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The Demand for Excess Reserves in the Euro Area and the Impact of the Current Credit Crisis

The Demand for Excess Reserves in the Euro Area
and the Impact of the Current Credit Crisis[†]

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Abstract

One of the risks that banks need to manage, in their financial intermediation activities, is liquidity risk. Thus, banks hold reserves for precautionary reasons, in order to keep enough cash to meet their obligations. In this work, we analyze the demand for excess reserves by Euro Area banks, since the change in the framework of the single monetary policy in March 2004. Our main conclusions are that there is a positive relationship between the demand for reserves and its financing cost and also that the environment of uncertainty present in the credit crisis is not significant in the demand for excess reserves: the ECB achieved control over the money market tensions.

Keywords: banks; excess reserves; liquidity risk.

JEL Classification: G21, E52, E58.

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1. Introduction

Banks perform an activity of financial intermediation that involves risk. One of the main risks that banks need to manage is the liquidity risk. Liquidity risk means the possibility that a bank could not meet its obligations to depositors and could not satisfy its costumer loan demand. If a bank faces a liquidity problem, he needs to solve it quickly and discretely. A liquidity problem of a single bank could spread to other credit institutions, causing bank runs; creating a serious problem of systemic risk in the banking sector.

The management of the liquidity risk as gained new interest with the financial crisis triggered by the US subprime mortgage credit meltdown. The problems faced by banks all over the world, and in particular in Europe following this crisis, like the run on the Northern Rock and the uncertainty and the lack of confidence between peers that lead to a shortage of liquidity in money markets, accompanied by high short-term market interest rates, contributed to a new focus on liquidity risk. Also, banking regulation may need to put more emphasis on banks' liquidity, instead of been focused only on solvency.

The banks intermediation activity is characterized by the acceptance of short-term deposits (demand or term deposits) and the granting of medium and long term loans. They must be prepared to meet their withdrawals of deposits at any moment of time. In order to do so, banks hold two types of reserves: required reserves, imposed by the central bank; and excess reserves, demanded by precautionary reasons. Holding reserves entails an opportunity cost but it represents an insurance against liquidity risk.

In the Euro Area, and according to the Single Monetary Policy, the European Central Bank (ECB) requires the credit institutions to hold minimum reserves, according to an average provision. This minimum reserve system pursues two objectives: the stabilization of money market interest rates and the creation or enlargement of a structural liquidity shortage. The European credit institutions also demand excess reserves, as documented in Bindseil et al. (2004), in order to hold a buffer against deposit withdrawals and banking transfers.

The main objective of this work is to study the demand for excess reserves by the Euro Area banks, its determinants, and how it changed with the beginning and development of the credit crisis. Our study is focused on the period after the changes in the procedures of the Single Monetary Policy in March 2004 until the most recent data available. Thus, our

data spans over 18 months of data (August 2007 - December 2008) that covers the ongoing credit crisis.

This article proceeds as follows: Section 2 provides a review of the literature. Section 3 details the institutional features of the reserve system of the single monetary policy, allowing the comprehension of the framework in which European banks hold reserves. Section 4 describes the data and the behaviour of market variables and presents the results of estimation. Concluding remarks can be found in Section 5.

2. Review of the literature

The demand for precautionary money balances has two fundamental determinants: the uncertainty that affects the economic agents and against which they represent a buffer[1] and, their opportunity cost. The models of reserve management by banks[2] develop these two features of the demand for excess reserves by banks. These well-know models in the literature were presented by Orr and Mellon (1961), Poole (1971), Frost (1971) and Baltensperger (1974) and in the surveys of Baltensperger (1980) and Santomero (1984). More recently, Allen (1998), Nautz (1998), Clouse and Dow Jr. (1999), Selgin (2001), Heller and Lengwiler (2003) and Bindseil et al. (2004) were new applications of these models[3].

According to the reserve management models, the objective of the bank is to minimize the expected cost of holding reserves. In each reserve maintenance period, the bank needs to decide the amount of reserves to hold, given the uncertainty in the net cash drain the bank will face, and the penalty that he will suffer in case of illiquidity. Given these hypothesis, the optimality condition of the model implies that banks hold an amount of reserves in which the marginal cost of holding reserves is equal to the marginal reduction in expected liquidity costs.

Nautz (1998) presents an interesting extension of this model because it reinforces the idea of uncertainty in the demand for reserves. The model is developed in a framework of two periods of time; in the second period the bank seeks a refinancing in the repo market. In the beginning of the period 1, when the bank decides the quantity of reserves to

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[1] See Borio (1997).
[2] These are inventory models like the one of Baumol (1952) that analyses the individual demand of money for precautionary reasons.
[3] See Sol Murta (2006) for more details about these developments.

hold, the future repo rate and the amount of refinancing obtained by the bank in the auction are unknown. The objective of this model is to capture the role played by the current procedures of monetary policy, and to study the effects of the expected refinancing conditions in the demand for reserves. Nautz (1998) concludes that in an environment characterized by higher uncertainty in the monetary policy features, banks increase their reserves. This work also concludes that a flexible monetary policy increases the importance of expectations about the future path of monetary policy.

Although the theory of bank reserve management has reached a mature stage of development, the empirical study of the determinants of the demand for reserves is not frequent. Nautz (1998) studies the behaviour of the German money market interest rate, in a period before the 3rd Stage of EMU, and finds that the increase in the uncertainty about the Bundesbank refinancing conditions leads to the decrease of the money market rate. This is interpreted as the effect of a lower demand of borrowed reserves in the market due to higher reserves balances hold by banks. Bennett and Peristiani (2002) test empirically the hypothesis that American banks with binding reserve requirements manage their reserves different from other banks. They conclude, for the period 1994-1998, that banks without binding requirements manage their reserves more actively than other banks.

