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THE EUROPEAN CENTRAL BANK QUANTITATIVE POLICY AND ITS CONSISTENCY WITH THE DEMAND FOR LIQUIDITY

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Abstract

In 2008 the European Central Bank added a new quantitative policy strategy to its traditional control of the interest rates. This new policy, sometimes called "enhanced credit support", consists of fully satisfying the demand for liquidity of banks, with the European Central Bank deciding only the timing and characteristics of its interventions. This study analyses the market conditions in which these measures have been taken and their consistency with the demand for liquidity by the banking system. Measures in favour of the sovereign debt of PIIGS countries are also considered.

Keywords: European Central Bank, financial crisis, liquidity supply, liquidity demand

JEL classification: E52, E4, G21

"We must not forget that trust, or its synonym "confidence", derives from the Latin fides, meaning faith, which cannot be produced simply by contract. In fact the legitimacy of central banks does not lie in their policy activism, or the ability to generate income, or even, save in a highly indirect sense, their efficiency. Rather, […] it derives from competence, moderation, the long-term approach, and the refusal to take on any tasks beyond their primary role".
(Curzio Giannini)

1. INTRODUCTION

The financial crisis and its aftermath have led to widespread debate on the role of financial stability in the conduct of monetary policy. This topic has attracted renewed interest in recent years, and for some years there has also been increasing concern about the sustainability of government debt in a number of European countries, which has led to an increased focus on sovereign risk and generated difficulties to the banking system of some EMU countries.

The European Central Bank has therefore set in motion a series of non-standard operations and programs with the objective of restoring the correct functioning of interbank and financial markets, as well as alleviating euro-area sovereign debt problems.

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These non-standard measures, implemented from October 2008 onwards, have been tailored to the specific bank-based financial structure of the euro-area, and aimed at supporting bank liquidity and funding. "They comprised five key elements, drawing in part on the experience with non-standard measures during the financial turmoil, namely regarding full allotment, supplementary liquidity provision at longer maturities, and currency swap agreements"(Cour-Thimann and Winkler, 2013). Only relatively recently (2004 and 2005), did ECB start employing non-standard measures also to tackle inflation and growth problems.

This paper presents an analysis of the ECB's unconventional monetary policy from 2008 to 2013 included. It examines ECB response to the various crises by considering both the types of the different non-standard monetary policy measures and their timing, along with the reasons the Bank gave to justify its quantitative measures. In order to complete the analysis we also build a model estimating the banking system demand for liquidity, the money market interest rates, and the interbank market risks. This model, explicitly considering all main institutional constraints, is used to simulate alternative ECB monetary policies in order to examine the following questions. First, if ECB had not intervened as it did with its non-standard measures, how would liquidity and interest rate paths have been, and second, did these measures meet the demand for liquidity from the banking system?

The paper is organized as follows. In Section 2, we give an overview of the literature of the field. Section 3 gives some background on the non-standard measures undertaken by the ECB over the period 2008-2013 together with some supply estimations, and in Section 4 some information on the measured in favour of PIIGS sovereign debts are given. In Section 5 we introduce a model of the demand for liquidity by the Eurozone banking sector. We focus first on equations and theoretical assumptions related to the interbank market liquidity risks, the interbank interest rates, and bank demand for Eurosystem liquidity, and then present our considerations and empirical results (Sections 6 and 7 respectively). Finally, in Section 8 we present the results of the simulation on the size of ECB liquidity interventions, showing the difference between the dynamic forecasts of the most important variables under alternative hypotheses and under actual ECB monetary policy. Conclusions and some considerations related to the monetary policy perspective follow in Section 9. A list of abbreviations used in this paper is provided in the appendix[1].

Some aspects of our analysis differ from the literature on this topic. First, we stress here the relevance of characteristic ECB operations both on the supply and the demand side. Second, particular attention is paid to the choice of regressors, as well as the shape and the constraints to include in all equations, with the objective of representing the most important institutional aspects of the bank liquidity market. Third, the use of simulation techniques based on dynamic forecasts allows us to verify how our model is consistent with actual EMU banking behaviour, and what might have happened to liquidity and interest rates under different hypotheses on ECB non-standard tools.

2. LITERATURE REVIEW

A review of empirical literature on unconventional ECB measures reveals that there is a wide variety of schools of thought.

Significant analytical contributions have been made by Borio and Disyatat (2009), who distinguish various forms of unconventional monetary policy and characterize the wide range of central bank responses to the crisis. They assess some of the key policy challenges with particular reference to the transmission mechanism.

