Daily Borrowing Behavior of Banks in the Euro Area

by

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ABSTRACT

The Eurosystem has two standing facilities in order to provide and absorb overnight liquidity, signal the general monetary policy stance and bound overnight market interest rates. This study aims to shed light on the standing facility which provides liquidity and constitutes the upper bound of the corridor in which the interbank overnight interest rate fluctuates, namely the marginal lending facility. The recourse to this standing facility has been always negligible compared to the open market operations. But persistent recourse to the marginal lending facility regardless of its higher interest rate makes searching the motivations behind the use of this facility interesting. In this thesis, possible determinants of the daily borrowing are investigated and an equilibrium model is applied for the interbank money market in the Euro area. The effects of the operational framework change within the Eurosystem (in March 2004) and the recent turmoil are examined. Banks' borrowing behavior does not differ in terms of the sensitivity to the explicit cost of borrowing before and after the operational framework change –excluding the turmoil period-. But banks become more sensitive to this cost in the turmoil period. One day lagged spread between the Eonia and the main refinancing rate, and the required reserves had become insignificant with the operational framework change. But they became important again in determining overnight borrowing needs after the start of the turmoil. Banks are becoming less likely to borrow on the last day of maintenance periods to meet their reserve requirements after the framework change. Borrowing behavior never changes according to special days. The turmoil period brings about a time trend which potentially stands for gradual changes in the market conditions that are not covered in the estimation. The equilibrium model used is taken from Artuç and Demiralp (2010) who examine borrowing from the Fed's discount window. The results suggest that this model is inconvenient for the interbank money market in the Euro area.

Keywords: Eurosystem, European Central Bank, standing facility, borrowing function, marginal lending facility.

ÖZET

Avrupa Merkez Bankaları Sistemi, bankalararası para piyasasına gecelik likidite sağlamak veya bu piyasadaki gecelik fazla likiditeyi depozito olarak kabul etmek amacıyla gecelik borç alma-verme olanağı sunmaktadır. Bu tez, bu araçlardan, bankaların ulusal merkez bankalarından gecelik borçlanabilmesini sağlayan ve gecelik faizin içinde dalgalandığı koridorun üst sınırını belirleyen marjinal borçlanma olanağını incelemek amacıyla yazılmıştır. Bu olanağın kullanımı, açık piyasa işlemleriyle karşılaştırıldığında her zaman önemsiz miktarlarda olmuştur. Borçlanma faizinin bankalararası piyasada oluşan faizden yüksek olmasına rağmen, az da olsa sürekli olan kullanım bu tezin motivasyonunu oluşturmaktadır. Avro alanındaki bankaların gecelik borçlanma davranışları incelenmiş ve bir genel denge modeli uygulanmıştır. Avrupa Merkez Bankaları Sistemi'nde Mart 2004'te yapılan operasyonel çerçevedeki değişikliğin ve son finansal krizin borçlanma fonksiyonunu nasıl etkilediği incelenmiştir. Sonuç olarak, Mart 2004'teki değişimin bankaların borçlanma maliyetine (gecelik borçlanma faizi ile gecelik piyasa faizi arasındaki fark) olan duyarlılığını değiştirmediği gözlemlenmiştir. Ancak finansal kriz ile birlikte, bankalar bu maliyete daha duyarlı hale gelmişlerdir. Eonia (bankalaraarası piyasada oluşan gecelik ortalama faiz) ile politika faiz oranı arasındaki bir gün gecikmeli fark ve zorunlu rezervler, 2004'teki değişimle birlikte bankaların gecelik borçlanmasındaki etkilerini kaybetmişler; daha sonra finansal krizle birlikte kaybettikleri etkilerini geri kazanmışlardır. Ayrıca, rezerv döneminin son gününde daha fazla borçlanmaya başlamışlardır. Finansal kriz, gecelik borçlanmanın rezerv döneminin son gününe olan duyarlılığını değiştirmemiştir. Öte yandan, gecelik borçlanma ay sonu, yılsonu gibi özel günlere bağlı olarak değişmemektedir. Finansal kriz, borçlanma fonksiyonunda güçlü bir zaman trendine yol açmıştır. Artuç ve Demiralp (2010)' te kullanılan denge modeli, ulaşılabilir datalar çerçevesinde uygulanmıştır. Ancak, modelin Avro alanındaki bankalararası piyasada gecelik borçlanma için uygun olmadığı görülmüştür.

Aahtar kelimeler: Avrupa Merkez Bankaları Sistemi, Avrupa Merkez Bankası, gecelik borç alma-verme olanağı, borçlanma fonksiyonu, marjinal borçlanma olanağı.

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Chapter 1

INTRODUCTION

Central banks play significant roles in overall economy; affecting price level, growth rates, and financial stability by setting interest rates. Central banks need to ensure orderly functioning of the interbank money market which is the first step of monetary policy. To judge the efficiency of the money markets, interest rate stability can be viewed as a first criterion.

In recent years, most industrialized countries' monetary policies trying to hit a target overnight interest rate have been implemented by employing a system of reserve averaging, a corridor for interest rates between the central bank's lending and deposit rates, or a combination of a corridor and averaging (Whitesell, 2006). Facilities that provide credit to and accept deposits from banks are of importance as their interest rates constitute upper and lower boundaries of the corridor for the target interest rate.

For the purpose of controlling short-term interest rates in the money market, and in particular limiting their volatility, many central banks provide credit and/or accept deposits from banks through standing facilities. In this context, the European Central Bank[1] (ECB) within Eurosystem[2] has two standing facilities to absorb and provide overnight money to the interbank market within the Euro area, the deposit facility and the marginal lending facility respectively. The operational aspects and the interest rate of these facilities are determined by the ECB. As the

[1] The European Central Bank (ECB) has been responsible for conducting single monetary policy in the Euro area since January 1, 1999. The Euro area consists of 16 EU countries that have adopted the euro: Belgium, Germany, Ireland, Greece, Spain, France, Italy, Cyprus, Luxembourg, Malta, The Netherlands, Austria, Portugal, Slovenia, Slovakia and Finland.

[2] The Eurosystem comprises the ECB and the national central banks of those countries that have adopted the euro.

interbank money market and the operational framework of the Eurosystem regarding to the open market operations can not always provide enough liquidity for the banking system these facilities are needed. Unfavorable interest rates applied to the standing facilities do not stimulate the banks to use them in normal times. On the other hand, in exceptional times when the system suffers from less or more supply of liquidity than demanded by the banks, any eligible bank can borrow or lend from its national central bank through the standing facilities.

This study aims to shed light on the standing facility of the ECB which constitutes the upper bound of the corridor in which the interbank overnight interest rate fluctuates, namely the marginal lending facility. The recourse to this standing facility has been always negligible compared to the open market operations. But persistent recourse to the marginal lending facility regardless of its higher interest rate makes searching the motivations behind the use of this facility interesting.

A preliminary look at the amount of borrowing through marginal lending facility draws the attention to two dates. Of these dates, March 2004 is the month an operational framework change took place. The second date is August 2007, the start of the financial turmoil that caused interbank funding markets to stop functioning. Borrowing from the marginal lending facility picked up after the collapse Lehman Brothers. The following paragraphs summarize the scope of these important dates that will be explained in detail in the third section of this thesis.

Prior to March 2004, the key ECB rates could be changed within a reserve maintenance period –not only at the start of the reserve maintenance period. So banks could expect any rate change within the prevailing reserve maintenance period. The two week maturity of the weekly main refinancing operations -the most important open market operation in the Eurosystem- was implying an overlap of the last operation of the maintenance period with the subsequent maintenance period. Therefore, banks could form expectations of a rate change to take place in the subsequent reserve maintenance period. As a result, expectations of a rate change in the prevailing and the following maintenance period affected bidding in main refinancing operations. Ideally, bidding should be such that obtaining liquidity either from the central bank or from the interbank money market is arbitrage-free. However, an expectation of a reduction in the key ECB interest rates led banks to submit bids that fell short of the amount needed to ensure that the

reserve requirements met. Banks running short of liquidity had to take recourse for borrowing from the ECB.

In March 2004, the ECB revised its operational framework such that interest rate changes could only take place at the start of the maintenance period. As the operational framework change aimed to remove the impact of expectations of interest rate changes within a maintenance period, the new framework was expected to enhance the efficiency of open market operations. If it really had increased the efficiency and provide a more balanced liquidity situation in the market, we would expect a decrease in the recourse to the marginal lending facility.

Since August 2007, the implementation of the monetary policy has been subject to unprecedented challenges. The crisis, which has appeared in the US first, affected the money market in the Europe inevitably. The investors who hold assets based on US subprime mortgages became reluctant to hold and to further invest in these assets. Banks providing liquidity became concerned about their own liquidity positions. With rising uncertainty, risk-aversion and liquidity drain, the ECB interbank markets failed in terms of lending and borrowing transactions. Banks with excessive liquidity preferred to use deposit facility of the national central banks which seem to be more secure than any other alternative. The banks in need of liquidity could not find a counterparty to borrow. So they were forced to borrow from the marginal lending facility. In this thesis, I try to provide a deeper understanding of the underlying reasons that cause banks to use the standing facilities of the ECB despite unfavorable rates.

The structure of the rest of this thesis is as follows: The next chapter is literature review. The third chapter provides background information about the operational framework of the ECB. The fourth chapter identifies the change in the operational framework in March 2004. In the fifth chapter some stylized facts are given for the key rates of the Eurosystem and the use of the marginal lending facility. The sixth chapter motivates the possible determinants of the daily borrowing and how the changes in the operational framework and the financial turmoil have influenced the relation between the basic determinants of borrowing. In the seventh chapter, an equilibrium model, which is almost the same as the model developed in Artuç and Demiralp (2010), is applied (but failed) for examining the borrowing behavior in the Euro area. The last chapter section concludes.

Chapter 2

LITERATURE REVİEW

This thesis investigates the borrowing from the ECB and applies an equilibrium model for the interbank money market of the Eurosystem. Previous literature is mainly related to the Federal Reserve (Fed)'s discount facility in this manner. The borrowing behavior of banks within the Euro area is examined for the first time in the literature.