The aim of the work of Evanoff (1990) is to test empirically the model of the demand for reserves, using American commercial banks data, for the period 1975-1985. He estimates a linear relationship between the excess reserves of banks and its determinants. He concludes that excess reserves are a negative function of its opportunity cost and a positive function of 1) the penalty cost (of lack of liquidity), 2) the expected interest rate change and 3) the variance of reserves.

In this work we will analyze empirically the demand for excess reserves in the Euro Area, in the last years, with the objective of understanding its determinants.

3. The demand for reserves in the Euro Area

3. 1. The minimum reserve system of the Single Monetary Policy

The primary objective of the Eurosystem is to maintain price stability. In order to achieve its objectives, it has several instruments at its disposal: open market operations, standing facilities and reserve requirements.

The Eurosystem requires credit institutions to hold minimum reserves, in a reserve account on its national central bank, with the aims of stabilizing interest rates and create (or enlarge) a structural liquidity shortage. The minimum reserves are calculated according to an average provision[4], along a maintenance period of about one month. The coefficient of reserves is 2% of the reserve base and the system is lagged. The required reserves are remunerated at an average of the marginal rate of the Main Refinancing Operations (MRO). When credit institutions fail to comply with their reserve requirement, the ECB imposes one of several sanctions, applied to the amount the institution failed to provide: a payment up to 5 percentage points above the marginal lending rate; a payment of up the double the marginal lending rate applied to the same amount; or the constitution of a non-interest-bearing deposit up to 3 times this amount.

The other instruments of the Single Monetary Policy are the open market operations and the standing facilities[5]. Open market facilities play an important role for the purposes of steering interest rates, managing the liquidity situation and signaling the stance of monetary policy. The most important ones are the MRO that are weekly liquidity-providing reverse transactions. Other open market operations are the Longer-Term refinancing operations (LTRO), the Fine Tuning Operations and the Structural Operations.

Finally, the ECB offers two standing facilities: the marginal lending facility at which banks can obtain overnight liquidity and the deposit facility at which banks can make overnight deposits. The two interest rates of the two facilities are determined by the ECB and represent, respectively, a ceiling and a floor to the overnight interest rate of the money market.

To obtain liquidity through refinancing operations or through the marginal lending facility, the credit institutions must possess eligible collateral.

The ECB always tried to improve the effectiveness of monetary policy and the stabilization of interest rates: since July 2000 the MRO were carried out as minimum variable rate tenders (instead of fixed rate tenders) and, at the same time, the ECB began the publication of liquidity estimations. Also, in November 2001 the bank decided to assess its monetary policy only in the first Governing Council meeting of the month. Finally, in March 2004, the Eurosystem also modified some of the characteristics of its procedures:

[4] See the details of the minimum reserve system in ECB (2008).
[5] The details of the open market operations and standing facilities are also in ECB (2008).

1) The reserve maintenance period has since started always on the settlement day of the MRO following the Governing Council meeting at which the assessment of monetary policy is pre-scheduled. This change aimed to reduce the impact of interest rate expectations on bank's bidding behaviour in the MRO, and to reduce the likelihood that the maintenance periods start and end on days when the TARGET[6] is closed.

2) The maturity of the MRO was shortened from 2 weeks to 1 week.

These two changes eliminated the expectations of interest rate changes in a particular reserve maintenance period, and contributed to the stabilization of the conditions in which banks bid for MRO funds.

In the last 4 years, from March 2004 to December 2008, the amount of minimum reserves in the Euro Area increased, as we can see in the figure 1. The figure shows a "jump" in the volume of minimum reserves, in the beginning of the year 2007, due to the accession of Slovenia to the Euro Area. According to the Annual Report of the ECB (2006), the entry of Slovenia in to the Euro Area increased the aggregate reserve requirements of Euro area credit institutions by 0,3 billions of Euros.

Figure 1: The volume of minimum reserves in the Euro Area (millions of Euros)
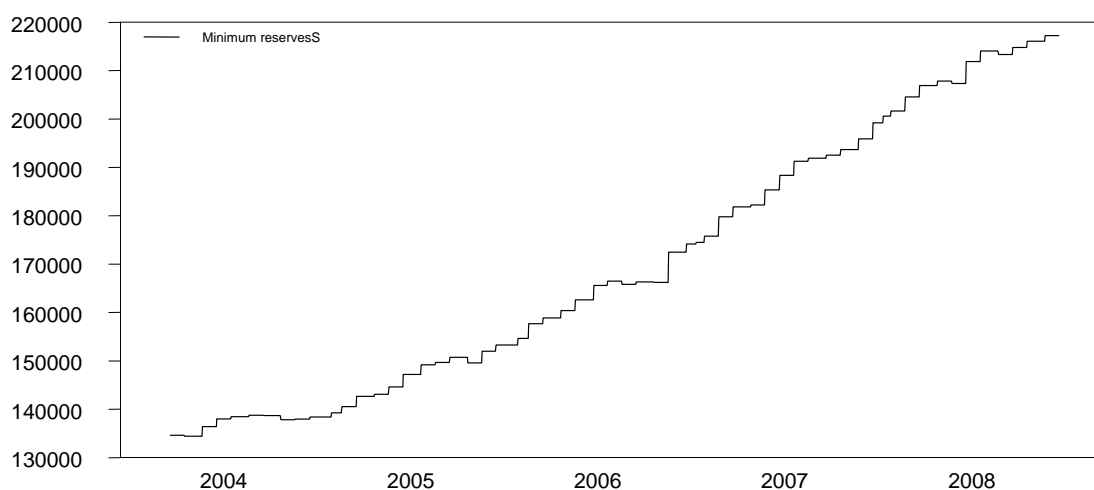
Source: ECB

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[6] TARGET- Trans-European Automated Real-Time Gross Settlement Express Transfer System is the real-time gross settlement for the Euro and it is, since November 2007, on its second version.