Interesting empirical evidence on the effect of monetary policy in the downturn is provided by Bech *et al.* (2012). The analysis presented by Giannone *et al.* (2012) and the earlier results shown in Lenza *et al.* (2010) and Giannone *et al.* (2011) promote the idea that ECB intervention has had several significant effects not only on credit markets, but also "indirectly" on economic activity in the euro-area.

Cour-Thimann and Winkler (2013), interpreting response to the financial and sovereign debt crisis consider, in the first instance, a flow-of-funds perspective. They find that the crisis calls for deleveraging by financial and non-financial sectors, but that it is not worth using monetary policy as a unique and universal tool to address directly the underlying causes of the crisis.

The macroeconomic impact of 3-year long-term refinancing operations (LTROs), implemented by the ECB in December 2011 and February 2012, is analysed by Darracq-Paries and De Santis (2013). These authors suggest that when acute tensions occur, non-standard central bank liquidity measures may be helpful to support the provision of bank lending. Furthermore, the unconventional monetary policy measures are complementary to interest rate decisions and, as the authors note, "are essentially predicated on the basis of emerging financial frictions in the credit intermediation sector". Reichlin (2014) detects a progressive dismantling of financial integration involving the interbank market since the first crisis, and the same process in the government bonds market since the second. Abbassi and Linzert (2012) suggest that non-standard monetary policy measures help to lower Euribor rates. Tamakoshi and Hamori (2014) in studying EONIA and the 3-month Euribor rate relations found the best model to be a two-regime threshold cointegration with regime-dependent short-run dynamics

Baumeister and Benati (2010) explore the macroeconomic impact of a compression in the long-term bond yield spread within the context of the Great Recession of 2007-2009 via a Bayesian time-varying parameter structural VAR. They identify a 'pure' spread shock that leaves the policy rate unchanged on impact. This allows characterization of the "macroeconomic consequences of a compression in the yield spread induced by central banks' asset purchases within an environment in which the short rate cannot move because it is constrained by the zero lower bound."

Pattipeilohy *et al.* (2013) suggest that although the ECB's balance sheet has increased dramatically during the crisis, the non-standard monetary policy measures have had only moderate impact on the composition of the ECB's balance sheet compared to other central banks, such as the US Federal Reserve Bank and the Bank of England. They also find that "the LTRO interventions in general had a favourable (short-term) effect on government bond yields. Changes in the SMP only had a visible downward effect on bond yields in summer 2011, when the program was reactivated for Italy and Spain, but this effect dissipated within a few weeks".

Some authors focus on the existing empirical evidence on the effectiveness of non-standard monetary policy measures adopted by the European Central Bank and by the Federal Reserve. Cecioni *et al.* (2011) compare two ways in which monetary policy measures operate: through the signalling channel and through the portfolio balance channel. In the first, "the central bank can use communication to steer interest rates and to restore confidence in the financial markets; the latter hinges on the hypothesis of imperfect substitutability of assets and liabilities in the balance sheet of the private sector and postulates that the central bank's asset purchases and liquidity provision lower financial yields and improve funding conditions". The authors conclude that "the interventions of the

Fed and the ECB were crucial in avoiding a larger collapse in output, persistent deflation and in sustaining credit growth. Still, the magnitude of the stimulus is very uncertain" Freixas *et al.* (2011) suggest that "the central bank should lower the interbank rate when confronted with a crisis that causes a disparity in the liquidity held among banks." More recently, Iyer *et al.* (2014) "find that banks that rely more on interbank borrowing before the crisis decrease their credit supply more during the crisis". In considering ECB's QE, Putnam (2014) claims that its focus on liquidity loans was mainly intended to calm distressed financial markets.

An important critical contribution to the discussion of possible "unintended" consequences of non-standard monetary policy measures in the current context of weak economic activity is made by Belke (2013). Belke underscores the specific risks for price stability and asset-price developments and discusses how differences in money and credit growth in the euro-area cross-country could be a source of policy implications. It also investigates how the new course of "forward guidance" may improve ECB policies. The author argues that the ECB "should respond with its single monetary policy only to euro-area wide risks, leaving to national macroprudential instruments the task of dealing with idiosyncratic risks".

Belke's earlier work (2012) discusses the value of Europe's gold reserves, and explains that gold has been used as collateral in the past and how it could lower yields in the context of the euro crisis. It outlines the specific benefits of using gold: "there is no transfer of credit risk between high risk/low risk countries, losses are borne by specific countries and not by the largest shareholder of ECB. It would prove to be more transparent, it would not be inflationary and it would foster reforms". The author explains that "this move is then compared to the ECB's now terminated Securities Markets Programme (SMP) and its recently declared Outright Monetary Transactions (OMTs). Namely, a central bank using its balance sheet to lower yields of highly distressed countries where the monetary policy transmission mechanism is no longer working".

