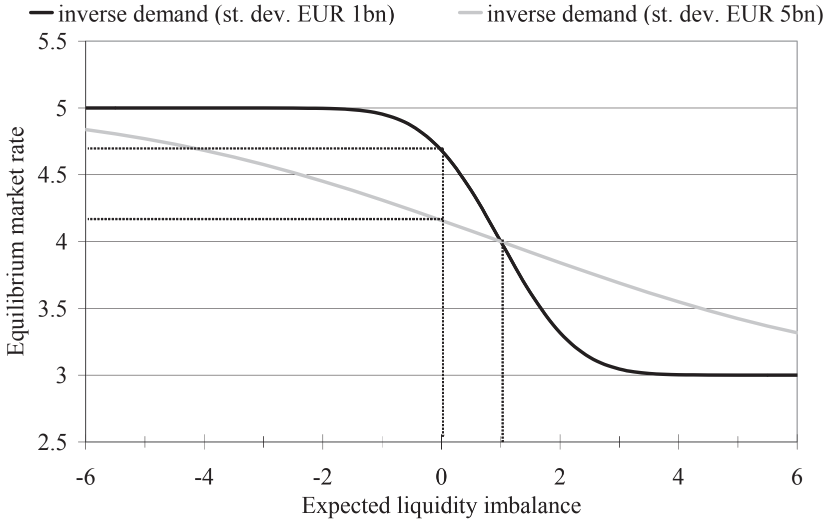


rate. Therefore, the expected overnight rate would be higher than the policy rate ($\text{E}\left[r_T \mid l^{bm}\right] > r^{mid}$), and as presented in Section 2.2 this would result in the marginal MRO rate exceeding the minimum bid rate, i.e. a non-zero tender spread.

Furthermore, the magnitude of such a tender spread would depend not only on the size of the bias in the benchmark volume, but also on the distribution of liquidity shocks between the final allotment and the end of the period. This is illustrated in Figure 6, in which banks final day demand for liquidity at the policy rate RMP exceeds the benchmark liquidity by EUR 1 billion. The two inverse demand curves in the figure represent one and eight day liquidity uncertainties.[16] The smaller the remaining liquidity uncertainty (i.e. the more

[16] Whereas only the liquidity shocks that occur on the last day of the reserve maintenance period affect the liquidity imbalance when final day fine tuning operations (FTO) are conducted regularly, the uncertainty covers eight day's liquidity shocks if FTOs are not conducted. Here, the one and eight day uncertainties are illustrated by a shock distributions with standard deviations of EUR 1 and 5 billion respectively. This calibration is not meant to be precise, but only illustrative to the qualitative effect of the remaining uncertainty.

Figure 6: Inverse demand functions when neutral demand exceeds the benchmark allotment



accurate the central bank's liquidity provision), the larger the possible effect of a non-neutrality would be. Intuitively, the more certain banks can be on their forthcoming liquidity positions, the stronger the deviation off the mid-point will be.

Based on the analysis above, the decrease in the end-of-period liquidity uncertainty following the increase in fine-tuning activity could be a potential source for an increase in the tender spread. The uncertainty about the end-of-period liquidity imbalances is manyfold, when the last liquidity injection by the central bank reserves is decided eight days before the end of the period, compared to the case where last allotment takes place in the morning of the final day. According to the ECB Monthly bulletin (February 2005) the accumulated standard deviation of the liquidity shocks (i.e. autonomous factor forecast errors) over 8 days was normally EUR 7 billion compared with EUR 3 billion over five calendar days. Hence, the standard deviation of one day errors is not likely to exceed EUR 1 billion significantly. That is, the increase in the end-of-period fine tuning frequency must have had a considerable impact on the demand elasticity of liquidity at the time of the last regular allotment. Even if the ECB does not fine tune small (expected) imbalances, merely the knowledge of the fact that any significant (accumulated) shock will be fine tuned, is enough to reduce the liquidity uncertainty banks face at the last MRO.

However, the change in the interest rate elasticity can account for the evolution of the tender spread only, if the benchmark allotment volume is biased or banks' demand for liquidity is larger than the amount resulting directly from the reserve requirements. Based on the analysis in section 3.3, we are tempted to conclude that the ECB's actual liquidity provision is not biased (at least towards tightness). Yet, one should bear in mind that in several cases since November 2004, the fact that the net use has been on deposit facility has followed from banks underbidding the liquidity absorbing fine-tuning operations (i.e. not an active decision of the central bank). Furthermore, even if the benchmark allotments were not ex post biased, it cannot be ruled out that the banks could have anticipated tight liquidity provision (perceived tightness).