3. 2. The demand for excess reserves in the Euro Area

The daily reserve holding of an institution is calculated as the end-of-day balance on its reserve account and the compliance with the minimum reserves is calculated according to an average provision along the maintenance period. Thus, in each maintenance day, a bank can hold an amount of reserves that is above or bellow the average minimum requirement. The amount that is above the minimum represents excess reserves. The banks follow a conservative strategy, holding excess reserves in the beginning of the maintenance period; or postpone the holding of the minimum volume of reserves to the end of maintenance periods, according with their expectations about withdrawals, interest rates[7], etc.

The management of excess reserves is of crucial importance to banks. They are demanded due to the uncertainty that affects banking business, by precautionary reasons. However, holding excess reserves implies an opportunity cost. In the Euro Area they are not remunerated. Therefore, credit institutions must develop a flexible and frequently revised management of reserves, containing simply and clear daily rules with the aim of avoiding overdrafts and liquidity crisis[8].

In the Euro Area credit institutions keep a low level of excess reserves, corresponding, on average, to 0,5% of minimum reserves. In 2004, the average volume of excess reserves floated around €0,6 billions, and reached an average amount of €0,8 billions in 2005. In the year 2006 the average volume decreased by €0,1 billions relatively to the amount of 2005. In 2007 this level was €0,9 billions, which is around €0,15 billion above the average recorded since March 2004. Finally, in 2008 the excess reserves were, on average, €1 billion, the highest amount since March 2004. In spite of this increase in the volume, the importance of excess reserves continued stable around 0,5% of required reserves[9].

In the reserve maintenance periods ending on 7 October and 11 November 2008, the amount of excess reserves reached, respectively, €2 billions and €2,4 billions, the highest

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[7] After the changes in the procedures of the Single Monetary Policy, in March 2004, the effectiveness of a new value of official interest rates coincides with the start of the maintenance period, which eliminates the expectations of a change in official rates inside a maintenance period. However, interest rates on money markets are not constant.

[8] This subject is detailed in Basel Committee on Banking Supervision (2000).

[9] See the Annual Report of the Banco de Portugal, 2004, 2005 and 2006, and the Annual Report of 2007 of the ECB and the Monthly Bulletin of the ECB, December 2008.

levels[10] since March 2004. Since the beginning of the financial turmoil, in August 2007, the concerns about creditworthiness and the risk aversion of investors in general, and banks in particular increased. The possibility of the financial institutions suffering losses due to their exposure to subprime mortgages and other related instruments, originated an increase in uncertainty in money markets and other financial markets. As a result, the balances of liquid assets became larger and short-term interest rates increased[11]. Since the beginning of this credit crisis, the ECB augmented its supply of liquidity in the first part of the maintenance periods and reduced it at the end of reserve periods. These actions had the effects of: 1) maintaining the volumes of liquidity lending unchanged, and; 2) allowing the credit institutions to hold their required reserves sooner, at the beginning of maintenance reserve periods.

However, after September 2008, with the failure of Lehman Brothers, the problems in AIG and in several European banks, the turbulence in financial markets and the lack of confidence in the financial institutions intensified. The ECB reinforced his liquidity supply and adopted further measures to ensure the existence of liquidity in interbank markets[12]:

- in the MRO, it allots larger amounts in excess of the benchmark amount;

- it decided to carry out the MRO and the LTRO through fixed rate tender procedures, and with full allotment;

- the frequency of every month LTRO augmented to two 3-month operations, one 6-month operation and one operation with the same length of the relevant maintenance period (until the end of March 2009);

- the corridor formed by the interest rates of the standing facilities narrowed, from 200 to 100 basis points (until the end of the first maintenance period of 2009).

- the ECB extended the list of eligible collateral and enlarged its swap line with the Federal Reserve in order to increase the provision of US dollars.

The objective of this work is to study the demand for excess reserves in the Euro Area. We test empirically the model of reserve management presented in the literature, searching for the determinants of the demand for excess balances of the European banks.

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[10] These are average levels recorded at the end of the maintenance period.
[11] See the ECB's Monthly Bulletin, September 2007.
[12] See the ECB's Monthly Bulletin, December 2008.

4. Empirical Estimation

4.1. Data

We study the period since the implementation of the changes in monetary policy procedures of March 2004, until the most recently available data (and covering complete reserve maintenance periods), that coincides with the end of the last reserve maintenance period of the year 2008. This allows the study of the determinants of the demand for excess reserves in a period of financial markets stability (from the beginning of the period until the financial turmoil of August 2007) and also in a period of credit crisis and turbulence (August 2007- December 2008) and to analyze the effects of the credit crisis in the demand for excess reserves in the Euro Area. The data were collected from the ECB's site and from the Euribor's site[13].

The ECB publishes aggregate daily data on reserve requirements and current reserve account. Using the selected data, we calculated the difference between the current account and the reserve requirement, obtaining the daily volume of excess reserves, in €billions.

Figure 2 shows the daily series of excess reserves of Euro Area credit institutions. Since August 2007 the series is represented in a shadowed area, allowing us to note higher and lower (negative) volumes of reserves, that is, an increase in its volatility. The volatility of the series is associated with the turbulence in the money market due to the current credit crisis, triggered by the subprime mortgage crisis of the USA, in August 2007.

When the average level of reserves is lower than the requirement, the credit institution needs to obtain funds from the other banks or from the central bank. The occurrence of a reserve deficit implies having to obtain costly funds. We use the spread between the EURIBOR[14] and the minimum rate of MRO as a proxy to the cost of funds. The use of a spread is usual in the literature because it is the deviation from an official rate that is relevant to the study of the cost of holding reserves. We calculated the spread from the EURIBOR - 1 week and EURIBOR-2 weeks[15][16].