For the borrowing function, Goldfeld and Kane (1966) underlie the dominance of the spread between the interbank money market interest rate (namely federal funds rate as they focus on the Fed) and the interest rate applied for overnight borrowing from central bank (namely discount rate as they focus on the Fed) in explaining borrowing from the Federal Reserve. But the relationship between this spread and borrowing had evolved over time. Pearce (1993) found empirical evidence that bank borrowing behavior at the discount window changed when the Federal Reserve changed its short-run operating procedures and reserve accounting rules.[3] He pointed out diminishing sensitivity of borrowing to the spread between the funds rate and the discount rate overtime as the operational framework changed. However, in spite of this decline in the traditional borrowing function, Dow (2001) showed the usefulness of distinguishing the spread between the targeted Federal funds rate and the discount rate from the spread between the actual Federal funds rate and the targeted rate.

From one point of view, the reluctance to borrow from the Fed (like diminishing sensitivity of borrowing to the spread between the funds rate and the discount rate) was due to the discount rate below the rate that banks faced in the federal funds market. As a result, borrowing from the

[3] Specifically, Pearce (1993) investigated the borrowing function for different operational frameworks: Federal Funds rate targeting (1975-1979), nonborrowed reserves targeting (1979-1982), contemporaneous reserve accounting under borrowed reserves targeting (1984-1991).

Fed was generally cheaper than borrowing on the interbank market. This would appear to present an arbitrage opportunity as noted in Courtois and Ennis (2010). To discourage the recourse to the discount window borrowing for arbitrage purposes, the Fed required banks to explain why they were in need of funds. But this non-price rationing mechanism (non-price cost for banks) made banks remain reluctant to borrow from the Fed (see Goodfriend (1983); Pearce (1993); Dutkowsky (1993); Clouse and Dow (1999), Dow (2001), Furfine (2003), Darrat et al. (2004), Artuç and Demiralp (2010)).To address this reluctance; the Fed revised its discount window lending program in 2003. Hereafter, the interest rate applied for borrowing is set above the rate that banks faced in the federal funds market and banks do not need to provide a reason for their desire to borrow (a reduction in implicit cost).

Artuç and Demiralp (2010) investigate whether the borrowing function reappears after the mentioned changes in 2003. They noted that the borrowing function reemerged with the establishment of the new borrowing facility from the Federal Reserve in 2003. Constituting a base for this thesis, Artuç and Demiralp (2010) estimate the borrowing function with factors that may affect borrowing decisions at the aggregate level with daily data. They use the spread between the funds rate and the discount rate to identify the reluctance to borrow from the Fed. Also they use a variable that captures those instances when the maximum funds rate traded for that day deviated from the target by at least one percentage point to measure the extent to which market participants turn to the new borrowing facility if the federal funds rate exceeds the discount rate (or the primary credit rate after 2003). They check for the sensitivity of borrowing to late-day tightness following Madigan and Nelson (2002) by using the spread between the federal funds rate ar the close of the day and the target rate. Daily liquidity conditions are also considered by using deviation of the funds rate from the target in the previous day (capturing the persistence of market tightness), required operating balances, dummies for the last day of maintenance period and special pressure days. For clarifying borrowing due to technical difficulties, they use a dummy for the days on which Fedwire system (facility for electronic transfer of funds) extensions occurs. Intraday fed funds volatility is also considered for reflecting any turmoil in the funds market. Lastly, as Demiralp and Farley (2005) reveal that factors that contributed to the decline in fed funds volatility (such as improvements in internal information systems, banking industry consolidation, or adjustments to the Desk's reaction function,) could

reduce the need for borrowing, they also use a linear time trend to capture the gradual improvements due to aforementioned factors.

Overall, their results provided strong support for the argument that the borrowing function re-emerged after 2003, consistent with the decline in the implicit cost of borrowing in that period. In this thesis, the borrowing function used by Artuç and Demiralp (2010) is applied to the ECB framework (dependent upon data availability) to analyze the changes in the borrowing behavior before and after the operational framework change of the ECB and before and after the recent financial crisis.

Previous literature on modeling the funds market goes back to the typical simple model of the funds rate (see Poole (1969)). The federal funds market is the interbank market in which banks meet their daily liquidity needs. In this typical model, the supply of funds is determined by the Federal Reserve, subject to exogenous shocks. The demand for funds is determined by reserve requirements and excess reserves which are used as a buffer to avoid an unexpected withdrawal of funds. If reserve requirements are not met, there is a penalty rate. Banks face an uncertain flow of funds. Each bank chooses a level of reserves, of which the opportunity cost is the federal funds rate.

Clouse and Dow (1999) modified this simple model. They made the model dynamic by adding a second period. Also they added a fixed penalty in addition to a variable penalty for banks that can not meet the reserve requirement and introduced bank-specific as well as system-wide shocks. Artuç and Demiralp (2010) follow the model of Clouse and Dow (1999) by modifying it to explore the changes in the fixed cost of borrowing empirically (as they focused on the changes in the fixed cost of borrowing after the disappearance of the borrowing function) and make some simplifications to the model.

This thesis follows the empirical model developed by Artuç and Demiralp (2010) with certain modifications due to data availability. The equilibrium model for the ECB interbank market is almost the same with the model developed by Artuç and Demiralp (2010). The regression model as well as the equilibrium model is estimated to understand the underlying motivations behind the

use of the marginal lending facility of the ECB. In order to understand the empirical framework, the next section provides information on the operational structure of the ECB.

Chapter 3

THE OPERATIONAL FRAMEWORK OF THE ECB[4]

The ECB formulates monetary policy for the Euro area relating to monetary objectives, key interest rates and supply of reserves. But the operational aspects of monetary policy, such as open market operations, administration of reserve requirements and the management of the standing facilities, are undertaken by the national central banks of the Euro area in a decentralized fashion. The primary objective of the Eurosystem, which comprises the ECB and the national central banks of those countries that have adopted the Euro, is to maintain price stability. To achieve this aim, by virtue of its monopoly, the ECB is able to manage the liquidity situation and influence interest rates in the money market. It plays a pivotal role for the healthy functioning of money market by helping credit institutions meet their liquidity needs in a smooth manner.

Bank's liquidity needs mainly arise from two factors: minimum reserve requirements and autonomous factors. Minimum reserve requirements are imposed on credit institutions by the Eurosystem; so, they are under the direct control of the central bank. On the other hand, autonomous factors are comprised of banknotes in circulation, government deposits (current account balances held by national treasuries in national central banks), net foreign assets (purchases of foreign assets by the Eurosystem) and other net factors. They are called autonomous factors because they are normally outside the control of the ECB and constitute by far the largest source of uncertainty about the liquidity needs of banks. Of the autonomous factors, banknotes in circulation and government deposits absorb liquidity from the banking system whereas net foreign assets provide liquidity to the banking system. As the banking system has structural liquidity deficit by the factors above, it is reliant on refinancing from the Eurosystem.

[4] See European Central Bank (2004).

The ECB manages the liquidity by assessing the liquidity needs of the banking system and supplying or absorbing the appropriate amount of liquidity through open market operations. In order to adequately adjust the liquidity supply to the liquidity needs via weekly main refinancing operations, the ECB needs to forecast autonomous factors weekly. Also for alleviating the stress of overnight liquidity needs, the ECB provides or absorbs liquidity within the banking system by standing facilities. The scope of the thesis is based on one of these kinds of facilities, namely marginal lending facility.

3.1 Open Market Operations

Through open market operations, the ECB steers the short term interest rates in the interbank market, manages the liquidity condition in the market, and signals the stance of monetary policy. Open market operations are divided into four categories: main refinancing operations, longer-term refinancing operations, fine-tuning operations, and structural operations. These categories are differentiated by their aim, regularity, and the procedures followed.

The most important open market operations conducted are the main refinancing operations. These are regular, weekly, liquidity providing reverse transactions which mature in one week (prior to March 2004, it was two weeks)[5]. In open market operations of this kind, the ECB provides the bulk of liquidity to the banking system either by buying assets under repurchase agreements or by granting a loan against collateral. These refinancing operations are conducted according to a pre-announced schedule; in other words, executed through standard tenders. The tenders may take the form either fixed rate or variable rate.[6] The rate for the main refinancing operations is set by the Governing Council and is one of the key interest rates, in particular, the

[5] Reverse transaction is an operation whereby the central bank buys or sells assets under a repurchase agreement or conducts credit operations against collateral. Where a reverse transaction takes the form of a repurchase agreement, repurchase price includes the interest to be paid. In the form of a collateralized loan, the interest is determined by applying the specified interest rate on the credit amount over the maturity of the operation.

[6] Fixed and variable rate tenders will be explained in detail later.

ECB's policy rate.[7] Although this interest rate is not an implicit target rate like the Fed's federal funds rate, it is a primary tool to signal the ECB's policy stance as an explicit target rate.

Another type of open market operations is longer-term refinancing operations which are executed monthly with three month maturity. As it is understood from its name, longer-term refinancing operations aim at providing longer term liquidity. Like the main refinancing operations, they are conducted as reverse transactions and standard tenders but with pure variable rate tender where bids of banks are all satisfied at the individual bid rates.

In addition to regularly conducted operations, Eurosystem also considers operations on an ad hoc basis via fine tuning operations. These are either liquidity absorbing or liquidity providing operations depending on the liquidity fluctuations and maturity is not standardized. Fine-tuning operations may take the form of reverse transactions, outright transactions, foreign exchange swaps and the collection of fixed-term deposits.[8] Different form other kinds of open market operations, only a limited number of selected counterparties may participate in. Also they may be bilateral, meaning that transaction takes place with a few banks without a tender.

To adjust the structural liquidity position, the ECB can also use structural operations. They may be liquidity absorbing or liquidity providing with non-standardized maturity.

3.2 Standing Facilities

The standing facilities are the other operational tools available to the Eurosystem conducted for the purpose of controlling short-term interest rates in the money market. They provide or absorb liquidity especially in exceptional circumstances with an overnight maturity on the initiative of banks. They signal the general stance of monetary policy and bound overnight

[7] The Governing Council is the main decision-making body of the ECB.

[8] Outright open market transactions refer to operations where the Eurosystem buys or sells eligible assets outright on the market. Foreign exchange swaps executed for monetary policy purposes consist of simultaneous spot and forward transactions in euro against a foreign currency. Collection of fixed-term deposits refers to the Eurosystem's invitation of counterparties to place remunerated fixed-term deposits with its national central bank.

market interest rates. The Eurosystem offers credit institutions two overnight standing facilities: the marginal lending facility and the deposit facility.