Gros *et al.* (2012) argues that although the ECB is responding massively to the crisis through 'credit easing', it cannot provide fully effective policy because it is trying to minimize its own risk. "With the LTRO the ECB not only provided longer-term funding against an extended pool of assets eligible as collateral, it also increased considerably the haircuts applied to these newly eligible assets, in some cases up to 50% and even 75%. This means that huge overcollateralization is required to access the LTRO. Banks have to pledge assets between two and four times the amount of the funding they are receiving. Because of this, in case of insolvency, (unsecured) creditors of banks will have little left for them and private investors will thus become even more reluctant to provide the banks with funding. There is thus a danger that even the LTRO might not work if it were tried again".

Central banks, whether on the basis of a formal mandate for financial stability or as an informal obligation as a consequence of the recent crisis, are faced with a tremendous challenge, concludes Otmar Issing (2011). "The independence of the central bank would be hard to defend if it also had the competence to deal with individual financial institutions up to the question of whether such a firm should be closed. The crisis management and some forms of unorthodox measures or quantitative easing have also raised concerns about the relation of the central bank to the fiscal authority".

Continuing the discussion on the role of monetary policy and the responsibilities of central banks, Orphanides (2013) identifies three additional problems that contribute to the overburdening of monetary policy: "beyond what ought to be understood as its primary goal

– to maintain price stability. The first of these public policy goals is the achievement of full employment and related nebulous concepts of real economic activity". The second problem is "the achievement of fiscal sustainability" and the third is "the continued preservation of financial stability, taking into account the weakened private sector balance sheets in many economies". Several years following the crisis were marked by low interest rates and unprecedented liquidity provision by major central banks. Orphanides (2013)warns that the current state of affairs means that certain desirable measures do not necessarily fit into the realm of traditional monetary policy, and also have potential costs. "Failing to appreciate the limits of what central banks can reliably do poses risks. Long-term adverse consequences could outweigh more immediate and more visible benefits."

Gambacorta and Signoretti (2013) analyse interaction between asset-price developments and monetary policy, and highlight the importance of co-operation between the central bank and the macroprudential authorities (Borio, 2006; Angelini *et al.*, 2011).

Finally, literature also covers the impact of the Basel III liquidity risk regulations on banks making recourse to Eurosystem monetary policy operations. It is suggested that central banks should take steps to counter the possible impact. Bech and Keister (2013) argue: "The liquidity coverage ratio (LCR) introduced as part of the Basel III regulatory framework will change banks' demand for liquid assets and their behaviour in money markets". According to Scalia *et al.* (2013), in view of the new Basel III liquidity rules, the evidence suggests that, "when evaluating non-standard monetary policy measures, central banks should also take into account their impact on the fulfilment of the NSFR and the possible cliff effects related to their expiration."

3. USE AND TIMING OF NON-STANDARD MEASURES

In ECB terminology, "non-standard" measures are defined as those "policies that directly target the cost and availability of external finance to banks (Bini Smaghi, 2009)", they "facilitate the functioning of the euro-area money market" and "they are expected to support the provision of credit to households and non-financial corporations (Draghi and Constâncio, 2011)".

Such operations were carried out for first time in October 2008 following the bankruptcy of Lehman Brothers, and aimed "to support the effectiveness and transmission of interest rate decisions (Trichet, 2010)": the "monetary policy decisions in the domain of non-standard measures … help restore a better transmission of monetary policy in circumstances in which we have markets that are not functioning correctly or segments of market that have been disrupted. (Trichet and Constâncio, 2011)" Typical of non-standard measures is the close link between their characteristics and the problem addressed.

Table 1 reports all major decisions on quantitative non-standard measures in euro. The dates refer to the day the decisions were taken by ECB and announced. The main communication channels are the monthly President's "Press conferences" and the ECB "Press releases". Other policy measures, such as the "covered bond purchase programme" 1 and 2 (CBPP1 and CBPP2), non-euro swaps, and eligible collateral expansion are beyond the scope of this paper.