Moreover, the liquidity conditions can be tight even if the benchmark allotments are unbiased, if banks' demand at the policy rate exceeds the benchmark liquidity. In such a situation we say that the banks have 'structural demand for the deposit facility'. There are plenty of potential sources for such a bias in the demand for liquidity. First, if the liquidity shock distribution was skewed to the left, the banks would have a positive structural demand for the deposit facility.[17] In such a case, a neutral liquidity provision would not minimize the use of the standing facilities. Second, the interbank market is not perfect, e.g. banks face transaction costs when entering the market. Hence, (some) banks may prefer to place small excess balances in the deposit facility rather than lend them to the markets. As the penalty for non-compliance with the reserve requirement is penalized heavier than the marginal lending rate, some institutions may want to avoid the risks of accidently not fulfilling the requirement by holding small extra amounts of money with their central banks. This demand would be very similar to the motivation for holding unremunerated excess reserves laid out in the ECB's Monthly Bulletin (ECB, 2005). In Section 5, we will try to briefly asses whether there is any evidence of structural excess demand for the deposit facility, misperception on the liquidity policy or asymmetry of the liquidity shock distributions.

4.2 Individual allotment uncertainty

In this section, we argue that a non-zero tender spread can result from individual banks' bidding behavior in the main refinancing operations even if the actual and perceived liquidity provisions are unbiased, and there is no structural demand for the deposit facility.[18] Here, the spread is explained by banks' desire to secure at least part of their liquidity needs directly from the central bank combined with the individual allotment uncertainty they face when bidding at the marginal MRO rate.

Banks aim at minimizing the cost of obtaining the liquidity needed to meet their reserve requirements. While optimizing this cost a single bank needs to consider the expected price of reserves at the central bank operations on one hand and at the interbank market on the other hand. As explained in Section 2.2, the expected price of liquidity at the interbank market equals the effective tender rate at the central bank operation, as long as the banks are risk neutral and the money market is efficient.

However, this needs not be the case, if banks have target volumes for the allotments from the central bank. When banks prefer to cover at least part of

[17] See Välimäki (2003) for a discussion on the effect of asymmetric shock distributions.

[18] This section develops further the idea originally presented in Välimäki (2006).

their liquidity needs directly from the central bank, they have to take this kind of a 'private cost' factor into account while preparing their bids for the tender operations. Such incentives may originate e.g. from risk aversion, market frictions or capital adequacy requirements. First, risk averse banks may prefer low exposure to the interbank market, even if the expected market rate equals the policy rate, as long as the second moment is not zero (i.e. market rate fluctuates around the policy rate). This holds especially for the last operation of a *RMP*. Second, credit lines may limit some banks' capability to trade extensively at the interbank market. Third, the range of eligible collateral in the ECB operation is wider than that of general collateral (GC) repo market. So, banks that are constrained in the GC repo market by their collateral possessions, may prefer receiving liquidity directly from the CB to using the collateralized interbank markets. Fourth, some banks may want to try to limit their interbank trading volumes due to capital adequacy reasons.

In MROs, each bank may place bids up to ten different interest rates. Henceforth, we denote the market rate that is comparable (maturity, collateralization, etc.) to the operations, the marginal MRO rate and rates exceeding the marginal rate by r, r^m and r^+. Bank i's bid array $(\overline{b_i})$ will be divided in three parts (b_i^+, b_i^m, b_i^-) that reflect the bid volumes at rates above, equalling or below r^m. The banking sector wide counterparts to the bid volumes will be denoted $\overline{b} = [b^+, b^m, b^-]$. Furthermore, l_i denotes the liquidity the bank needs to obtain either from the central bank or interbank market to hold its preferred amount at the end of the day, while the central bank's target liquidity provision is d. Finally, we denote the percentage of allotment at the marginal MRO rate by A (henceforth the *allotment ratio*, $A = (d - b^+)/b^m$). Consequently bank i's allotments for the three bid levels will be $q_i^+ = b_i^+, q_i^m = Ab_i^m$, and $q_i^- = 0$ $(q_i = q_i^+ + q_i^m + q_i^-)$. That is, bids above the marginal MRO rate are fully satisfied, the bid at the marginal rate is rationed according to the central bank preferences, whereas bid volumes at rates below the marginal rate are discarded.

Banks' cost minimization problem consist of three parts. First, the direct cost bank i faces for participating in an MRO equals the allotment volumes multiplied by the bid rates $(q_i^+ r_i^+ + q_i^m r_i^{r^m})$. Second, the common cost/revenue from interbank trading equals the difference between the target end-of-day reserve balances and the actual reserves after the central bank allotment multiplied by the price for liquidity at the interbank market $((l_i - q_i)\, r)$. The third part of the problem is the bank's private cost resulting from the deviations from the target allotment $(c_i \left(l_i - b_i^+ - Ab_i^m\right)^2)$, where c_i denotes the individual weighting parameter for the private costs). We assume a quadratic form for the private costs to reflect the idea that the banks have a real target (instead of a minimum level) for CB allotments. By this construction, banks suffer not only from receiving too little CB liquidity, but they can also be allotted with too much. The symmetric treatment of liquidity deviations (off the target) can be justified especially, when the main factor behind the private value for allotments is risk aversion. Alternatively, one could have formulated the private cost component so that it would punish the banks only for being allotted less than their target liquidity. We opted for modelling the banks with target allotments instead of having merely minimum levels for their allotments, as we are especially interested to find out whether a symmetric target for allotment volumes could be a sufficient condition for a tender spread to emerge.[19] It is quite obvious that if this is the case for a symmetric target, it is the more so if banks have only minimum target levels. Finally, we assume here that each bank is small enough, so that we can neglect the effect of its own bid to the A and r^m.[20]