The marginal lending facility is a tool for providing liquidity whenever a bank needs it. Lending is on an overnight basis and accessed at the discretion of banks in need. Except for the collateral, there are no limits on the access. But the interest rate for this facility is set substantially above the daily interest rate in the interbank market, Eonia (the Euro Overnight Index Average)[9]. As it is more costly to borrow through the marginal lending facility -due to the higher interest rates compared to the market-, other than the exceptional circumstances banks prefer borrowing from the interbank market rather than using this facility.

The other standing facility within the Eurosystem is the deposit facility. A bank may recourse to the deposit facility to make overnight deposits with its national central bank. It has an overnight maturity, like the marginal lending facility. The interest rate for this facility, the deposit rate, is set substantially below Eonia. Hence the banks, which have excess end-of-day liquidity, try to avoid using the ECB's permanent overnight deposit facility unless there are no other secure alternatives to deposit.

3.3 Reserve Requirements

The ECB requires credit institutions to hold compulsory deposits on accounts with the national central banks in order to create a structural liquidity shortage of the banking system and stabilize the money market interest rates. In this manner, the major component of the liquidity needs of the banking system is reserve requirements. The amount to be held by each institution is determined by its reserve base which comprises of the bank's liabilities to which a positive reserve ratio is applied. Banks do not have to hold the required amount on every day of a maintenance period. Their current account holdings can fluctuate freely around the reserve requirement allowing banks to smooth out daily liquidity fluctuations. Nevertheless, the average current account holdings must at least be equal to the reserve requirement over the whole

[9] Eonia is computed as a weighted average of all overnight unsecured lending transactions in the interbank market, initiated within the euro area by the panel banks. Only the most active banks located in the euro area are represented on the panel and the geographical diversity of banks in the panel is maintained.

maintenance period. At the end of the period, the reserve requirement becomes binding and banks can no longer transfer a liquidity surplus or deficit to another day in the relevant maintenance period. As this is the case, towards the end of each maintenance period the Eonia departs from the main refinancing rate more than it departs in any day of the period.

Chapter 4

CHANGES IN THE OPERATIONAL FRAMEWORK

From January 1999 to June 2000 the ECB conducted its main refinancing operations as fixed rate tenders. In fixed rate tenders, the interest rate is fixed in advance by the Governing Council. Then, the counterparties bid the amount of money they wish to transact at this fixed rate. On several occasions, there were market expectations in the direction of an increase in the key ECB interest rates. On these occasions short-term money market rates were significantly above the main refinancing rate (the fixed rate under the fixed rate tenders procedure) as noted in European Central Bank (2004). The existence of a wide and persistent spread between the fixed rate and the money market interest rate motivated the banks to bid for larger amounts of liquidity than they needed. To overcome the overbidding problem under the fixed rate tenders, a new tender procedure was introduced.

Starting from June 28, 2000, the Governing Council decided to switch to variable rate tenders in the main refinancing operations. In this procedure, the Governing Council sets a minimum bid rate. Then, eligible counterparties bid both the amount of money and the respective interest rate at which they wish to transact this amount. Bids below the minimum bid rate are discarded. In a variable rate tender, overbidding is not attractive because if the banks overbid to obtain more liquidity they would have to pay more. Hence banks submit bids that are closely to their actual liquidity needs.

Over time, the variable rate tenders with a minimum rate led to underbidding during times when the markets expected a reduction in the key ECB interest rate as noted in European Central Bank (2004). Since banks would have to pay a higher price if they want to obtain more liquidity, an expectation of rate reduction led to bank to underbid and wait for the rate reduction to get more liquidity with lower cost.

Underbidding and overbidding behavior showed that preventing the occasional tensions could not be eliminated within the current framework due to the impact of expectations. Therefore, the Governing Council decided to adjust its operational framework as of March 2004.

Overbidding and underbidding problems were both caused by the independence of the timing of the reserve maintenance periods and the dates of the Governing Council meetings at which the interest rate decisions are taken. The Governing Council's meetings are held on Thursday in the first and third week of each month. The stance of the ECB's monetary policy is assessed by the Governing Council, as a rule, only at the first meeting of the month. Accordingly, interest rate decisions are normally taken during that meeting. Prior to March 2004, the maintenance periods were formed from 24th calendar day of each month to the 23rd calendar day of the following month. In addition, prior to March 2004, the maturity of the weekly main refinancing operations were two weeks. Therefore, the maturity date of, at least, the last weekly main refinancing operations of a reserve maintenance period overlapped with the subsequent reserve maintenance period. Also, prior to March 2004 the key ECB interest rates could change within a reserve maintenance period as the first meetings of the Governing Council took place within a reserve maintenance period.

The response of banks to these challenges was to bid in the main refinancing operations conducted at the end of a maintenance period according to their expectations. The expectations of an increase in the key interest rates led banks to bid in excessive amounts (overbidding). In a similar manner, whenever there were expectations that the key interest rates were about to be decreased, banks submitted bids lower than the amount needed for the smooth fulfillment of reserve requirements (underbidding).

To respond to these problems, the Governing Council made two changes within the operational framework of the ECB effective from March 10, 2004: (i) the reserve maintenance period would start on the settlement day of the first main refinancing operation following the Governing Council meeting at which the monthly assessment of the monetary policy stance was pre-scheduled, and would end on the day preceding the corresponding settlement day in the

following month.[10] (ii) The maturity of the main refinancing operations was shortened from two weeks to one week. Hereby, the interest rate change speculation for the main refinancing operations and the standing facilities during a maintenance period would be prevented and the impulsive force of market expectations towards improper bidding behavior would be eliminated (European Central Bank, 2004).

[10] With the new definition, the length of the maintenance period varies from 20 to 43 days.

Chapter 5

DESCRIPTIVE DATA

The main objective of the Eurosystem's operational framework for monetary policy is to steer short term interest rates and to provide a stable path for the overnight money market interest rate over the policy rate (which is the rate for main refinancing operations). So, closer looks at the corridor in which the Eonia fluctuates and the spread between the Eonia and the main refinancing rate are of importance. Also a preliminary look at the recourse to the marginal lending facility assesses the performance of daily borrowing within the Euro area.

Figure 1 graphs the Eonia, the ECB policy rate, the deposit rate and the marginal lending rate. It reveals that the overnight rate has tracked the ECB policy rate rather closely within the corridor formed by the rates applied on the standing facilities.

From January 4 through January 21, 1999, the interest rates on the two standing facilities were set 50 basis points apart, 25 basis points on either side of the main refinancing rate. It was aimed to help the transition to the single monetary policy system by market participants within the Euro area. Then, until October 8, 2008, a wider corridor of 200 basis points was set between the marginal lending rate and the deposit rate.

However, from October 8, 2008 to January 21, 2009 the corridor was narrowed down to 100 basis points. Specifically, the marginal lending rate was set 50 basis points above the main refinancing rate and the deposit rate was set 50 basis points below the main refinancing rate. This move was an attempt to cure the distorted money market because of the global financial crisis and to strengthen the role of the ECB. With the failures of major investment banks such as the bankruptcy of Lehman Brothers and the reluctance of liquidity rich banks to lend to those in need of liquidity for fear of counter party risk, the liquidity supply in the market decreased significantly. Banks with excessive liquidity preferred to use the deposit facility of the national

central banks. In other words, the global financial crisis lead to "flight to safety" phenomenon which meant that banks deposited more through the deposit facility which seemed to be more secure than the interbank market. On the other hand, those banks who wanted to borrow could not find a lender in the market place at the ongoing Eonia rate. They were forced to borrow funds from the relatively expensive marginal lending facility.

Since the massive amounts of deposits at the national banks distorted the functionality of the money market, the ECB decided to re-widen the corridor to 200 basis points on January 21, 2009. This move was an attempt to discourage the use of deposit facility, to bring the conditions in the interbank market back to normal and to revive bank lending again.

As seen form Figure 1, the interest rates applied for the standing facilities are effective as the Eonia fluctuates within the corridor they constitute. The operational framework also has been robust when faced with exceptional challenges, like the transition to the millennium year 2000, the terrorist attacks of September 11, 2001 or the Euro cash changeover in January 2002. The marginal lending rate and the deposit rate have constituted the upper and lower limits for the Eonia respectively. The operational framework also has been robust to the turmoil that started in August 2007. As the corridor framework is observed for the whole sample period covered –from 1999 to May 2009-, the framework had considerable success all over the period the ECB has existed.

A closer look at the spread between the Eonia and the main refinancing rate is also of importance by the aforementioned aims of the ECB. Figure 2 plots this spread. The figure is helpful in supporting the argument that the new framework in 2004 decreased the spread. The absolute value of the average spread before March 2004 was 11 basis points while it was 8 basis points from March 2004 through August 2007. Meanwhile the crisis period suffered form very high spread. The absolute value of the average spread from August 2007 through May 2009 increased to 20 basis points.

Figure 3 shows the recourse to the standing facilities. As the standing facilities help to provide and absorb liquidity only in exceptional circumstances, the recourse to the standing facilities are very low compared to open market operations. The only point that captures attention

is the turmoil period in this figure. Looking at Figure 4 which excludes the turmoil, the date of the operational framework change in March 2004 becomes clear. With a preliminary look, enormous spikes of the recourses to both standing facilities observed under the old framework seem to decrease after the framework change. Since this thesis investigates the details of borrowing from the ECB, I will focus on the marginal lending facility hereafter.

Table 1 summarizes the recourse to the marginal lending facility over time for different periods. Under the old framework, the mean recourse to the marginal lending facility was three times as much as the mean recourse under the new framework excluding the turmoil (EUR 508 million under the old framework, EUR 165 million under the new framework). This is largely due to the outliers seen in Figure 4 corresponding to the end of the first maintenance period of the ECB, the transition to the millennium year 2000, the last day of the last maintenance period of the Euro cash changeover in January 2002 and some underbidding episodes. These outliers caused a large average recourse under the old framework compared to the new framework.[11] At the same time, borrowing is more volatile under the old framework as the standard deviations in the forth column of Table 1 demonstrate (EUR 2.1 million under the old framework, EUR 0.6 million under the new framework). Together with the decreased spread between the Eonia and the main refinancing rate, decreasing mean and volatility of borrowing through marginal lending facility support the efficiency of the new framework. Although it is unrealistic to attribute the whole declines to the establishment of the new framework, it is helpful in supporting the new framework's efficiency.