The variables reported in Table 1 are the following. MROs refer to the "*main refinancing operations"*, which are always "liquidity-providing reverse transactions" with a weekly frequency (each Tuesday) and a maturity of one week. LTROs are the "*longer-term refinancing operations*", and are always "liquidity-providing reverse transactions". They can

be divided into three groups: (i) "regular LTROs" (RLTROs), with usually a monthly frequency (the last Wednesday) and a maturity of normally three months; (ii) "supplementary LTROs" (SLTROs), used from time to time by ECB, with a maturity usually longer than 3 months (up to 3 years); (iii) "special LTROs" (STROs) which are offered on the last day of the "required reserves maintenance period" and with maturity corresponding to the "reserve requirements maintenance period" (about 1 month). The other operations (OTs) are mainly *fine-tuning operations* introduced by the ECB on days of temporary shortage or excess of liquidity; they can be both liquidity-providing and liquidity absorbing operations; maturity varies but is usually as short as one day.

The data reported in the other columns of Table 1 refers to ECB decisions on non-standard measures. In "full allotment" columns, the number 1 indicates that ECB announced the introduction (or reintroduction) of a "fixed interest rates with full allotment" procedure, while a 0 indicates when the procedure was abolished (There is just one 0). The numbers in the columns denominated "end" indicate how many months a decision is intended to have effect. For "supplementary LTROs", the "number" is the number of operations announced, and the "maturity" column gives the number of months of maturity of the various SLTROs.

Table no. 1 – The "non-standard" euro quantitative measures

	Fine-tuning **OT**		**MRO**		**LTRO**								**Sovereign debt**	
					regular (RLTRO)		**supplementary (SLTRO)**				**special (STRO)**			
date	**FT**	**FTROB**	Full allotment	End	Full allotment	End	Full allotment	Number	Maturity	End	Full allotment	End	**SMP**	**OMT**
8/10/2008		(1)	**1**	3										
15/10/2008					**1**	5	**1**	3	3/6	3 (10 Sep 2009)	**1**	5		
18/12/2008			1	3										
5/03/2009			1	8	1	8					1	10		
7/05/2009							**1**	3	12	7 (>end 2009)				
3/12/2009	**1**		1	4			**1**	1	12	4 (7 Apr 2010)	1	5		
4/03/2010	**1**		1	6	**0**	6	**1**	1	6	1 (31 Mar 2010)	1	7		
10/05/2010					**1**	2	**1**	1	6	0.1			**1**	
10/06/2010					1	4								
2/09/2010	**1**		1	4	1	3					1	4		
2/12/2010	**1**		1	4	1	4					1	4		
3/03/2011			1	4	1	4					1	4		
9/06/2011			1	4	1	3					1	5		
4/08/2011			1	3	1	5	**1**	1	6	0.1	1	4		
6/10/2011			1	9	1	9	**1**	2	12	2	1	9		
8/12/2011		**0**					**1**	2	36(*)	2				
16/12/2011	**1**													
6/06/2012			1	7	1	6					1	*12*		
6/09/2012													**0**	**1**
6/12/2012			1	7	1	6					1	6		
2/05/2013			1	14	1	14					1	14		
7/11/2013			1	8	1	8					1	8		

The fine-tuning OTs are divided into two columns. In the first, the number 1 means that ECB activated a particular fine-tuning operation; in the second, the number 1 indicates when the 1-day maturity absorbing operations on the last day of the maintenance period were introduced, and 0 indicates when they were abolished. In the column denominated SMP and OMT, the number 1 identifies when the *Security Market Program* and the *Outright Monetary Transactions* of purchase of sovereign securities were announced; a 0 indicates that the corresponding measure was abolished.

Table no. 2 – Main ECB monetary interventions and its official explanation

8-October-2008 (liquidity problem)	-… provision of liquidity to **reduce strains in financial markets**. -… Some **easing of global monetary conditions** is … warranted. -The ECB will continue to **steer liquidity** towards balanced conditions in a way which is consistent with the **objective to keep short-term rates close to the interest rate on the main refinancing operation**.	**Liquidity problems.** Indicators: risk6, EONIA-Repo, Eurepo-Repo
13 October 2008 (liquidity problem)	- Measures designed to address **elevated pressures in the short-term US dollar funding markets …** Central banks will continue to work together and are prepared to take whatever measures are necessary **to provide sufficient liquidity in short-term funding markets.**	**Liquidity problems.** Indicators: risk6, EONIA-Repo, Eurepo-Repo
15 October 2008 (liquidity problem)	-The ECB will continue to **steer liquidity** towards balanced conditions in a way which is consistent with the **objective to keep short-term rates close to the interest rate on the main refinancing operation.**	**Liquidity problems** Indicators: risk6, EONIA-Repo, Eurepo-Repo
4 March 2010 (liquidity abundancy)	-In view of economic and financial market developments, the Governing Council of the European Central Bank **has today decided to continue the gradual phasing-out of its non-standard operational measures. …**	**Reduced liquidity problems** Indicators: risk6, EONIA-Repo, Eurepo-Repo
10 May 2010 (sovereign debt problem)	-ECB decides on measures to address **severe tensions in financial markets**. The Governing Council of the European Central Bank (ECB) decided on several measures to address **the severe tensions in certain market segments which are hampering the monetary policy transmission mechanism** and thereby the effective conduct of monetary policy oriented towards price stability in the medium term. The measures will not affect the stance of monetary policy.	**Sovereign debt problems** Indicators: Spread_PIIGS, CDS_PIIGS
8 December 2011 (liquidity problem)	-ECB announces **measures to support bank lending and money market activity.** The Governing Council of the European Central Bank (ECB) has today decided on additional enhanced credit support measures **to support bank lending and liquidity in the euro-area money market.**	**Liquidity and bank lending problems** Indicators: risk6, EONIA-Repo, Eurepo-Repo, GPFI22
6 September 2012	**-Outright Monetary Transactions.** As announced on 2 August 2012, the Governing Council of the European Central Bank (ECB) has today taken decisions on a number of technical features regarding the Eurosystem's outright transactions in secondary sovereign bond markets **.**	**Sovereign debt problem**: Indicators: Spread_PIIGS, CDS_PIIGS, Target2_saldi