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[13] The Euribor site (www.Euribor.org) contains historical data about the Euribor and the EONIA.

[14] The EURIBOR (Euro Interbank Offered Rate) is the rate at which euro interbank term deposits are offered by one prime bank to another prime bank.

[15] An alternative is to use the interest rate of the marginal lending facility. However, banks use this facility as a last resource, after using refinancing operations and money market, to obtain liquidity.

[16] The historical data on EURIBOR 1-week and 2-weeks doesn't contain information about week-ends and holidays. Therefore, on these days, we use the value of the interest rate of the previous day. This is a usual procedure in the literature.

Figure 2: Excess reserves in the Euro Area (€billions), March 2004- December 2008
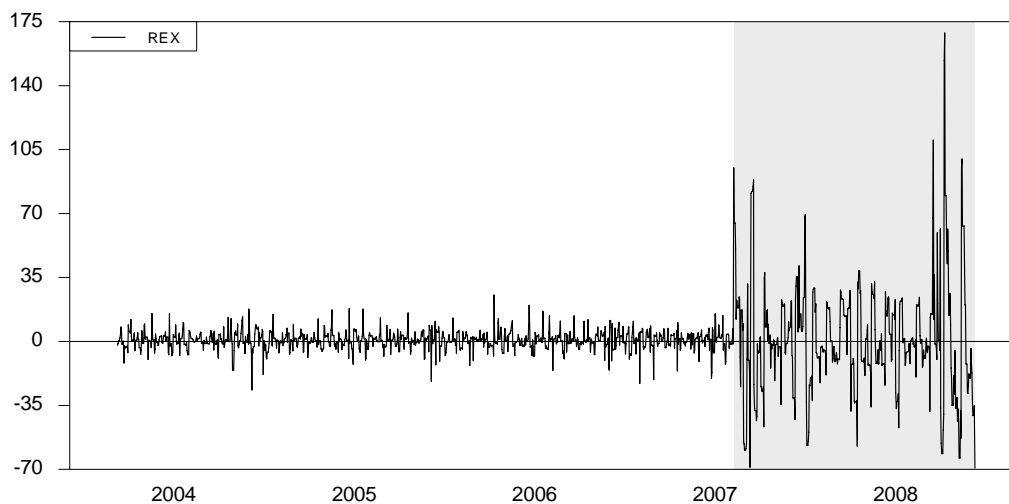
Source: ECB

Another determinant of the demand for excess reserves is the uncertainty about the liquidity needs of banks. At the aggregate level, the liquidity needs of the banking system arise from the minimum reserve requirements (that are known at the beginning of each maintenance period) and from the autonomous factors, the exogenous determinants of banking liquidity that are banknotes in circulation, government deposits and other autonomous factors. The ECB publishes (weekly) forecasts about autonomous liquidity factors[17] and also the realized ex-post daily values of autonomous factors, in €billions. We calculated the difference between the actual ex-post values and the forecasts, obtaining the series of the forecast error. A positive (negative) forecast error means that the effective liquidity need of the banking sector is higher/lower than expected. Figure A.1 in the Appendix shows the series of the ECB forecasts error[18], and table A.1 shows the statistics of this and other series. We can observe that the ECB produces good quality forecasts; the error is close to zero and, in the period studied, the forecast error was, in average, negative and equal to -0,44 €billions: the ex-post liquidity needs were lower than the ECB forecast.

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[17] Expressed as daily averages.
[18] The series presented some outliers, which we removed before the construction of the graphic.

4.2. Estimation

The aim of this work is to study the behaviour of banks in its demand for excess reserves.

The estimated equation is:

$$excessres_t = \alpha_1 + \alpha_2 spread_t + \alpha_3 averror_t + \alpha_4 rexweek_t + \alpha_5 endmonth_t +$$
$$+ \alpha_6 endperiod_t + \alpha_7 crisis_t + \varepsilon_t$$

where $excessres_t$ represents the excess reserves, $spread_t$ is the spread between the EURIBOR and the minimum rate of MRO and $averror_t$ is the ECB's error on the forecasts of the banking sector liquidity needs, defined as the average error of the two previous days. We use the average of the two previous days because banks react to the error with a delay.

We also include other variables in the estimation. The demand for excess reserves balances depends on the excess reserves of the previous days, that we represent by $rexweek_t$, equal to the average daily volume of the previous week[19]. Doing this, we are supposing that the banks follow a constant balances strategy; a high (low) volume of reserves is balanced by a low (high) volume on the following days.

The variable $endmonth_t$ is a dummy that captures the end of month effect on reserves. It takes value 1 on the last day of each month and value 0 on the other days. The reference to the end of month effect in interest rate spreads or interest rate volatility is usual in the literature and explained by the occurrence of payments activities and equity restrictions of banks[20].

The variable $endperiod_t$ is a dummy variable introduced to take into account the effect of the end of reserve maintenance period. In the last days of maintenance periods the volume of excess reserves held by banks is higher, as Bindseil et al. (2004) note. The authors explain this increase above trend by the fact that many banks fulfill their reserve requirements in the beginning of the maintenance period and accumulate excess reserves to prevent against liquidity shocks. The variable $endperiod_t$ is equal to 1 in the days since the last MRO of each reserve maintenance period until the end of the period. It allows us to

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[19] Every 7 days of each week, this variable is equal to the average level of excess reserves of the previously week.
[20] See, among others, Bindseil et al. (2003).

analyze the behaviour of the banking system after the last operation that provides liquidity to the system.

Finally, we introduce the dummy variable $crisis_t$, which takes value 1 after 9 August 2007 and 0 before. The figure 2 shows an increase in the volatility of the demand of excess reserves after the beginning of the financial crisis. In this period the interbank markets suffered a contraction in its activity. Therefore, the variable $crisis_t$ is introduced in order to study the impact of the credit crisis on the demand for excess reserves in the Euro Zone.