Taking into account the allocation rules, the cost minimization problem at the MRO for the expected profit maximizing bank i can be formulated as follows:[21]

$$\begin{aligned}\min_{\overline{b_i}} \mathrm{E}_i [L_i] &= \underbrace{\left(\mathrm{E}[A]\, b_i^m r^m + b_i^+ r^+\right)}_{\text{cost of CB liquidity}} + \underbrace{\left(l_i - b_i^+ - \mathrm{E}[A]\, b_i^m\right) r}_{\text{net cost of interbank trading}} \\ &\quad + \underbrace{c_i \mathrm{E}\left[\left(l_i - b_i^+ - A b_i^m\right)^2\right]}_{\text{cost of deviating from target}} \qquad (3) \\ &\quad \text{s.t. } b_i^m \geq 0, \text{ and } b_i^+ \geq 0.\end{aligned}$$

Rearranging equation (3), we get:

$$\begin{aligned}\min_{\overline{b_i}} \mathrm{E}_i [L_i] &= \left(\mathrm{E}[A]\, b_i^m + b_i^+\right)(r^m - r) + b_i^+ (r^+ - r^m) + l_i r \qquad (4) \\ &\quad + c_i \mathrm{E}\left[\left(l_i - b_i^+ - A b_i^m\right)^2\right] \\ &\quad \text{s.t. } b_i^m \geq 0, \text{ and } b_i^+ \geq 0,\end{aligned}$$

in which the first term is the cost from a potential tender spread, the second term is the 'insurance premium' the bank faces for securing its allotment volumes (i.e. bidding at rates above the expected marginal MRO rate), the third term is the opportunity cost of interbank lending, and the final term is the bank's private cost from being exposed to the interbank markets.

Based on equation (4), it is easy to see that, *if there was no private cost (resulting from deviations from the target liquidity) or if there were no uncertainty about the forthcoming allotment ratio, it would be optimal for banks to place bids*

[19] Note that, a tender spread is more likely to emerge, if the banks have only minimum allotment volumes instead of target levels, as the optimal bid in the first case needs to be at least as large as with symmetric targets. This will be obvious based on the analysis in the next section.

[20] Naturally each bid may affect the allotment ratio and the marginal rate, but as there are normally several hundreds of bidders in the MROs, this assumption is probably not too restrictive.

[21] Note that, here the expectation is taken only with respect to the allotment ratio. I.e. the forthcoming marginal MRO rate is expected to be know already when the bids are placed. Our aim here is to show that the allotment uncertainty itself is already a sufficient condition for a non-zero tender spread to emerge. If also the forthcoming marginal MRO rate was uncertain, the potential for a tender would increase considerably.

only at the marginal MRO rate and for volumes that equal their target liquidity divided by the allotment ratio. In such a case, the marginal MRO rate and the weighted average rate would both equal the expected market rate, which should under neutral liquidity policy also equal the policy rate.

However, banks face uncertainties while preparing their bids. With the current stability evidenced in the marginal MRO rate (see Section 3), a major source of uncertainty for a single bank is the bid volumes of the other banks. The allotment ratio A varies for two reasons. First, even if $\sum_{i=1}^{\text{number of banks}} l_i$ and d both are unbiased estimates of the same underlying factor (ex post neutral liquidity), they differ from each other in a single operation. Furthermore, A decreases with the aggregate bid volume at rates above or equal to the marginal MRO rate. Hence, each bank must anticipate not only the bid rates of other banks, but also how much there is to be allotted at the marginal rate, and by how manyfold the other banks' bid volumes are compared to this amount. Therefore, the forthcoming allotment ratio is a stochastic variable, the expectation for which must be based on each bank's subjective view on the bid behavior of the rest of the banks. The past allotment ratios normally serve as a focal point for estimating the forthcoming ratios. So far, the allotment ratio has varied between 0.003 and 1, with mean at 0.60 and standard deviation of 0.28.[22]