The mean borrowing in the financial crisis period (EUR 1668 million) is about ten times of borrowing in the period before the turmoil under the new framework (EUR 165 million), three times of borrowing under the old framework (EUR 508 million). Also the standard deviation during the crisis period is very high compared to its past values (EUR 3.9 million). Focusing on the period after the collapse of Lehman Brothers, the mean and the standard deviation of the borrowing through the marginal lending facility increase further (to EUR 4417 million and to EUR 5.6 million respectively). These results confirm the liquidity drain that forced those banks who could not find a counterparty to borrow to use the marginal lending facility.

[11] See European Central Bank (2003) for the exact underbidding dates.

Chapter 6

ESTIMATION OF THE DAILY BORROWING BEHAVIOR

The previous section points to the changing borrowing behavior of the banks within the Eurosystem in the course of time. In this section the determinants of the borrowing behavior of the banks in the Eurosystem are analyzed. Firstly, the old and the new framework before the beginning of the turmoil will be examined. Then, the effect of turmoil on the borrowing behavior will be analyzed only under the new framework.

Daily data is used for borrowing through the marginal lending facility. The sample period starts on January 4, 1999 which corresponds to the introduction of the single monetary policy under the authority of the European Central Bank. The starting date of the sample period underlines the single currency, Euro, and the single monetary policy framework. The sample period ends on April 31, 2009. The time interval of the sample includes March 2004, which is the date of the changes in the operational framework of the ECB. This date will be one of the key dates of the daily borrowing estimation. Also the sample period includes the liquidity crisis that started in August 2007. The crisis gives rise to the abnormal usage of the marginal lending facility, which was seen from Figure 1 and Table 1. Borrowing data and the key interest rates of the Euro area are obtained from the official website of the ECB. The historical Eonia rates are provided by the Euribor website of the European Banking Federation at www.euribor.org.

6.1 Pre-March 2004 and Post-March 2004 Periods

In this section, I estimate a regression equation that focuses on the borrowing function. In order to purely focus on the effects of the new framework that is introduced on March 2004, the liquidity crisis period is excluded. The sample is divided into two sub-periods, before and after March 9, 2004 by interactive dummy variables I specify an equation with the volume of

borrowing through the marginal lending facility as dependent variable. The specification of the right hand side variables follows Artuç and Demiralp (2010), depending on data availability.

The regression results are shown in Table 2. The second column and the third column show the estimates for pre- and post-Mach 2004 periods respectively. The last column of the table presents the test of hypothesis whether the coefficients from each sample are significantly different across periods. In particular by running Wald tests I test the null hypothesis that the value of each coefficient before the operational framework change is the same in the rest of the sample. After March 2004, the interest rate change speculation for the main refinancing operations and the standing facilities during a maintenance period would be prevented and the impulsive force of market expectations towards improper bidding behavior would be eliminated. So, in particular, I expect a significant decrease in recourse to the marginal lending facility with the operational framework change.

The borrowing behavior may be sensitive to the last day of the maintenance period. Figure 5 shows the daily average use of the marginal lending facility within a reserve maintenance period. The figure confirms that the use of the marginal lending facility is particularly high on the last day of the reserve maintenance periods. The reason beyond this fact is the averaging mechanism of the minimum reserve system. The averaging mechanism allows banks to run daily reserve deficits and surpluses. Accordingly, banks can either bring forward the fulfillment of the reserve requirements or postpone it until the end of the maintenance period. On the last day of the maintenance period liquidity deficits or surpluses can not be compensated by opposite imbalances within the same period anymore. As the reserve requirements become binding, the use of the marginal lending facility reaches its peak level. The dummy variable for the last day of the maintenance period checks the sensitivity of borrowing to this special day for the two sub-sample periods. Both periods' coefficients are positive and significant (27.73 and 13.85 for pre- and post-March 2004 respectively) Comparing the coefficient estimates from pre-March 2004 sample with post-March 2004 sample, we see that banks' sensitivity in the second period decreases to less than the half of the first period. This difference is highly significant as shown in the last column. This suggests that banks are more likely to borrow on the last day of the maintenance period to meet their reserve requirements in pre-March 2004 period. The better

overlap of maintenance periods and refinancing operations in the later period likely reduced the need to borrow on the last day of the maintenance periods in this era.

The spread between the Eonia and the marginal lending rate is one of the independent variables that are used for the estimation of daily borrowing. This variable corresponds to what Goldfeld and Kane (1966) noted about the dependence of borrowing on the spread between the funds rate and the discount rate through the discount facility of Fed. For the Eurosystem, when a bank borrows from the interbank market, it pays the interbank interest rate, Eonia. On the other hand, if it borrows through the ECB's standing facility channel, it pays the marginal lending rate as the interest rate. Ceteris paribus, borrowing from the national central banks should be positively related to the spread between the Eonia and the marginal lending rate decided by the Governing Council. Pre-March 2004 period coefficient is 32.67. Post-March 2004 sample's is 41.09. For both sample periods the coefficients of this spread are very close to each other, positive and significant. The slight difference between these two coefficients is not significant as shown by Wald test in the last column. This suggests that the second sample period is as sensitive as the first sample period to the spread between the Eonia and the marginal lending rate and there is no reluctance regarding borrowing from the marginal lending facility all over the Euro area.

The next variable captures the daily liquidity conditions in the interbank money market. It is one day lagged spread between the main refinancing rate, which is the key interest rate decided by the Governing Council to reflect the monetary stance of the ECB, and the Eonia. This is taken from Carpenter and Demiralp (2006) who studied the liquidity effect in the federal funds market at a daily frequency. They showed that there is a daily persistence of the tightness in the federal funds market. Following this paper, in the later study by Artuç and Demiralp (2010), the deviation of the funds rate from the target in the previous day (t-1) is considered as an important variable that affects borrowing from Fed on a particular date (t). What Artuç and Demiralp (2010) found was a negative and significant coefficient for the deviation of the funds rate from the target in the previous day, using borrowing from Fed's discount window as the dependent variable. It was showed as evidence for the capability of the additional injection of balances by Fed on a daily basis for lessening borrowing needs. There are, however, a few key differences between the use of open market operations by the Federal Reserve and the ECB (for further

details see Pollard (2003)). One of these differences is that the ECB conducts main refinancing operations only once per week in contrast to the Fed's daily operations. So tightness in one day is carried over to the following day because ECB does not intervene with daily operations. In this regard, the deviation of the Eonia from the main refinancing rate in the previous day reflects the persistence of banks' response for the liquidity conditions in the market. For the pre-March 2004 sample period, the banks in the Euro area respond the market tightness in the previous day by increasing their borrowing through the marginal lending facility. The coefficient is 10.10. It is positive and significant. A significant and positive coefficient for the corresponding spread in the Euro area is probably due to the weekly -not daily- intervention of the ECB. Open market operations are conducted only once a week. So, banks suffering from liquidity drain can not benefit from open market operations everyday. Therefore, they are forced to borrow from the marginal lending facility to eliminate the persistence of overnight liquidity pressures. For the second sample period, post-March 2004, the coefficient is negative, -3.25, and insignificant. But, the difference between significance of the coefficients for two periods is not significant as shown in the last column. This indifference indicates that banks do not change their behavior in the case of tightness whatever the operational framework is.

The next variable investigates the relationship between required reserves and borrowing. As noted in Artuç and Demiralp (2010), a negative relationship is expected between them. This is because when banks hold low levels of reserves, any unexpected withdrawals would make banks suffer from insufficient liquidity. Hence they may need to borrow more if there is an unexpected overnight liquidity drain in the interbank market. The coefficient of log of required reserves is -42.15 and significant for the first sample period whereas it is 36.83 and insignificant for the second sample period. The coefficient of the first period is negative and significant as one may expect. This difference is significant at 1% level of confidence as shown in the last column of Table 2.

Daily borrowing may also be affected by special pressure days such as month-ends, quarter-ends, year-ends and first day of a year as payment-related demand of funds are elevated on such days. While the argument is highly plausible, the coefficients of the dummy for special days are

turned out to be insignificant for both periods. Also they are not different from each other as the last column of Table 2 shows.

Lastly, a time trend is added to the model to control for any gradual improvement over time that is not captured by the variables used. Such improvements could be better reserve management strategies by the ECB. The time trend is not significant in either sample. Insignificancy may be due to the set of control variables taking account of the presence of a common trend in the data or due to the insufficient trend modeling. There is no significant difference across periods as shown in the last column of the table.

In this sub-section, I investigated whether there were any distinguishable patterns in the borrowing behavior after the introduction of operational changes in March 2004. As I expect, I found that the recourse to the marginal lending facility on the last day of the maintenance period significantly decreases after the operational framework change. It seems to reduce sensitivity of borrowing on the last day of the maintenance period. Also, the borrowing behavior does not differ across periods in terms of the sensitivity to the explicit cost of borrowing. Before March 2004, in maintenance periods with liquidity deficit, tightness in one day is carried over to the following day until an open market operation is conducted. Banks are forced to borrow more in overnight maturity in order to fulfill the reserve obligations. The short maturity and removing of expectations had reduced persistence of overnight liquidity pressures by providing a more certain outlook. The operational framework change did not affect borrowing on special days or insignificancy of the time trend.

6.2 Pre-crisis and Post-crisis Periods

In the second part of the analysis, the focus is on the days after March 9, 2004 what I call the new framework. In this section, I investigate whether the recent financial turmoil caused any changes in the borrowing behavior from the ECB. As one may expect, banks, which can not seek out a lender because of the distorted interbank market during the crisis, may go to the marginal lending facility to satisfy their liquidity needs. Figure 2 documents the ample use of the marginal lending facility during the recent liquidity crisis. To analyze this drastic effect on the daily

borrowing behavior, the sample after March 2004 is split up into two periods before and after August 2007. The regression model is the same as the previous estimation.

Table 3 shows the regression results. In this subsection, I investigate the effects of the turmoil on the borrowing behavior of banks. So it is meaningful to repeat the estimation for the period between March 2004 and August 2007 and compare it to the turmoil period. In this manner, the second column and the third column of Table 3 show the estimates for pre- and post-August 2007 periods respectively. The estimation in the second column covers the same period with the previous section's second sample period (from March 2004 to August 2007). The last column of the table presents the test of hypothesis whether the coefficients from each sample are significantly different across periods. In particular by running Wald tests I test the null hypothesis that the value of each coefficient before the operational framework change is the same in the rest of the sample. In particular, there may be a decline in the recourse to the marginal lending facility that may be attributed to the unexpected changes in the interbank market due to the recent decline of excess global liquidity. This recourse may also be seen in the last day of the maintenance period. Besides, I expect a significant time trend for the financial turmoil period capturing the gradual changes in the interbank money market.