Source: ECB Press conferences and Press releases

The official justifications given by the ECB for its main interventions are reported in Table 2. The most serious problems tackled by non-standard measures were (i) interbank market risk and liquidity problems, (ii) low growth in bank loans, and (iii) the sovereign debt crisis.

From the beginning of the financial crisis in 2007 and until 2011, an increase in both interbank market risk and liquidity shortage was indicated by a higher spread between unsecured and secured interest rates (Euribor minus Eurepo or OIS), also termed "interbank risk premium". Every time this spread widened, (Figure1) the number of interbank market transactions fell and banks with liquidity shortage faced more difficulty in finding a lender.

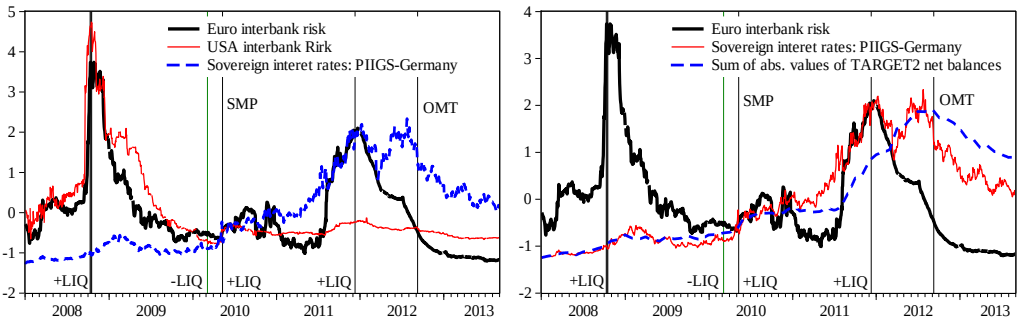
The two periods of greatest interbank market difficulties relating to a high interbank risk premium were the period starting from the Lehman Brothers default to the first quarter of 2009, and the period starting from the third quarter of 2011 to the second quarter of 2012.

The first period was related to the American financial crisis (Figure1, left), and the second occurred in conjunction with the sovereign debt crisis of the PIIGS countries (Figure1, right).

When the sovereign debt crisis worsened again in the third quarter of 2012, a new type of interbank market risk developed: like monetary and financial markets, the Eurozone banking system also started to become, in the words of ECB Chairman Mario Draghi, "fragmented". Not only did sovereign bonds interest rates differ between PIIGS and non-PIIGS countries, particularly Germany, but TARGET 2 flows also became increasingly diversified. See Figure1 left, where the sum of the absolute values of the TARGET 2 flows are reported. This fragmentation was actually endangering the "single monetary policy" rule of the whole Eurozone.

This public debt crisis, in fact, prevented most PIIGS banks from raising funds in the interbank market only because they had a large amount of bad national sovereign securities in their portfolio: risky portfolios caused the banks to become risky, and, at the same time, the collateral such banks could offer in the interbank market lost value. On the other hand, the efforts made by government to reduce public deficit caused economic difficulties to households and firms. This further worsened bank asset quality and made it more difficult for PIIGS banks to receive money from other banks.