We performed the Hausman's test with the aim to test the hypothesis of endogeneity between the dependent variable and the independent variables[21]. The results obtained didn't allow us to exclude the presence of endogeneity between the dependent variable and the spread. Therefore, the model was estimated by the method of the instrumental variables[22]. We also performed tests that did not allow us to reject the presence of autocorrelation of the errors and heteroskedasticity. The problem of autocorrelation was solved by the introduction of the lagged depend variable and the problem of heteroskedasticity by the procedure *robusterrors* of the econometrics program[23]. All the series were submitted to ADF (Augmented Dickey-Fuller) tests that allow us to accept that the series were stationary.

4.3. Results

In all the estimations performed, using the formulation of the previous equation, or other similar formulations, we obtained non significant coefficients in two variables: the forecast error ($averror_t$) and the dummy of the crisis ($crisis_t$). Therefore, we estimated the equation without these two variables. The results obtained, using the spread of the Euribor– 1 week in the estimation can be observed in table 1.

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[21] The estimations were realized with the program WinRATS 6.2.

[22] The instrumental variables chosen were: spread, spread{1}, rexweek, endperiod, endmonth, crisis, excessres{1}.

[23] The procedure *robusterrors* computes a consistent estimate of the covariance matrix allowing for heteroskedasticity.

Table 1: Results of the model estimation on the demand for excess reserves

Period studied: 10/4/2004 – 9/12/2008

Variable	Coefficient	Standard deviation	t-stat	Significance
constant	-0.26113814	0.78905880	-0.33095	0.74068308
spread	15.0573916	7.60928199	1.97882	0.047836939
rexweek	-0.22645863	0.05310956	-4.26399	0.00002008
endperiod	-5.38335951	0.91263406	-5.89871	0.00000000
endmonth	-4.58526510	1.90534309	-2.40653	0.01610489
excessres{1}	0.64361772	0.05081678	12.6654	0.00000000
Number observations: 1735	Degrees of freedom: 1729			

The results allow us to conclude that the demand for excess reserves in the Euro Area changes in the same direction than the Euribor spread. When the spread increases, a situation of lack of liquidity implies a higher cost of obtaining reserves, which can not be avoid. Thus, banks hold a higher volume of excess reserves to prevent these situations.

If we use the spread of the Euribor–2 weeks the coefficient obtained is similar, but the spread is not significant[24]. This result is expected since that, after the introduction of the changes to monetary policy procedures, the maturity of the MRO is 1 week.

The coefficient estimated on the variable *rexweek* is negative which is explained by the average condition of the minimum reserve system. Banks balance their end of day volumes of reserves, in order to meet their requirements. Therefore, they demand more (less) excess reserves when the average value of past reserves is lower (higher).

The positive coefficient of the variable lagged excess reserves does not counter the average condition, that is valid along the maintenance period, and which we find that works from a week to the following one. The positive, and lower than one, sign of the variable *excessres{1}* only means that there is some inertia in the demand for reserves, and banks can not change their amounts of reserves overnight.

The calendar variable related to the end of month presents an estimated negative coefficient, as expected. The ECB aims to avoid disruptions on the end of month

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[24] The results obtained with the spread of the Euribor – 2 weeks are not presented here since they are similar to the ones of the table 1. They are available upon request.

compliance of liquidity obligations, and supplies a higher amount of reserves. The banks use it to meet their business needs and hold less excess reserves.

The estimated effect end of reserve maintenance period is negative which means that, on these days, banks continue to hold minimum reserves and the volume of excess reserves is lower. After the changes in the Single Monetary Policy procedures, the compliance with minimum reserves is regular along the maintenance periods. Bindseil et al. (2004) say that excess reserves increase slightly at the end of reserve periods. However, they study a period of time earlier than those changes. In the Appendix 1, figure A.2 we see some peaks in the spread, at the end of maintenance periods that point to unbalanced liquidity situations. According with the ECB, the changes in monetary policy procedures contribute to a higher probability of liquidity imbalances after the allotment of the last MRO of each maintenance period. In the new framework, the allotment of the last MRO takes place 8 days before the end of the period[25], and it is also more difficult to forecast the autonomous factors. Thus, the volatility of the overnight interest rate is higher. The ECB decided to publish the MRO *benchmark allotment* [26] and the forecast about the autonomous factors in the day of the announcement of the MRO and also in the day of the allotment, making explicitly clear to the market the existence of liquidity imbalances after the last MRO of the period[27].

Finally, it is important to put forward an explanation to the fact that we do not found significance on the variables forecast error and financial crisis.

The ECB offers liquidity to the banking sector, according with his forecasts of the autonomous factors, promoting adequate liquidity conditions. The estimated coefficients on the variable average forecast error are always non significant. In fact, it is recognized the good quality of ECB liquidity forecasts and also its improvement along the last 6 years[28]. This measure of uncertainty is not a determinant in the demand for excess reserves because banks keep confidence in ECB's liquidity forecasts.

Finally, the estimated coefficient of the dummy variable *crisis*, that introduces the effect of the credit crisis triggered by the deteriorating US subprime mortgage loans, is also

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[25] Before the changes in monetary policy procedures, the timing of the last MRO varied from 2 and 8 days before the end of the reserve maintenance period.

[26] The benchmark allotment of a MRO is the amount required to establish balanced liquidity conditions.

[27] See the ECB's Annual Report, 2004 and the ECB's Monthly Bulletin, February 2005.