Due to the uncertainty about the forthcoming A, the private cost component in bank i's cost minimization problem becomes positive, or the bank must pay a premium for the whole allotment it receives (i.e. either $\mathrm{E}_i\left[\left(l_i - b_i^+ - Ab_i^m\right)^2\right] > 0$ or $b_i^+ = l_i \wedge b_i^m = 0$). That is, for a given total allotment (q_i) bank i needs to trade-off the cost of bidding at rates above the marginal MRO rate with the benefits stemming from the certainty over the allotment volume. Taking the first order conditions with respect to the bid volumes yields the following optimal bids volumes:

$$\begin{aligned} b_i^m &= \max\left[0, \frac{r^+ - r^m}{2c_i} \frac{\mathrm{E}[A]}{\mathrm{E}[A^2] - \mathrm{E}[A]^2}\right] \\ b_i^+ &= \max\left[0, l_i - \left(\frac{\mathrm{E}[A^2]}{\mathrm{E}[A^2] - \mathrm{E}[A]^2}\right) \frac{r^+ - \mathrm{E}[r^m]}{2c_i} - \frac{\mathrm{E}[r^m] - \mathrm{E}[r]}{2c_i}\right] \end{aligned}$$

Whereas bank i's bid at the marginal MRO rate decreases with the uncertainty over the allotment ratio and with the individual weighting parameter, the bid volume at rate(s) exceeding the marginal rate increases with them. Furthermore, when it is optimal to bid at rate(s) above the marginal MRO rate, the optimal bid grows with the target liquidity (l_i), while it decreases with the expected spread between the price of liquidity at the operation compared to that of at the interbank market.

[22] The allotment ratio during the period with fixed rate tenders varied between 0.008 and 1. The average allotment ratio was 0.08, while the standard deviation stood at 0.12.

The total volume bid by bank i in the tender operation is given by:

$$b_i^* = l_i + \left(\frac{\mathrm{E}[A] - \mathrm{E}\left[A^2\right]}{\mathrm{E}[A^2] - \mathrm{E}[A]^2} \right) \frac{r^+ - \mathrm{E}[r^m]}{2c_i} - \frac{\mathrm{E}[r^m] - \mathrm{E}[r]}{2c_i}.$$

That is, bank i's total bid decreases with uncertainty and also with the spread between the marginal MRO rate the market rate. This is rather intuitive, as first an increase in the uncertainty shifts the bid volumes towards rates at which the bids are not rationed. Second, even if a smaller bid (especially at rates above the marginal rate) increases the bank's exposure to the interbank markets, a higher expected market spread reduces the bank's incentives to secure allotments from the central bank.

Unless the individual weighting parameter c_i is high for most credit institutions or the (positive) spread between the marginal MRO rate and the market rate is wide, it is unlikely that the total aggregate bid volume falls below the central bank's target allotment (i.e. the probability for underbidding is low). Therefore, the central bank should normally be able to decide not only the average liquidity held over the reserve maintenance period, but also the path of liquidity holdings within the periods. Note also that, the wider the expected spread between the marginal MRO rate and the market rate becomes, the more banks will hold back their bids at rates exceeding the marginal rate. Therefore, *there is a resistance level beyond which the spread between the effective tender rate and the market rate cannot grow. The maximum level for this spread is the higher, the wider pervaded and the stronger the preference for secured central bank allotments is.*

Note that, as the bid behavior is derived here as a function of expected rates, it is probable that different equilibrium marginal MRO rate exist for different expectations. Expectations on the forthcoming marginal rate are (under normal circumstances) pinned down quit closely by the comparable market rates (e.g. the repo and swap rates of the relevant maturities). Yet, even if the interest rate expectation is common due to this market information, it can be the case that it is driven by the adaptive behavior due to the recurrence of the operations. For example, if the tender spread was n bps in several latest operations, it can be rational to expect it to be the same in this operation. Similarly, if the tender spread was growing in the latest operations, it could be rational to expect it to do so in the following operations until the 'resistance level' is reached. The adaptive formation of the expectations is not restricted to the interest rate expectations, but it is very likely that also the expectations on the allotment ratio are driven by the latest operations.

In this section we have argued that, if banks dislike stochastic allotments, a non-zero tender spread can exist even if banks are rational and the liquidity policy of the central bank is neutral. Furthermore, we have argued that there needs not be a unique equilibrium for such a spread. Instead, the tender spread that results from a single operation, is largely determined by banks expectations of it. Moreover, as the formation of the expectations over the forthcoming marginal rate is largely based on adaptive behavior, the development of the tender spread may show trend behavior. To avoid this, a quantity oriented central bank may need to deviate from its benchmark liquidity policy in order to shift the market from a 'bad equilibrium' to a better one. From monetary policy implementation point of view, a bad equilibrium is such that it affects interest rates of maturities that are relevant for the monetary policy transmission. An example of an unpleasant equilibrium would be such that banks expect the tender spread to grow in time, as such an expectation would be discounted into longer money market maturities.

The maturity of the main refinancing operations was halved in the March 2004 reform. Ceteris paribus, this means that the amount of liquidity to be rolled over in each operation doubled simultaneously. For a representative bank this means that its refinancing need and also the target allotment (l_i) doubles. Based on the analysis above, this is reflected as an increase in the bank's incentives to bid at rates above the policy rate. This could have contributed to the unexpected behavior of the tender spread after the reform.