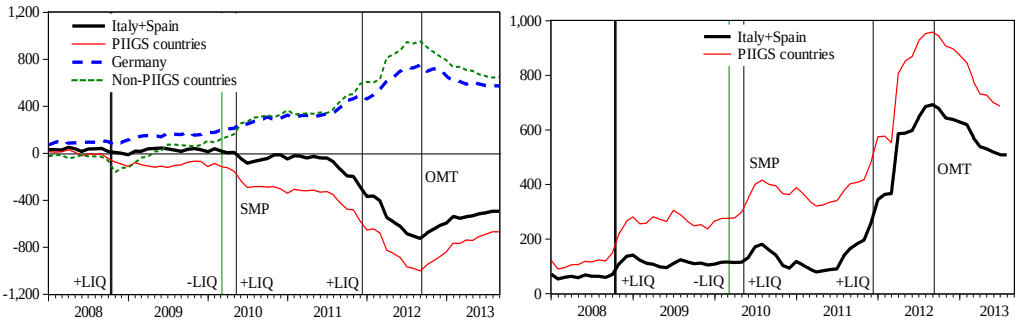
Events after 2011 are shown in Figure1-left and Figure 2. As soon as PIIGS countries were hit by the sovereign debt crisis, large cross-border outflows (TARGET 2) were directed from PIIGS countries to Germany and other non-PIIGS countries (see Figure 2, left). PIIGS bank liquidity dropped, but these banks could not turn to the interbank market to raise new funds.



Euro and USA interbank risk and PIIGS spread *Euro interbank risk, PIIGS spread and Target 2*

Source: ECB, Euribor, Eurepo, Bloomberg, Euro Crisis Monitor; normalised scale

Figure no. 1 – Crisis indicators and ECB main interventions (vertical lines)

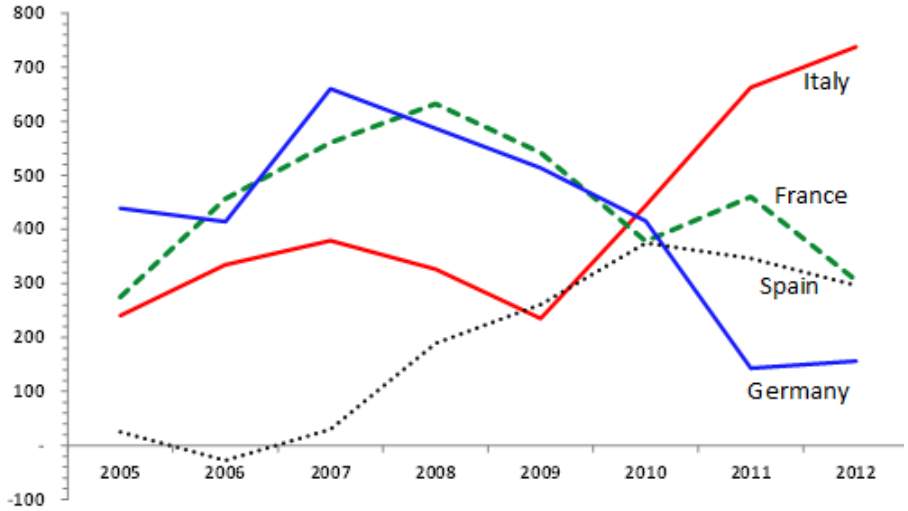


Net Balance with the Eurosystem / Target2 *Eurosystem lending to euro-area credit institutions*

Source: ECB, Euribor, Eurepo, Bloomberg, Euro Crisis Monitor; normalised scale

Figure no. 2 – Eurozone "fragmentation" and main ECB interventions (vertical lines)

Figure 3 completes the picture: in 2011-2012 France and Germany, taken together, reduced their net interbank market borrowing. Owing to the liquidity loss, Italian and Spanish banks, on the other hand, were obliged to increase their borrowing but the sum they could actually raise was not enough. PIIGS banks were thus forced to turn to the Eurosystem for loans.



Source: Bankscope; Borrowing minus lending on interbank market (stock) (mln. of euro)

Figure no. 3 –Net interbank market borrowing for countries

Focussing on the timing and the reasons for ECB non-standard intervention, econometric estimations were run (Table 3 and 4) to better identify circumstances (Tables 1 and 2).The software used in this paper is Eviews 8.1, and in the tables reporting the main results the number of stars of a coefficient indicate its (two-tail) level of significance. Thus *, ** ,*** denote 10%, 5% and 1% probability level.