[28] In earlier (and non-published) versions of this work, using a short period of time (also beginning in March 2004 but ending about one year earlier) we found a positive and significant coefficient on this variable. This supports the idea of the improvement of the quality of ECB forecasts.

non significant. The environment of uncertainty is not significant in the demand for excess reserves. Trying to test for the robustness of this result, we used different specifications for the variable crisis, focusing on the volatility of interest rate (using the squared spread of the Euribor-1 week as a proxy for the volatility of money market) and focusing on the volatility of returns of the European stock market (using the squared return of the Index Euronext 100 as a proxy for the volatility of financial markets). Banks perform financial activities in the stock markets, which affect their return; their own stocks are quoted in the market; therefore, the volatility of the returns on the European stock market describes the environment of uncertainty that affects banking activities.

The results obtained, and described in Appendix 2, confirm that the estimated coefficients are very stable and that the credit crisis is not determinant in the bank's demand for excess reserves.

In fact, during this period, the ECB achieved the control over the market tensions, using several measures, especially in the pikes of the crisis. The ECB offered higher refinancing volumes in the beginning of the maintenance periods (and lowered it in the end of the period) and adopted further measures to ensure the existence of liquidity in interbank markets (referred in section 3.2).

The figures A.3 and A.4 in the Appendix show the behaviour of excess reserves along the reserve maintenance periods, before and after the subprime crisis. The pattern observed is different in the two figures: in the period after August 2007 the excess reserves are higher in the beginning of the periods and then decrease until the end. This pattern shows that the banks hold minimum reserves sooner, in each reserve maintenance period (with the support of ECB, which supply the reserves in the MRO).

Concluding, we find that the spread is the most important determinant of the demand for excess reserves by banks. Thus, the credit institutions must observe and understand the behaviour of this variable in order to achieve a better reserve management. The ECB plays an important role: offering liquidity along the maintenance periods, forecasting (and publishing) the banking sector liquidity needs, reducing the uncertainty in period of crisis; thus, contributing to minimize the uncertainty and to an efficient reserve management.

5. Concluding remarks

In its business activity, credit institutions face several risks. One of them is the liquidity risk; banks need to hold liquid assets in order to manage this risk and to avoid that contagion effects spread to the other banks.

The aim of this work is to analyze the demand for precautionary reserves in the Euro Area, its determinants and to test for its changes after the beginning of the current credit crisis.

The literature reviewed identifies the opportunity costs and the probability of being in a situation of lack of liquidity, which is due to the uncertainty of net payments of banks, as the main determinants of the demand for precautionary reserves.

We studied the period since March 2004, when ECB introduced some changes in its operating procedures, until the most recent available data that covers 17 months of the current credit crisis. We tested an empirical model of bank's behaviour in the demand for excess reserves. We concluded that there is a positive relationship between the demand for reserves and its financing cost, due to the need to avoid illiquidity situations. There is also evidence that the demand for excess reserves does not react to the ECB's liquidity forecast error. The inertia in the demand for reserves is explained by the high quality of the ECB's forecasts and its improvement over the time. We also found calendar effects in the demand for excess reserves like the end of the month and the last days of the reserve maintenance periods (after the settlement of the last MRO of the period). We found evidence that, in the end of maintenance period, the banks are still holding minimum reserves, and excess reserves are lower than in the previous parts of the period. This effect is different from previous literature findings, which we relate with the period studied: after the changes in the Single Monetary Policy procedures.

We didn't find evidence of changes in the demand for excess reserves by European banks after of the beginning of the subprime credit crisis. The ECB, trough the implementation of several measures, softened the crisis in the money markets.

This study contributed to the understanding that, in a banking sector where the central bank contributes to minimize the impact of a crisis that affects the balance sheet of banks, and contributes actively to reduce uncertainty, the credit institutions must focus on the cost of obtaining reserves, in order to minimize it.

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Appendix 1

Figure A.1: Forecast error of the ECB on the autonomous liquidity factors
Time span: 10/4/2004 - 9/12/2008
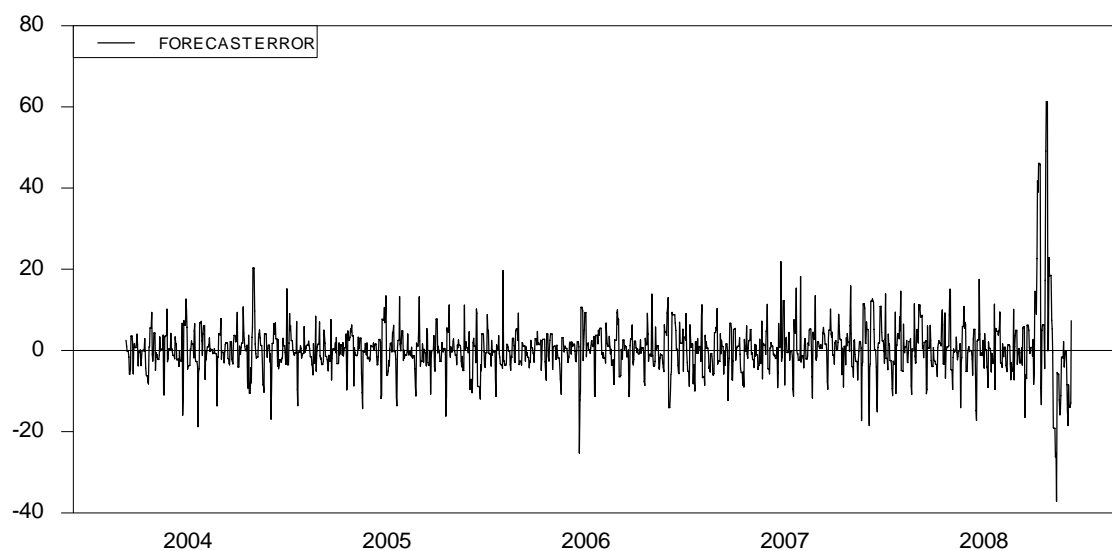
Source: ECB