The next section takes a second look at the empirical evidence from the euro markets to make a tentative attempt to assess the validity of the hypothesis presented above as valid explanations behind the evolution of the EONIA and the Eurosystem tender spreads.

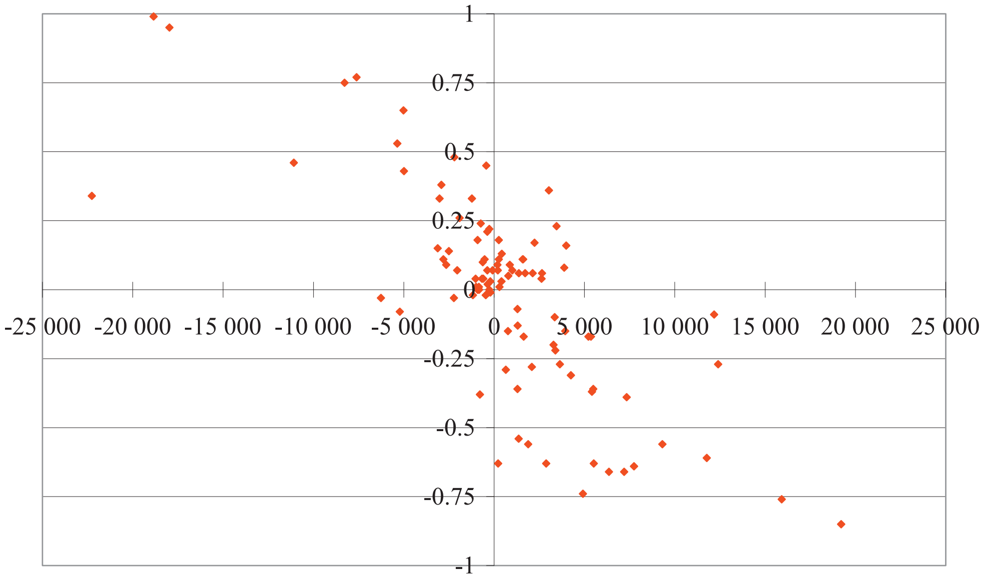
5 Tentative empirical evidence

5.1 Structural demand for deposit facility

In previous sections, we have argued that a non-zero tender spread may result from a 'biased' demand for liquidity or from multiplicity of equilibrium levels for the marginal *MRO* rate that results from the individual allotment certainty. As the analysis in Section 3 already indicated that the liquidity provision of the ECB has generally not been tight compared to the liquidity need stemming from the reserve requirements, our analysis on the aggregate liquidity provision focuses here on identifying potential signs of structural demand for the standing facilities.

Figure 7 plots the EONIA spreads against liquidity imbalances on the final days of the *RMPs*. The relation between the level of liquidity and interest rates is not linear, but it depends on the liquidity shock distribution. However, we tried to make a linear approximation of this relation for observations that are close to the benchmark liquidity. That is, we regressed the final day EONIA spread against the net recourses to the standing facilities, using observations whose net recourse was below EUR 5 billion in absolute value. The result suggested, that the EONIA spread with the benchmark liquidity was 4bps, but due to the volatility of this relation the 95% interval covers the EONIA spreads between -1bps and +9bps. Based on this estimation, an increase of EUR 1 billion to the final day liquidity lowers the EONIA spread by 6 bps (the 95% confidence interval for this was -8.4 and -3.6). Assuming that the natural spread between the uncollateralized overnight rate and the rate of the collateralized policy operations is close to 2 bps, we cannot determine, whether or not the final day behavior of the market rate indicates banks' demand structurally exceeding the benchmark volume. Yet, if such a bias existed, it probably would most probably be below EUR 1 billion, judging by the observed relation between the liquidity imbalances and interest rates.

Figure 7: EONIA spreads and liquidity imbalances at the ends of reserve maintenance periods



Whereas the net use of standing facilities is largely determined by the liquidity injections of the ECB, money market inefficiencies are reflected in the gross volumes. That is, the interbank flow of liquidity is not perfect when some banks obtain liquidity from the marginal lending facility and simultaneously other banks deposit reserves with the central bank's deposit facility. We may try to identify, whether such an inefficiency demand (structural demand) is larger for either of the two facilities by analyzing, how intensively the deposit facility (marginal lending facility) is used when the aggregate liquidity condition is tight (loose).

The observations between the beginning of 1999 and end of July 2007 show that, whereas the average use of the deposit facility has been EUR 840 million when the net usage has been on the marginal lending side, the marginal lending volume has averaged at EUR 556 million when the aggregate market conditions were loose. The difference of is not larger than EUR 285 million, but this figure is statistically significant. Similarly, the minimum aggregate use of deposit facility under tight liquidity conditions was EUR 406 million, i.e. EUR 250 million above the EUR 156 million, which was recorded as the minimum use the marginal lending facility under loose liquidity condition. So, based on the use of the 'wrong facility', there could be a small structural bias in banks' demand for liquidity. Yet, the bias does not seem to be larger than EUR 300 million. A bias of this magnitude would probably not make a notable difference, if the last MRO takes place eight days before the end of a period. However, it cannot be totally ruled out that even a small bias like this in the final day operations could impact the banks' expectations over time.