In Table 3, the dependent variable is a dummy (Dummy_TOT) given by the sum of all the other dummies indicating the presence (or absence) of a "fixed rate with full allotment

procedure" in: "main refinancing operations" (MROs), and "regular", "supplementary" and "special" LTROs" (RLTROs, SLTROs and STROs). In the case of "supplementary LTROs" (SLTROs), used only during the most severe crisis period, the corresponding dummy assumes a value 1 only in the periods of the announced interventions. The "other operations" (OTs) were not considered in this regression since they are carried out for different reasons; either to face very short periods of liquidity shortage (usually one day), or to reduce the cost of excess reserves on the last day of the reserve requirements maintenance period. Time deposits are used to sterilize the monetary base created by ECB's bond purchases on the market.

The regressors in the equations are based on the reasons ECB gave for its major interventions (Table 2) and are listed below. The values are those known at the time of ECB decisions.

- Risk in the interbank market (Risk1m): the higher the risk, the stronger the expansion in liquidity aiming to reduce unsecured interest rates needs to be.

- The spread between the 1-month maturity secured interbank interest rate (Eurepo) and Repo (Eurepo1m-Repo): the greater the spread, the greater the lack of liquidity.

- the official Repo interest rate: the lower the official rate, the more difficult is for ECB to reduce it again, and a greater use of quantitative measures is needed.

- Annual growth of bank loans to non-financial corporations and households (gLoan): the ECB tends to expand liquidity if there is a credit crunch risk.

- The economic confidence index (Sentiment): the lower the degree of economic confidence, the more appropriate are quantitative expansionary measures.

Since the dependent variable (DummyTOT) assumes only integer values, an ordered regression estimation was used. The equation is reported in Table 3. All coefficient signs are exactly as expected and consistent with the explanations given by ECB shown in Table 2.

Since ECB considers the "supplementary LTROs" (SLTRO) one of its most important instruments (Draghi, 2013), and one of their main characteristics is their maturity, we also estimated an equation for this variable (Table 3).The result is consistent with our previous analysis and confirms that the maturity of the supplementary LTRO operations are positively related to the tensions in interbank and banking markets.

Table no. 3 – Estimations of ECB intervention decisions

	DummyTOT	**SLTRO matutity**
const	-	48.669***
Risk1m(t-1)	3.863***	58.721***
Eurepo1m(t-1)-Repo	2.035***	46.120***
Repo(t+1)	-0.819***	-25.329***
gLoan(t-1month)	-0.011***	-0.232***
Sentiment(t-1month)	-0.085***	-
Pseudo R-squared	0.434	-
adjR2	-	0.980
n. obs.	1479	8
Estimation tool	Ordered regression	OLS (White)

Period: 1 Jan 2008 –31 Aug 2013, daily data

4. THE MEASURES IN FAVOUR OF PIIGS SOVEREIGN DEBT AND AGAINST FRAGMENTATION OF THE BANKING SYSTEM

The other group of non-standard measures, i.e. the open market operations in PIIGS sovereign securities to tackle the main sovereign debt crises, are those actions taken by ECB on May 10, 2010 (SMP program) and September 6, 2012 (Outright Monetary Transactions OMT). These are shown by vertical bars denoted SMP and OMT in Figures 1 and 2. These measures however are not considered in the empirical analysis of the present paper and are treated as exogenous. They were introduced by ECB when the spread between the 10 year sovereign bonds PIIGS and Germany bund yield was considered too high, and when the banking system fragmentation reached a maximum.

In particular, the OMTs were introduced in 2012 and aimed to restore the transmission mechanism of monetary policy, and to maintain its principle of uniqueness, which were both endangered by the distorted conditions in some sovereign debt markets. ECB's opinion was that some excessive sovereign debt spread could be partially caused by an unfounded concern about the solvency of the PIIGS countries public debt. In order to restore confidence in these markets, the ECB declared itself a purchaser ready to intervene in those secondary markets for unlimited amounts. Its purchases of government bonds would always be of an outright open market operation type, even if concerning only the short end of the yield curve, in particular from one to three-year maturity. OMTs would however to be suspended if the country concerned did not comply with its existing agreements on debt consolidation. Until 2014 the liquidity so created would always be sterilized by liquidity absorbing operations (OTs) in order not to compromise the objectives of ECB monetary policy.

Investors reacted to the OMTs favourably: unlike the previous SMP program where the announcement had only a temporary effect on PIIGS spreads, the trend towards the reduction of the spread continued throughout the following months (Figure 2). The SMP program was suspended when OMTs were started.

5. THE MODEL OF THE DEMAND SIDE OF ECB OPERATIONS: EQUATIONS AND THEORETICAL ASSUMPTIONS

The complete model used to estimate the interbank market risk, the money market interest rates, and the demand for bank liquidity is described in the flow-chart in Figure 4. The same model was also used to simulate the effects of alternative ECB monetary policy decisions.