Table A.1. Statistics of the series,
Time span: 10/4/2004 - 9/12/2008
Number of observations: 1736

Variable	Mean	Standard-deviation	Minimum	Maximum
Excess reserves	0.819686	16.826913	-69.2350	168.827000
Forecast error	-0.410534	6.6622807	-37.1260	61.289000
Spread Euribor 1week	0.130864	0.140915	-0.694000	0.1269000
Spread Euribor 2weeks	0.151352	0.150155	0.574000	0.1285000

Figure A.2: *Spread* between the Euribor 1 week and minimum interest rate of the MRO
Time span: 10/4/2004 - 9/12/2008
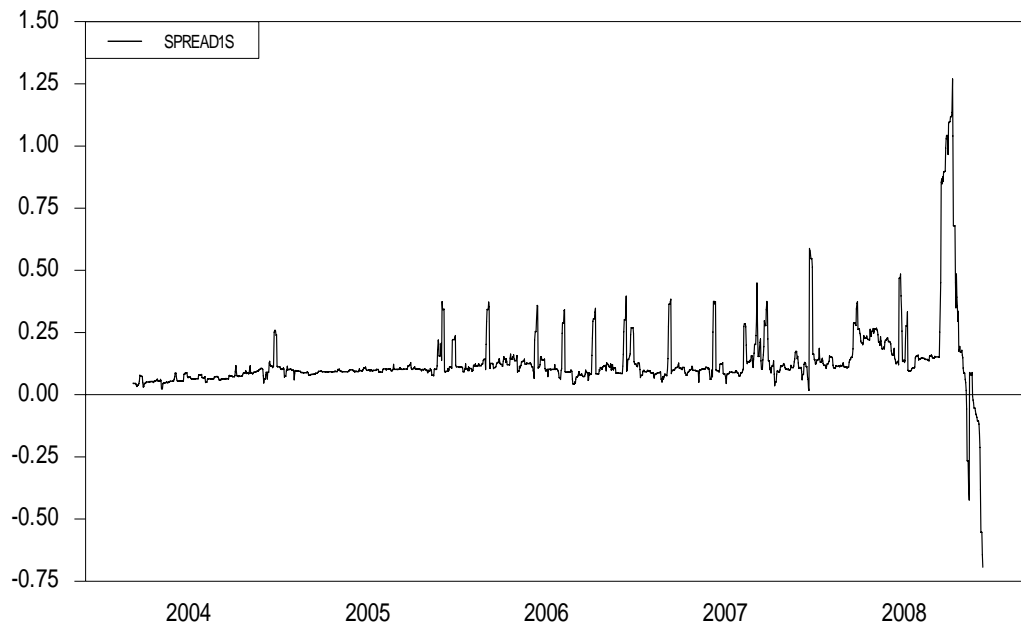
Source: ECB and Euribor site