As explained before, since reserve requirements become binding on the last day of the maintenance period, the use of the marginal lending facility is highest on these days (see Figure 3). The last day of the maintenance period positively and significantly affects the borrowing for both samples. This confirms the fact that when it is the last day, daily borrowing increases to meet the reserve requirements. However, banks are less likely to borrow from the central bank after the crisis. The coefficients are 13.85 and 8.43 for pre- and post-August 2007 respectively. The difference is not significant as shown in the last column of Table 3. Daily borrowing still exhibits sensitivity to the last day of the reserve maintenance period.

The difference between the Eonia and the marginal lending rate is the second independent variable considered. If this spread increases, the opportunity cost of using marginal lending facility -the price of borrowing- increases. So, it is expected that the spread between the Eonia and the marginal lending rate is positively related to the daily borrowing. For the pre-crisis period and the post-crisis period, the coefficient estimates of the spread are 41.09 and 78.56

respectively. They are both positive, as expected, and highly significant indicating the forcefulness of the interbank money market conditions on the daily borrowing behavior of the banks. In other words, the Euro area market participants have no reluctance to borrow by using the marginal lending facility and borrowing function is always sensitive to the price of borrowing. Nevertheless, the difference between these two coefficients is significant as shown in the last column, indicating that the sensitivity of borrowing to the explicit cost of borrowing increases after the start of the turmoil.

The third regressor is the one day lagged spread between the main refinancing rate and the Eonia which captures the daily liquidity conditions in the interbank market. The coefficient estimate of the one day lagged spread between the main refinancing rate and the Eonia is -3.25, negative but insignificant for the pre-crisis period under the new framework. But the liquidity scarcity following August 2007 again makes the borrowing function dependent on the market's liquidity conditions. The coefficient estimate for the crisis period is -39.16, negative and highly significant. A significant and negative coefficient for the corresponding spread in the Euro area is probably due to the loose monetary policy of the ECB. The difference between the coefficients of the spread is significant at about 1 percent level of confidence as shown in the last column of Table 3. It seems that the additional injection of balances through the turmoil period as a part of loose monetary policy reduces the borrowing need of banks from the central banks.

The next variable investigates the relationship between the required reserves and daily borrowing. A negative relationship is expected between log of required reserves and the normalizing borrowing. This is because when banks hold low levels of reserves, any unexpected withdrawals would make banks suffer from insufficient liquidity. Hence they may need to borrow more if there is an unexpected overnight liquidity drain in the interbank market. The coefficient for the log of required reserves is positive but insignificant for the period before turmoil. On the other hand, the sign of the coefficient is negative -as expected- for the turmoil period. Also it becomes significant in the turmoil period. The difference between coefficient estimates is highly significant level as shown in the last column of Table 3.

Daily borrowing may also be affected by special pressure days such as month-ends, quarter-ends, year-ends and first day of a year as payment-related demand of funds are elevated on such

days. While the argument is highly plausible, the coefficient of the dummy for special days is turned out to be insignificant for both periods. The difference between these two coefficients is not significant as shown in the last column.

The coefficient estimate of the time trend is insignificant before August 2007. However, it becomes positive (24.02) and significant post August 2007 as I expect. Furthermore, the difference is highly significant indicating a strong time trend at the turmoil period. It reveals unprecented inability of the independent variables to pick up gradual improvements over time and may be attributed to the unexpected changes in the interbank market due to the recent decline of excess global liquidity.

In this sub-section, I investigated whether there were any distinguishable patterns in the borrowing behavior after the start of turmoil in August 2007. The turmoil period has suffered from liquidity drain all over the world. With respect to interest rates, the ECB's Governing Council reacted promptly and lowered the key interest rates. It started to provide refinancing well above the levels that banks had absorbed to fulfill their reserve requirements in normal times and accept a very wide range of collateral. A featured characteristic of the borrowing after the turmoil is the strong time trend. This may be due to the present set of control variables that fell short in the turmoil period. These all amount to additional balances which have reduced the overnight borrowing needs in the Euro area. Banks are more sensitive to the cost of borrowing after the start of the turmoil. Sensitivity of borrowing to the last day of the maintenance period continued to exist. Borrowing on special days was neither significant nor different before and after the turmoil.

To sum up, in this section I examined whether the borrowing behavior of banks in the Euro area changed after the operational framework change in March 2004 and after the start of turmoil in August 2007. In particular, after March 2004, I expect a significant decrease in recourse to the marginal lending facility with the disappearance of the interest rate speculations. I found that banks are more likely to borrow on the last day of the maintenance period to meet their reserve requirements in pre-March 2004 period. The better overlap of maintenance periods and refinancing operations in the later period likely reduced the need to borrow on the last day of the maintenance periods in this era. After the start of the turmoil, the use of the marginal lending

facility continues to be high particularly on the last day of the reserve maintenance periods. A strong time trend was a featured characteristic of the borrowing after the starting of the turmoil as I expect. Also, I found that, the Euro area banks' borrowing behavior does not differ in terms of the sensitivity to the explicit cost of borrowing before and after the operational framework change-excluding the turmoil period-. But banks become more sensitive to this cost in the turmoil period. One day lagged spread between the Eonia and the main refinancing rate, and the required reserves had become insignificant with the operational framework change. But the turmoil period has made them important again in determining borrowing needs within the independent variables used. Besides, borrowing behavior never changes on special days over the whole sample period.

Chapter 7

A MODEL OF BORROWING

In this section, I use the model developed in Artuç and Demiralp (2010) which follows the static model used by Clouse and Dow (1999).

The simple framework of model is the following:

Bank i's goal is to keep its daily reserves holdings at a level L_1 on all days of a reserve maintenance periods except the last day. In fact, the Eurosystem's reserve maintenance system enables banks to make use of averaging provisions. In this respect, banks' daily holdings can fluctuate freely around the reserve requirements, but the average must be at least equal to the reserve requirement over the whole maintenance period. In this respect, it is reasonable to simplify the banks' reserve holdings at the same level L_1 on all days of a reserve maintenance periods except the last day. Because Figure 5 illustrates that borrowing from the marginal lending facility is highest on the last day of the maintenance period, only differentiation is for the last day of a maintenance period. On this day, the reserve requirements become binding. Therefore, bank i wants to keep its daily reserve holdings at a higher level than L_1. L_2 is the desired level of reserve holding on the last day of the reserve maintenance period which satisfies the condition $L_1 < L_2$.

On the other hand, a bank can not always satisfy its desired level of reserve holdings. The end of day balance may be lower or higher than the desired level. The reasons for this are the existence of aggregate and individual shocks to the average level of reserve balances ($\bar{R}$). In this manner, banks' balance holdings follow a stochastic process and the end of day balance of bank i is set equal to:

$$R_t^i = \bar{R} + U_t + V_t^i$$

where $U_t \sim N[0, X_u]$ is an aggregate shock and $V_t^i \sim U[-X_v, X_v]$ is an individual shock. X_u is the standard deviation of the aggregate shock while X_v represents the support of the mean zero uniform distribution. In addition, the distribution of U_t and V_t^i may get wider or narrower in a linear fashion over time. So I let:

$$X_u = A + D_t$$

$$X_v = B + E_t$$

To identify a bank as a lender or borrower in the funds market requires the comparison of the end of day balances with the desired level of reserve holdings for that particular day. For simplicity, I assume that $L_1 = L_2 = L$ for all banks. But banks differ by their reserve balances. Accordingly, if $R_t^i > L$ the individual bank has more holdings than its desired level and wants to supply excess funds in the market. Hence it becomes a lender. On the other hand, if $R_t^i < L$ the individual bank is short of reserves. It demands funds and becomes a borrower in the funds market for $L = L_1, L_2$.

Banks that are short of reserves, that is, any bank with $R_t^i < L$, have two options: They either choose to borrow from the interbank money market or they borrow from their own national central bank by using the ECB's marginal lending facility. If a bank chooses to borrow θ Euros from the interbank money market the cost per Euro is the market interest rate, namely the Eonia, r_t. Alternatively if a bank chooses to borrow the same amount of Euros from the national central bank, the cost per Euro is the marginal lending rate, r_m, and a fixed cost c. Thus, total cost per euro is $r_m + c/\theta$. Banks choose only one of these two options on their own behalf. As emphasized in Artuç and Demiralp (2010), partial borrowing from a national bank is not optimal. Since a bank has to pay the fixed cost independent of the amount it borrows from the central bank, partial borrowing wastes the fixed cost. This fixed cost may vary across countries and

banks depending upon the bank or country specific measures. However, it is assumed homogenous for all banks.

Up to now, I mentioned borrowing needs that are driven by market conditions subject to aggregate or individual shocks. In addition, there may also be borrowings due to technical difficulties such as network problems. Even though interbank money market is enough to meet the demand of funds, technical problems, such as a problem with the payment system connection of a bank, may leave banks with no choice but to borrow from their national central banks through the marginal lending facility. In order to capture this type of borrowing, I assume that a random fraction (p_t) of banks will borrow from central banks due to the technical problems which do not reflect the market conditions. p_t is a random variable which has a uniform distribution: $p_t \sim U[0, F]$. F is the interval parameter for the probability of a technical problem.

A continuum of banks is indexed from 0 to 1 according to reserve balance levels. A bank with the lowest level of reserve balances is indexed to 0. The one with the highest level of reserve balances is indexed to 1. Thus, a bank located close to 0 tends to demand funds from the market or the central bank and a bank close to 1 tends to supply funds to the market. Because of continuity, there are infinite numbers of banks. Each bank has zero individual measure while measures of all integrate to 1.

Figure 6 shows the distribution of indexed banks on the horizontal axis. Banks' goals are to keep their daily reserves at a level L. Because of aggregate and individual shocks reserve balances deviate from this level. Excess reserves are shown on the vertical axis reflecting shocks. Banks that have reserve balances higher than their desired level L supply funds in the interbank market. Total supply is the area of the triangle on the right. Meanwhile, those with reserve balances lower than L demand funds. Total demand is the area of the big triangle on the left.