5.2 Individual allotment uncertainty

We argued in Section 4.2 that the individual allotment uncertainty can account for an increase in bidding at rates above the marginal MRO rate as well as non-uniqueness of the equilibrium bidding, which consequently may result in a non-zero tender spread. Furthermore, it was shown that the level of refinancing needs may directly affect the allotment uncertainty, and consequently also the incentives to bid at higher rates.

The allotment volume of the ECB's MROs is presented in figure 8. Whereas banks' aggregate need for refinancing in single MROs fluctuated mostly between EUR 50 and 150 billion until the March 2004 reform, it has increased to some EUR 300 billion after the reform. Meanwhile, the average money market liquidity ($\simeq$ reserve requirements) has grown from EUR 100 to 190 billion. That is, in 1999-2003 some 50-100% of the money market liquidity was rolled over in each operation, whereas the percentage has been some 150-200% in 2005-2007 (see Figure 9).

This also means that, if a representative bank missed to obtain half of its target allotment in a MRO prior to March 2004, it would have had to obtain up to 25-50% of its average reserve balances from the interbank market. Yet, if it was not the last operation of a RMP, the bank could have alternatively alleviated its situation considerably merely by relying more intensively on the averaging provision. However, if the bank misses half of its target volume when the refinancing need is at the level we have seen for the last years, the bank would be almost totally out of central bank reserves before entering the markets. This has probably increased considerably the risk aversion (c_i) of at least some banks.

6 Summary and conclusions

It is important that the determination of the shortest money market rates is thoroughly understood, as the overnight rate is the starting point of the term structure of interest rates. Furthermore, the significance of the overnight market cannot be overemphasized as the overnight rate is widely used as the monetary policy operational target. Therefore, one should understand all the mechanisms relevant for the determination of the overnight rate to be able to draw correct conclusions over the development of this rate. The purpose of this study was to shed some light on the behavior of the difference between the effective price for money and the monetary policy steering rate (the tender spread), which is one

Figure 8: Aggregate allotment in the main refinancing operations

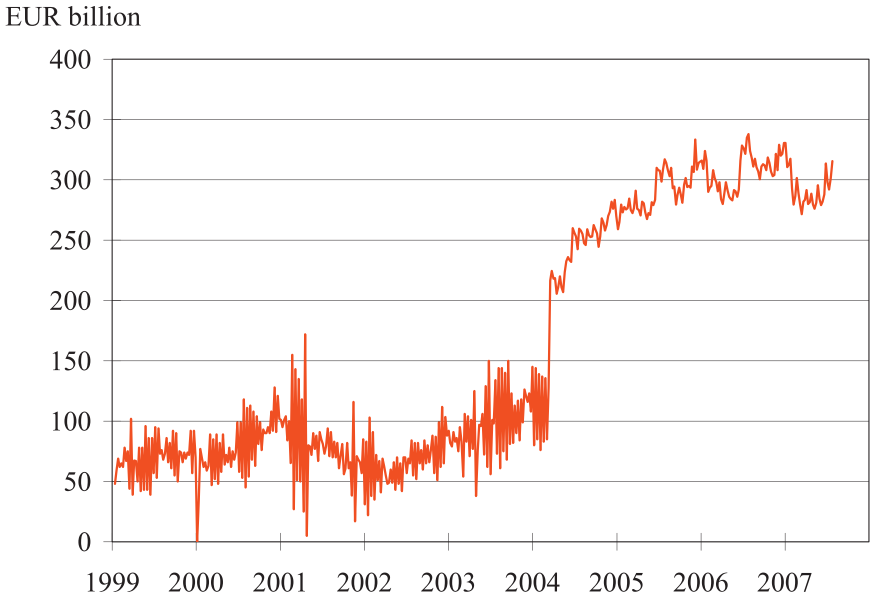
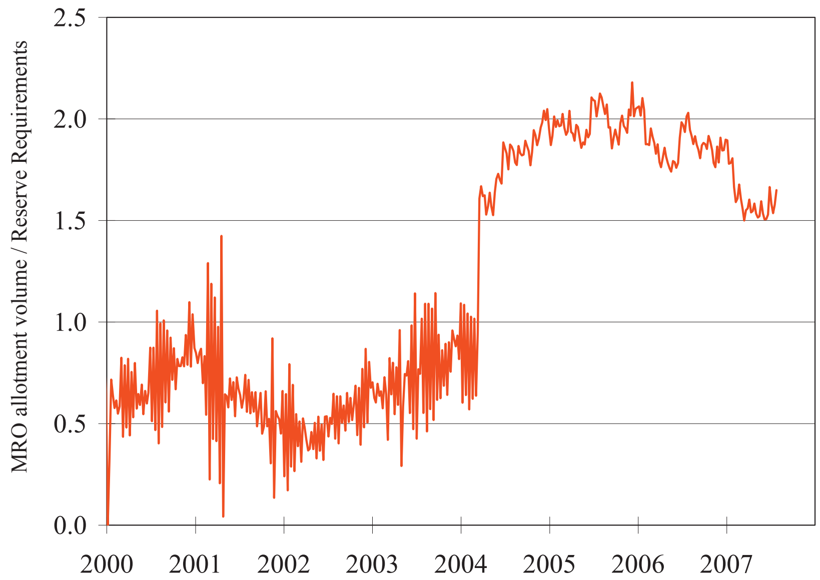