Figure A.3.: The demand for excess reserves before the subprime crisis
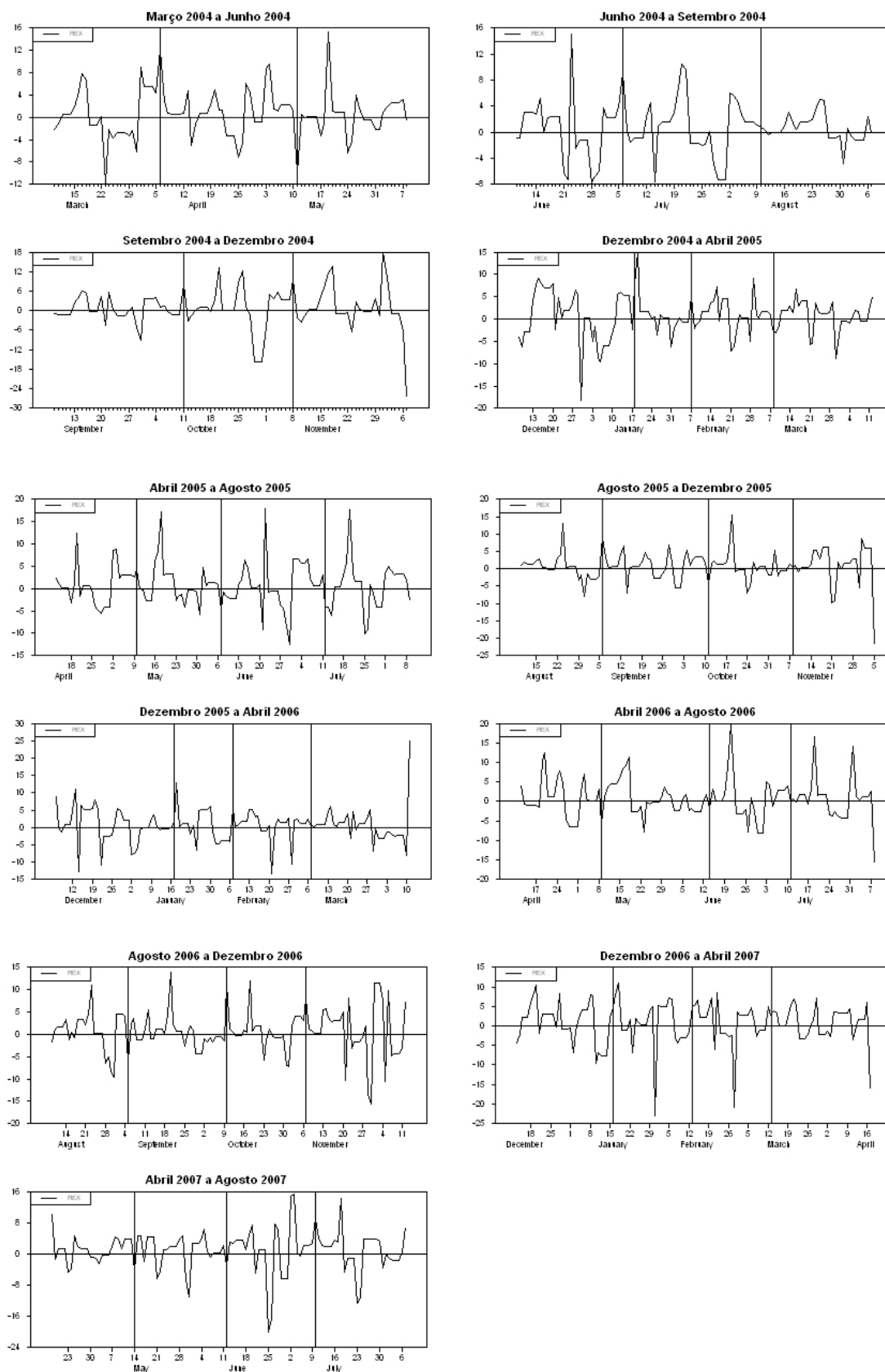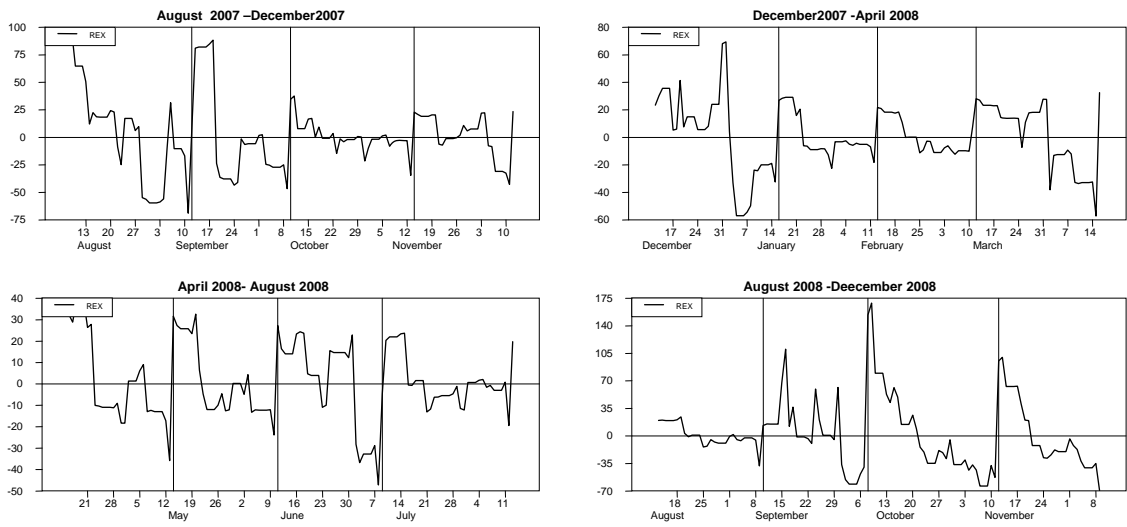
Figure A.4.: The demand for excess reserves after the subprime crisis

Appendix 2

Table A.2.1: Results of the model estimation on the demand for excess reserves using the square of Euribor spread as a proxy for the volatility of the market in the period of the credit crisis

Period studied: 10/4/2004 – 9/12/2008

Variable	Coefficient	Standard deviation	t-stat	Significance
constant	-0.59902136	0.7005600	-0.85568	0.39217661
spread	18.2311199	6.76315012	2.69566	0.00070250
rexweek	-0.23043223	0.05301182	-4.34681	0.00001381
endperiod	-5.31740161	0.92400954	-5.75470	0.00000001
endmonth	-4.51332620	1.92363654	-2.34625	0.01896354
D(squaredspread)	**-5.29210208**	**3.21806759**	**-1.64450**	**0.10007361**
excessres{1}	0.64317081	0.05064241	12.70003	0.00000000

Number observations:	Degrees of freedom:
1735	1729

The estimated equation is:

$$excessres_t = \alpha_1 + \alpha_2 spread_t + \alpha_3 rexweek_t + \alpha_4 endperiod_t + \alpha_5 endmonth_t +$$
$$+ \alpha_6 D_t (squarespread)_t + \varepsilon_t$$

where D_t is equal to zero in the period before the credit crisis and D_t is equal to one in the period after the credit crisis. The variable $squarespread_t$ is equal to the squared spread of the Euribor-1 week.

Table A.2.2: Results of the model estimation on the demand for excess reserves using the squared return of the Index Euronext 100 as a proxy for the volatility of the financial markets in the period of the credit crisis

Period studied: 10/4/2004 – 9/12/2008

Variable	Coefficient	Standard deviation	t-stat	Significance
constant	-0.27052218	0.78777329	-0.34340	0.73129676
spread	15.16349092	7.58305812	1.99965	0.04553766
rexweek	-0.22638397	0.05317810	-4.25709	0.00002071
endperiod	-5.37675838	0.91484246	-5.87725	0.00000000
endmonth	-4.58583708	1.90414041	-2.40835	0.01602480
D(*squareEuronext*)	**-80.43301182**	**83.04095897**	**-0.96859**	**0.33274757**
excessres{1}	0.64381556	0.05082770	12.66663	0.00000000

Number observations:	Degrees of			
1735	freedom: 1729			

The estimated equation is:

$$excessres_t = \alpha_1 + \alpha_2 spread_t + \alpha_3 rexweek_t + \alpha_4 endperiod_t + \alpha_5 endmonth_t + \alpha_6 D_t(squareEuronext)_t + \varepsilon_t$$

where D_t is equal to zero in the period before the credit crisis and D_t is equal to one in the period after the credit crisis. The variable $squareEuronext_t$ is equal to the squared changes of the Index Euronext 100 (source: Euronext site).

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