When total supply of funds in the interbank market is more than or equal to total demand of funds, the interbank money market can finance all the demand. On the other hand, when total supply in the interbank money market is not as large as total demand, some banks are forced to borrow from the central bank. Each bank determines to borrow from either the interbank money

market or the central bank according to their individual level of reserves. There is a threshold level θ_t of reserves such that banks with reserve shortages greater than θ_t go to the marginal lending facility. This threshold level is determined by equalizing the costs per Euro of borrowing from marginal lending facility and borrowing from market $r_m + c/\theta_t = r_t$. Hence, if $L - R^i_t > \theta_t$, then cost of borrowing is smaller if the bank i borrows from the central bank. Then it prefers borrowing from the marginal lending facility rather than borrowing from the market. Specifically, banks with larger reserve shortages are more likely to borrow from the marginal lending facility because total cost per dollar decreases as borrowing from the central bank increases. As revealed in Figure 6, the area of trapezoid is the demand for funds from the marginal lending facility, while the area of the triangle on the right of it is the demand for funds from the market. In fact, the actual demand from the market is the area of the triangle on the left times $1-p$. Borrowing from the central bank due to the technical difficulties is omitted from the figure for simplification.

Following Artuç and Demiralp (2010), supply of funds and demand for funds in the interbank money market calculated in the aforementioned manner is illustrated in Figure 7. There is a negative relationship between the market interest rate, Eonia, and the quantity of balances demanded in the interbank money market. As r_t increases, the threshold level θ_t which is the level determined by equalizing the costs per Euro of borrowing from market and borrowing from marginal lending facility, decreases. In the same fashion, borrowing from market decreases. Therefore the demand for funds is represented by the regular downwards sloping curve. On the other hand, the supply curve is drawn as a step-shape function as explained below.

On the days of market softness, when the supply is larger than the demand in the interbank market, the market always clears unless there is a technical problem. This is because any bank can lend its holdings in the interbank money market at the market interest rate, namely the Eonia, if there is a bank that wants to borrow from this bank. In this case, without loss of generality, I simply set the Eonia (r_t) equal to

$$r_t = \gamma + \omega_t$$

where γ is the average marginal benefit of holding balances and ω_t is the noise parameter such that $\omega_t \sim N(0, s)$. ω_t captures the probable deviation of the Eonia from the average marginal benefit of holding balances in the case of no market tightness. Average marginal benefit of holding balances (γ) is assumed to be identical and equal to the policy rate, which is the opportunity cost of holding money, across banks. The demand and supply curves intersect in the lower horizontal section of the supply curve reflecting. However the horizontal section may shift according to value of ω_t.

On the other hand, the upper horizontal section of the supply curve corresponds to the upper boundary of the Eonia by the interest rate applied to the marginal lending facility. The Eonia can not exceed the marginal lending rate (r_m) even if the demand for funds increases very much. In other words, the horizontal lines limit the level of the Eonia.

The vertical segment of the step-shape reflects that a bank can only provide funds up to some extent even if the market interest rate increases further. It also reflects the simplifying assumption that the average marginal benefit of holding balances (γ) is identical and equal to the policy rate, which is the opportunity cost of holding money, across banks. However, in real life γ differs across depository institutions that lead to a positive sloped supply curve.

In modeling the borrowing behavior, the focus is on days of market tightness. Because on those days the interbank money market can not meet the demand for funds borrowing from the marginal lending facility is more likely. The supply and demand curves intersect on the vertical segment of the supply curve on these days. I ignore the intersection of the curves which occurs at the upper horizontal section because the Eonia has never been equal to the marginal lending rate for the sample period covered in this thesis (see Figure 1). The market interest rate, r_t, is determined by the market equilibrium where the supply of funds and the demand for funds curves intersect.

Artuç and Demiralp (2010) provided support for the re-emergence of the borrowing function for the US money market after 2003 by estimating the borrowing behavior of banks. So they wanted to investigate whether the fixed cost of borrowing –implicit cost due to the non-price

rationing mechanism of the Fed- has decreased after 2003 by using the model above to reinforce their findings. As a result, they got strong evidence that the new policy was successful to reduce the fixed cost. On the other hand, the banks in Euro area have never put up resistance for borrowing as supported by the previous sections. Borrowing is always sensitive to the cost of borrowing, namely to the spread between the Eonia and the marginal lending rate. Nevertheless, because a decrease in the borrowing is observed within the new framework, we may still ask the question whether the implicit cost associated with borrowing from the ECB –if there is any before- increases. In this regard, to identify any potential move of the implicit cost, the cost is defined as:

$c = c_1$ before March 9, 2004

$c = c_1 + c_2$ after March 9, 2004

If the fixed cost of borrowing has indeed increased the post-March 2004 period $(c_2 < 0)$, then the curve of the demand for funds in the market shifts to the left and the interval in which the Eonia could deviate from the policy rate declines from |AC| to |AB|. This implied change in volatility may allow us to identify the size of the implicit cost before and after March 2004.

To sum up, the parameters of the model to be estimated are $A, B, c_1, c_2, D, E, F, \overline{R}$, s and L_2.

In order to estimate the model, Artuç and Demiralp (2010) used Indirect Inference (II), a method that uses the estimates of an auxiliary model to compare the actual and the simulated data. So long as the selected auxiliary model summarizes the data well, the estimates of the actual model will be consistent and asymptotically normal. In other words, an auxiliary model does not need to be correct for II to give consistent results. (for more details on II, see Gourieroux et al. (1993), Smith (1993)).

Following Artuç and Demiralp (2010), I use a simplified borrowing function that summarizes how borrowing from the ECB changed over time through a simple OLS regression as a part of the auxiliary model. The remaining part of the auxiliary model consists of the mean and variances

of three variables: the normalized borrowing (ζ_t), the spread between the Eonia and the main refinancing rate ($spread_t$) and the spreads which are below the median spread -lowest 50% spread$_t$- ($spread_t^{lowest}$).[12] The auxiliary model differentiates a little from the model in Artuç and Demiralp (2010) due to the lack of data from the ECB. Instead of the spread between the daily high funds rate and the federal funds rate, I use the spread between the Eonia and the main refinancing rate. Specifically, the auxiliary model is:

$$\zeta_t = \beta_1 + \beta_2 spread_t + \beta_3 t + \beta_4 spread_t t + \beta_5 spread_t D^{2004} + \beta_6 D^{mp} + \varepsilon_t$$

$$\beta_7 = mean(\zeta_t), \beta_8 = \text{var}(\zeta_t),$$
$$\beta_9 = mean(spread_t), \beta_{10} = \text{var}(spread_t),$$
$$\beta_{11} = mean(spread_t^{lowest}), \beta_{12} = \text{var}(spread_t^{lowest})$$
$$\beta = [\beta_1 ..... \beta_{12}]$$

The OLS estimates of β are calculated for both the actual data and simulated data derived from the model for borrowing described before, $\hat{\beta}$ and $\tilde{\beta}$ respectively. The model parameters $[A, B, c_1, c_2, D, E, F, \overline{R}, s, L_2]$ are picked up such that $(\hat{\beta} - \tilde{\beta}) w (\hat{\beta} - \tilde{\beta})'$ is minimized where w is the weighting matrix.[13]

The first two panels of Table 4 present the OLS estimates and moments derived form the auxiliary model. Although the algorithm minimizes the difference between the auxiliary model's estimates from the actual data and simulated data, the estimates are not as close as the estimates

[12] In other words, I assume that market tightness will be less than 50% of total days. Lowest 50% spread corresponds to the spread on days without market tightness.

[13] In the original model the weighting matrix is set equal to the inverse of the covariance matrix of β. But, when I use this kind of covariance matrix, the distance between the actual and simulated data is very large. To get a smaller distance, I use a weight matrix such that the diagonal elements are [1 500 1 10 1 5 1 1 1 5 1 1]. The difference between weights is in favor of closer results for corresponding variables of actual and simulated data.

derived for Fed's framework using the data in Artuç and Demiralp (2010). That is to say, when it comes to the ECB's framework and data available, the modified version (by using the Eonia instead of the daily high funds rate) the model developed for discount window of Fed is not able to produce numerically close simulations to the actual data. From a basic point of view, after March 2004, the responsiveness of borrowing to the spread between the Eonia and the main refinancing rate decreases for the actual data. On the other hand, it increases for the simulated data.

The auxiliary model does not need to be correct (capturing all related variables) for II to give consistent results. Still it needs to summarize the data well. For the ECB's marginal lending facility, the auxiliary model's estimates from the simulated data and the actual data are not very close to each other. So the auxiliary model may be inconvenient to capture the full facts about the issues analyzed in this thesis. Although the results of the simulated data do not coincide with that of actual data, this does not invalidate the model. These unfavorable results may well be a result of the incompleteness of the model.

Chapter 8

CONCLUDING REMARKS

This thesis investigated the standing facility of the ECB which constitutes the upper bound of the corridor in which the interbank overnight interest rate fluctuates, namely the marginal lending facility.

The corridor system has always been robust in the Euro area. Specifically, the market interest rate (Eonia) fluctuated in the corridor, between the interest rates applied to the standing facilities and closely to the policy rate (main refinancing rate). The operational framework change reduced the recourse to the marginal lending facility. This supports the efficiency of the framework change. Nevertheless the efficiency can not be attributed only to the recourse to the standing facilities. On the other hand, the recourse to the marginal lending facility mounts in the turmoil period with the support of declining overnight market interest rates and broadened types of eligible collateral. Lack of country-specific or bank-specific data do not allow us to differentiate borrowing functions of individual countries or banks. However, daily frequency of data allows us to capture the responses of borrowing to short-lived changes in the interbank money market.

The effects of the operational framework change within the Eurosystem and the recent turmoil are examined. The possible determinants of the daily borrowing are motivated by following Artuç and Demiralp (2010) who focus on the Fed's discount window. I found that the borrowing function within the Euro area did not differ very much across periods (1999-2004, 2004-2007 and 2007-2009). The signs of the coefficient estimates were in line with expectations.

Specifically, I expect a decline in recourse to the marginal lending facility after March 2004 because of the interest rate change speculation for the main refinancing operations and the standing facilities during a maintenance period would be prevented. Therefore impulsive force of market expectations towards improper bidding behavior would be eliminated. As a result, I found

that banks are more likely to borrow on the last day of the maintenance period to meet their reserve requirements in pre-March 2004 period. After the start of the turmoil, the use of the marginal lending facility continues to be higher particularly on the last day of the reserve maintenance periods. In addition, the turmoil period brings about a time trend which potentially stands for gradual changes in the market conditions that are not covered in the estimation. Besides, I found that banks' borrowing behavior does not differ in terms of the sensitivity to the explicit cost of borrowing before and after the operational framework change –excluding the turmoil period-. But banks become more sensitive to this cost in the turmoil period. One day lagged spread between the Eonia and the main refinancing rate, and the required reserves had become insignificant with the operational framework change. But the turmoil period has made them important again in determining borrowing needs within the independent variables used. Besides, borrowing behavior never changes on special days over the whole sample period.