Figure 9: MRO allotments compared to average money market liquidity (i.e. reserve requirements)



of the key determinants behind the development of the EONIA relative to the policy rate.
In previous studies, it has been shown that banks' expectations on the intra reserve maintenance period changes in the official central bank rates result in a non-zero average tender spread. In March 2004, the timing of the reserve maintenance periods was aligned with the interest rate decision of the Governing Council so that possible changes to the policy rate currently coincide with the change of the periods. The main purpose of this reform was to stabilize banks' demand for central bank reserves by isolating it form interest rate expectations.

Whereas the March 2004 reform seems to have been successful in stabilizing the demand for liquidity and consequently also the shortest market rates, the spread between the effective price for liquidity and the policy rate was not reduced as the ex ante expectations had suggested. On the contrary, the average tender spread (marginal MRO rate - minimum bid rate) was wider in 2005 and 2006 than in any single year after 2000, when the ECB switched from fixed to variable rate liquidity tenders. Furthermore, it was shown that the ECB's liquidity provision has not been tight compared to the banks' liquidity needs stemming from the minimum reserve requirements. So, the spread cannot be explained by the central bank preferences.

This paper offered two potential rationales for the unexpected behavior of the effective tender rate. First, as demonstrated in Section 3, the interest rate elasticity of the demand for liquidity in the final central bank operation for a reserve maintenance period decreased considerably after the ECB initiated the policy to regularly fine tune the last day's liquidity imbalance (i.e. the final allotment takes place on the last day of the period instead a week before). When this is combined with the quantity oriented liquidity policy, it is possible that even a small structural demand for the deposit facility or a small bias (genuine or perceived) in the liquidity supply may result in a strictly positive tender spread. Yet, the very tentative evidence presented in Section 5.1 suggested that the ECB's liquidity provision has not overall been biased and that there seems to be only a tiny (some EUR 300 million) structural demand for the deposit facility. A bias of this magnitude is not easily addressed by scaling the liquidity supply. However, the longer the horizon the smaller biases become visible. One way to address potential biases in the liquidity supply would be to increase the benchmark allotment volume in the last MRO so that the final day fine tuning operation would always drain liquidity from the market. If this was the case, it would be obvious that the ECB preferences are not biased towards tight liquidity conditions. Furthermore, if the final day liquidity draining operation was conducted as a fixed rate tender at the policy rate, banks' incentives to overbid (either in volumes or prices) in the last MRO would be reduced. As a matter of fact, the ECB has allotted the markets with volumes slightly above the benchmark liquidity since May 2006. However, the volume seems not to have been large enough to guarantee a liquidity draining final day operation, as still on average 1 out of 3 final day fine tuning operations have been liquidity providing.

Second, we argue that banks' risk aversion or money market inefficiencies may result in a strictly positive tender spread even, if the central bank liquidity supply was unbiased and the banks did not anticipate any intraperiod rate changes. Here, the driving force behind the tender spread would be uncertainty over the individual allotments at the expected marginal MRO rate. Furthermore, we show that incentives to bid at rates exceeding the marginal MRO rate grow with the level of banks' refinancing need, and consequently the maximum spread resulting from the allotment uncertainty is positively related to the refinancing volumes. The tender spread that materializes from a MRO accounts heavily for the banks' expectations over it. Under normal circumstances, the banking sector has rather uniform expectations over the forthcoming marginal rate, as they all observe continuously relevant market rate quotations (e.g. 1 week repo, depo and EONIA swap rates). However, these expectations are likely to contain heavy inertia, as due to the lack of a valid focal point for a unique equilibrium, they are likely to be based on the experience from the previous MROs. The link between the March 2004 reform and the allotment uncertainty results from the fact that the shortening of the maturity of the policy operations doubled the volume of refinancing that is rolled over in each operation. Therefore, the significant growth in the banks' target allotment volumes may have considerably increased their incentives to bid at higher rates. Also the fact that each MRO is nowadays almost double the size of the euro liquidity, may have increased banks' preference to secure at least part of their central bank allotments by bidding at higher rates.

There seems to be three different measures that can be taken to resist the effect of the liquidity uncertainty. First, the MRO volumes could be reduced by structural operations. That is, if the Eurosystem increased its outright holding of assets or conducted more longer term refinancing operations, the benchmark MRO volumes would become smaller. This would reduce banks' incentives to bid at rates above the marginal MRO rate. Second, the incentives to bid at higher rates could be resisted by increasing the supply of liquidity. The excess liquidity would push the market rates downward, and the negative spread between the market rates and the central bank allotments should give the banks enough incentives to reduce their bids in the tender operations. Third, the allotment uncertainty stems from the fact that allotments are rationed at the marginal MRO rate. If all bids at the marginal MRO rate were accepted in full, and this policy was pre-announced, there would not be any allotment uncertainty, as long as the marginal MRO rate was ex ante know. The most logical focal point for such uniform expectations is the key policy rate. That is, the easiest way out of all problems related to the allotment uncertainty would be substituting the fixed rate tender procedure with full allotment (i.e. satisfying all bids) for the current variable rate tender procedure.

References

[1] Ayuso, J. and Repullo, R. (2003) **A Model of the Open Market Operations of the European Central Bank**. *Economic Journal, 113: 883-902*

[2] Bindseil, U. (2002) **Equilibrium bidding in the Eurosystem's open market operations.** *European Central Bank Working Paper series 44.*

[3] Ejerskov, S., Martin Moss, C., Stracca, L. (2003) **How does the ECB allot liquidity in its weekly main refinancing operations: a look at the empirical evidence.** *European Central Bank Working Paper series 244.*

[4] European Central Bank (1999) **Annual Report.** *Frankfurt am Main.*

[5] European Central Bank (2000a) **The switch to variable rate tenders in the main refinancing operations.** in *Monthly Bulletin*, July 2000 *Frankfurt am Main.*

[6] European Central Bank (2000b) **Monetary Policy Decisions.** ECB Press Release 8 June 2000.

[7] European Central Bank (2002) **Liquidity management of the ECB.** in *Monthly Bulletin*, May 2002 *Frankfurt am Main.*

[8] European Central Bank (2004) **The Monetary Policy of the ECB.** ECB 2004.

[9] European Central Bank (2005a) **The Single Monetary Policy in Stage Three; General Documentation on ESCB Monetary Policy Instruments and Procedures.** *Frankfurt am Main* September 1998.

[10] European Central Bank (2005b) **Initial experience with the changes to the Eurosystem's operational framework for monetary policy implementation.** in *Monthly Bulletin*, February 2005 *Frankfurt am Main.*

[11] Ewerhart, C. (2002) **A Model for the Eurosystem's Operational Framework for Monetary Policy Implementation.** *European Central Bank Working Paper series 197.*

[12] Ewerhart, C., Cassola, N., Ejerskov, S. & Valla, N. (2004) **Optimal Allotment Policy in the Eurosystem's Main Refinancing Operations.** *European Central Bank Working Paper series 295.*

[13] Hamilton, J.D. (1996) **The daily market for federal funds.** *Journal of Political Economy,* 104, 26-56.

[14] Linzert, T., Nautz, D. and Bindseil, U. (2004) **The longer term refinancing operations of the ECB.** *European Central Bank Working Paper series 359.*

[15] Moschitz, J. (2004) **The determinants of the overnight interest rate in the euro area.** *European Central Bank Working Paper series 393.*

[16] Nyborg, K., Bindseil, U. and I. Strebulaev (2002) **Bidding and Performance in Repo Auctions: Evidence from the ECB Open Market Operations.** *European Central Bank Working Paper series 157.*

[17] Scalia, A. and Ordine, M. (2005) **Banks participation in the Eurosystem Auctions and money market integration.** *Bank of Italy Working Paper series, Temi di discussione, 562*

[18] Välimäki, T. (2001) **Fixed rate tenders and the overnight money market equilibrium**. in *Central Bank Tenders: Three Essays on Money Market Liquidity Auctions*, Bank of Finland Studies E:26..

[19] Välimäki, T. (2003a) **Bidding in fixed rate tenders**. in *Central Bank Tenders: Three Essays on Money Market Liquidity Auctions*, Bank of Finland Studies E:26.

[20] Välimäki, T. (2003b) **Variable rate liquidity tenders**. in *Central Bank Tenders: Three Essays on Money Market Liquidity Auctions*, Bank of Finland Studies E:26.

[21] Välimäki, T. (2003c) **Central bank tenders: three essays on money market liquidity auctions.** *Bank of Finland Studies E:26.*

[22] Välimäki, T. (2006) **Whthe marginal MRO rate exceeds the ECB policy rate.** *Bank of Finland Discussion Papers 20/2006*

[23] Würtz, F. (2003) **A Comprehensive model on the Euro overnight rate.** *European Central Bank Working Paper series 207.*

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