Borrowing from marginal lending facility had decreased for 2004-2007 period. This might be attributed to an increase in the implicit cost associated with borrowing from the ECB. I tried to present evidence that the implicit cost of borrowing declined with the operational framework change. I used the model developer by model Artuç and Demiralp (2010). Due to lack of data, I used the average rate (Eonia) is used instead of the maximum rate traded on a particular day for the auxiliary model. Applied for the pre- and post-operational framework change (excluding the turmoil period), the simulated data and the actual data remained distant although the algorithm minimizes the distance between them. The auxiliary model may be inconvenient to capture the full facts about the issues analyzed in this thesis. Although the results of the simulated data do not coincide with that of actual data, this does not invalidate the model. These unfavorable results may well be a result of the incompleteness of the model. But I believe that this model provides a good first step for the analysis of any implicit cost associated with borrowing.

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TABLES

Table 1: Borrowing through the Marginal Lending Facility (EUR million)

Time period	Number of observations	Mean	Median	Standard Deviation
January 1999 to March 2004	1323	508.1	91	2.1057
March 2004 to August 2007	863	165.3	11	0.5678
August 2007 to May 2009	444	1668.3	168.5	3.8785
September 2008 to May 2009	156	4417.3	1828	5.5606

Table 2: Estimation Results for the Borrowing Function before the Turmoil

Independent Variable	1999-2004	2004-2007	Difference
1. Constant	524.59**	-372.87	0.0062
	(130.66)	(300.99)	
2. D_t^{mp}	27.73**	13.85**	0.0000
	(1.81)	(2.27)	
3. $Eonia_t - LENDR_t$	32.67**	41.09**	0.2919
	(2.09)	(7.70)	
4. $Eonia_{t-1} - REFI_{t-1}$	10.10**	-3.25	0.1028
	(2.65)	(7.75)	
5. $\log\ RR_t$	-42.15**	36.83	0.0066
	(11.32)	(26.77)	
6. D_t^{sp}	-0.78	1.17	0.2676
	(1.11)	(1.37)	
7. t	0.31	-1.57	0.0919
	(0.29)	(1.08)	
R-squared	0.26		

*/** indicates significance at 90 percent and 95 percent level of confidence respectively. Standard errors are in parenthesis.

D_t^{mp}	Dummy variable for the last day of the maintenance period on day t
$Eonia_t$	Euro overnight index average on day t
$LENDR_t$	Marginal lending rate on day t
$REFI_t$	Main refinancing rate on day t
$\log(RR_t)$	Logarithm of required reserves on day t
D_t^{sp}	Dummy variable for special pressure day on day t
t	Time trend

Table 3: Estimation Results for the Borrowing Function under the New Framework

Independent Variable	2004-2007	2007-2009	Difference
1. Constant	-372.87 (202.79)	4188.74** (1117.43)	0.0001
2. D_t^{mp}	13.85** (1.53)	8.43** (4.32)	0.3144
3. $Eonia_t - LENDR_t$	41.09** (5.19)	78.56** (4.82)	0.0019
4. $Eonia_{t-1} - REFI_{t-1}$	-3.25 (5.22)	-39.16** (6.71)	0.0055
5. $\log\ RR_t$	36.83 (18.04)	-381.90** (98.91)	0.0000
6. D_t^{sp}	1.17 (0.93)	0.21 (2.66)	0.7690
7. t	-1.57 (0.73)	24.02** (4.04)	0.0000
R-squared	0.35		

*/** indicates significance at 90 percent and 95 percent level of confidence respectively. Standard errors are in parenthesis.

D_t^{mp}	Dummy variable for the last day of the maintenance period on day t
$Eonia_t$	Euro overnight index average on day t
$LENDR_t$	Marginal lending rate on day t
$REFI_t$	Main refinancing rate on day t
$\log(RR_t)$	Logarithm of required reserves on day t
D_t^{sp}	Dummy variable for special pressure day on day t
t	Time trend

Table 4: Indirect Inference and Auxiliary Model Estimations

PANEL 1: AUXILIARY OLS REGRESSION		
	Actual Data	***Simulated Data***
	Coefficient	Coefficient
1. Constant	0.36	0.9435
2. $spread_t$	0.05	0.0513
3. t	-0.03	-0.0755
4. $spread_t \times t$	-0.002	0.0597
5. $spread_t \times D_t^{2004}$	0.015	-0.1304
6. D_t^{mp}	1.79	1.6712
PANEL 2: MOMENTS		
1. *mean* ζ_t	0.3138	0.9964
2. *var* ζ_t	0.0677	0.0000
3. *mean* $spread_t$	2.2774	1.7580
4. *var* $spread_t$	0.0193	0.0634
5. *mean* $spread_t^{lowest}$	0.0609	-0.003
6. *var* $spread_t^{lowest}$	0.0046	0.0179
PANEL 3: INDIRECT INFERENCE ESTIMATION		
	Coefficient	St. Error
1. c_1	0.0201**	0.0038
2. c_2	-0.0453**	0.0008
3. A	0.3934**	0.0071
4. B	0.4079**	0.0086
5. D	-0.0008	0.009
6. E	0.0655**	0.0023
7. F	0.1308**	0.0082
8. $\overline{R}$	0.9757**	0.0173
9. s	0.0011**	0.0000
10. L_2	0.5047**	0.0097

** corresponds to 99 percent level of confidence.

ζ_t	Normalized borrowing on day t
$spread_t$	Eonia minus main refinancing rate on day t
$spread_t^{lowest}$	Lowest 50% of the Eonia minus main refinancing rate on day t
t	Time trend
D_t^{2004}	Dummy variable for March 2004 on day t
D_t^{mp}	Dummy variable for the last day of the maintenance period on day t
c_1	Implicit cost prior to March 2004
c_2	Implicit cost prior to March 2004
A	Interval parameter for the aggregate shock
B	Interval parameter for the bank specific shock
D	Time trend parameter for the aggregate shock
E	Time trend parameter for the bank specific shock
F	Interval parameter for the probability of a technical problem
$\overline{R}$	Average reserve balances
s	Variance of the noise parameter for the Eonia
L_2	Reserve target on the last day of the maintenance period

FIGURES

Figure 1: Key Interest Rates

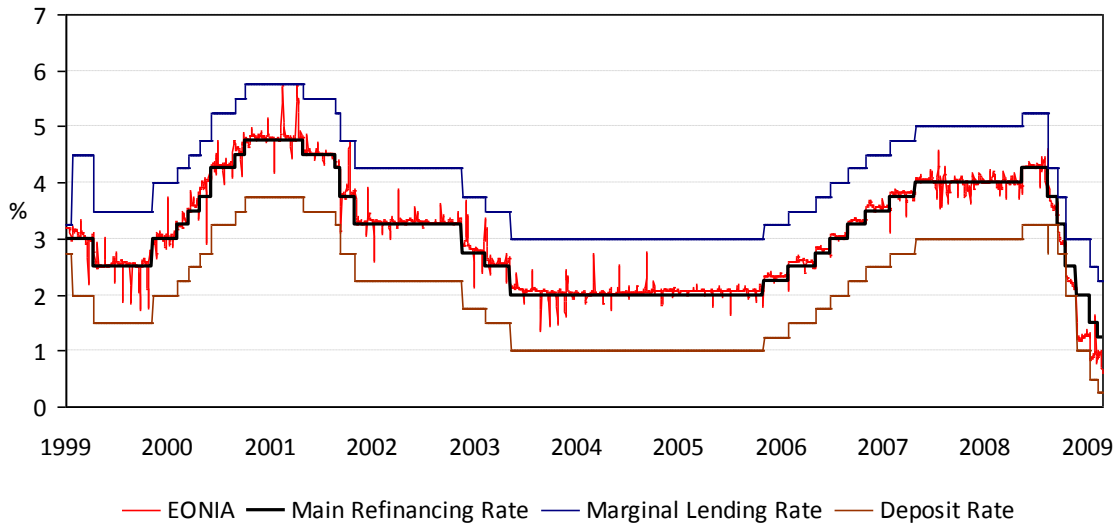
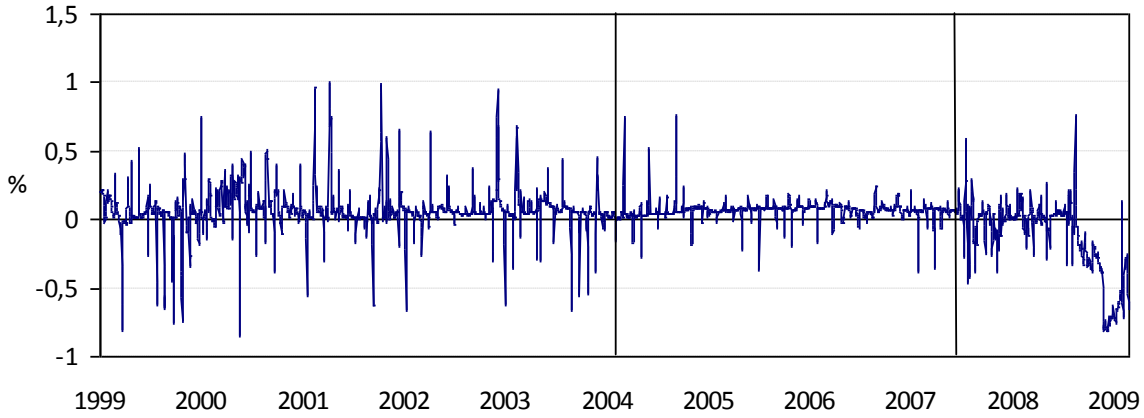


Figure 2: The Spread between the Eonia and the Main Refinancing Rate



First vertical line corresponds to the change of operational framework. Second vertical line corresponds to the start of turmoil.

Figure 3: The Recourse to the Standing Facilities

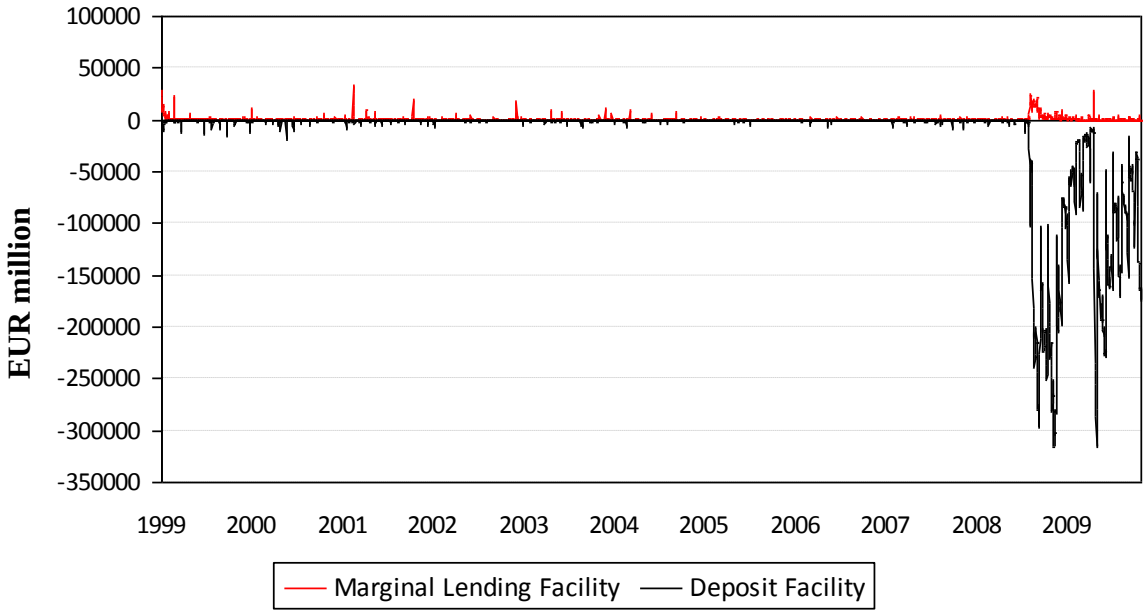
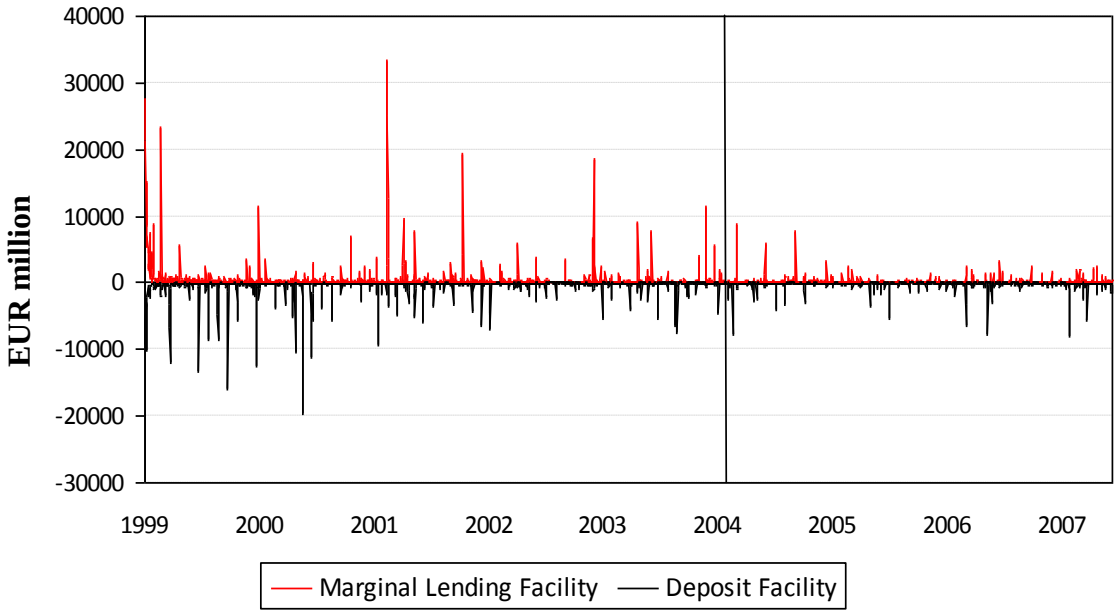
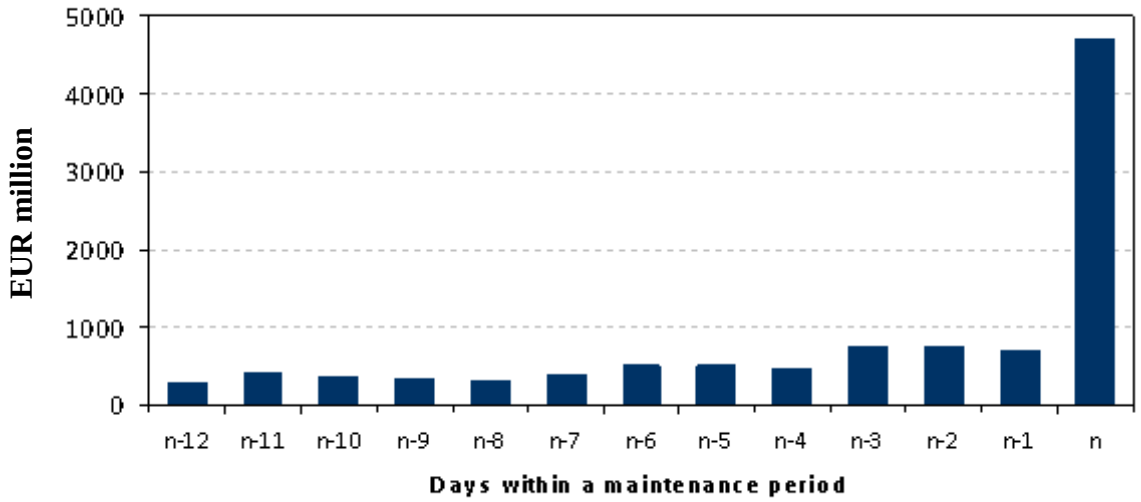


Figure 4: Recourse to the Standing Facilities before the Turmoil



The vertical line corresponds to the change of operational framework.

Figure 5: The Recourse to the Marginal Lending Facility within a Maintenance Period



The horizontal axis shows the days within a maintenance period where n is the last day of the maintenance period, n-1 is the day just before the last day, etc. The bars show the average of daily positions, from January 4, 1999 to April 30, 2009, on the corresponding days. The figure shows the averages of the last thirteen days since the shortest maintenance period over the whole sample consists of thirteen days.

Figure 6: Distribution of Banks and Their Reserves

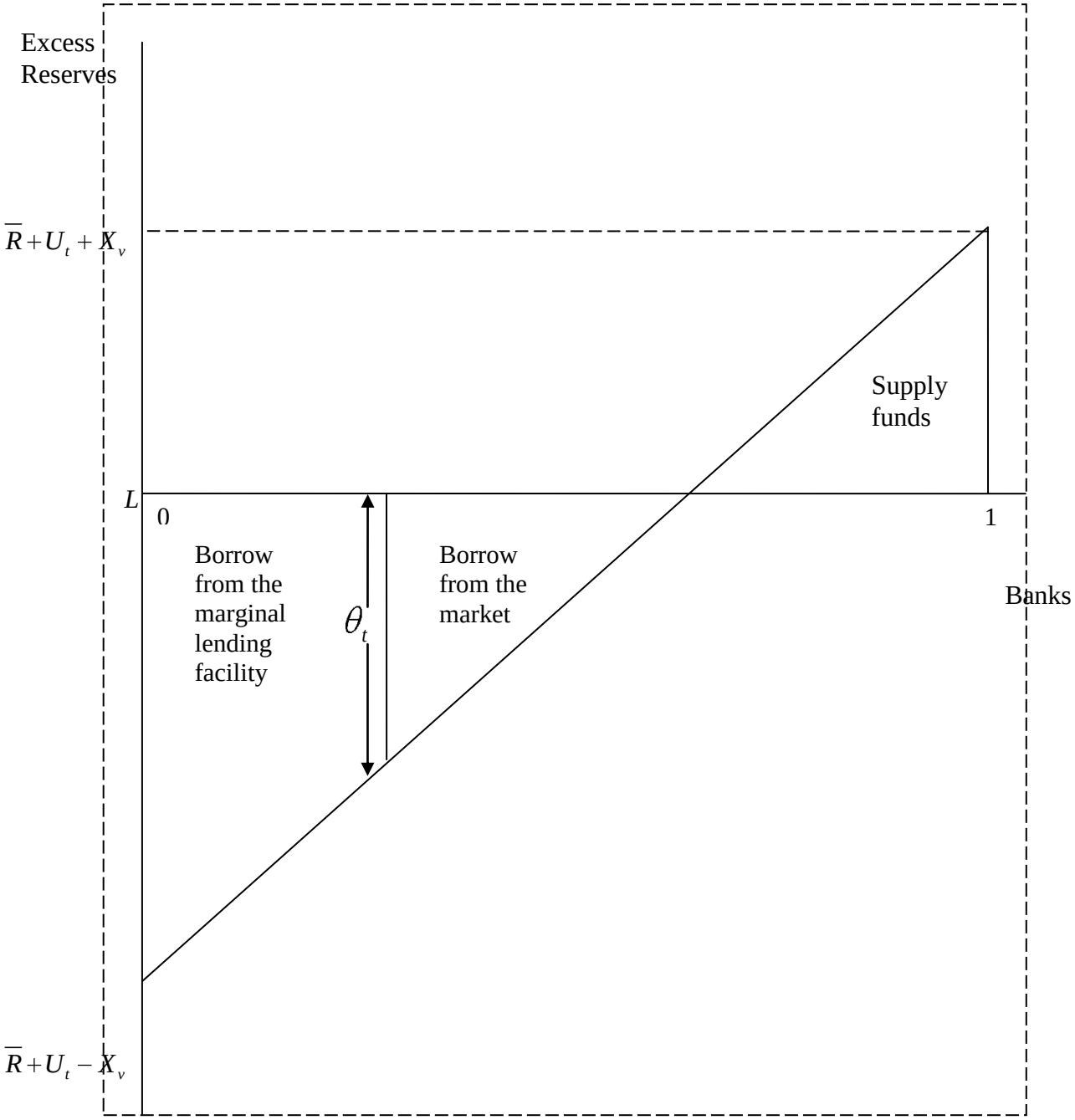


Figure 7: Interbank Market