This model is made up of three main blocks, and all equations follow an error correction scheme. The first block of equations explains the interbank market risk (measured by the spread between Euribor and Eurepo). Its exogenous variables are the dollar interbank risk and the spread between the 10-year PIIGS treasury securities yield and its corresponding German bund. Among other things, it was found that changes in risk were negatively correlated to the total bank liquidity on the previous day.

The second block contains all the interbank market interest rate equations (EONIA, Euribor and Eurepo). The exogenous variables are the official interest rate (Repo) and its expectations. The other regressors are: (i) the total liquidity available before interest rate quotations, (ii) the net repayments due to ECB, (iii) the interbank market risk. Its impact on interest rates is expected to be null or negative on Eurepo, but positive in the unsecured Euribor market. Up to 2011, a dummy for the last day of the reserve requirements maintaining period was also found to be significant for EONIA.

The last block refers to the demand for liquidity. The dependent variables are the allotments of MROs, LTROs and OTs. The exogenous variables are: (i) the characteristics of these operations (duration, etc.), (ii) the official interest rate Repo, (iii) the amount of absorbing OTs due to SMP and OMT sterilizations. Regressors include: (i) total bank liquidity already available (ii) net repayments due to ECB and already known, (iii) interbank interest rates, (iv) interbank market risk, (v) PIIGS banks outflows (measured by the sum of PIIGS Target2 flows), (vi) spread between short-term market interest rate and Repo, and (vii) the maturity on further future operations already announced by ECB.

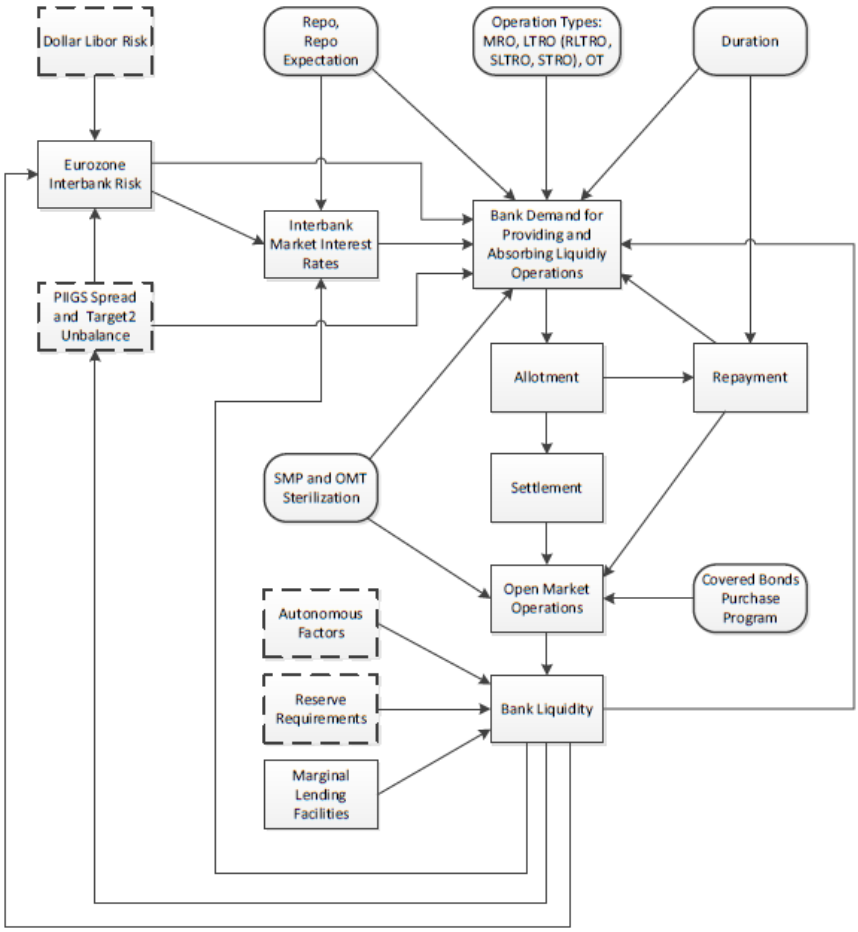


Figure no. 4 – Flow-chart of ECB quantitative policy and interbank interest rates

The stock of the open market operations ECB activated with banks on every day t is identical to its previous value on t-1 plus the amount of MRO, LTRO and OT allotments with settlement on t minus the previous operations matured on t and the OT sterilizations, plus the increase in the "amount of covered bonds purchasing program". These last two variables are considered exogenous.

The total bank liquidity on t is given by the open market operation stock on t, minus the so-called autonomous factors and the reserve requirement, plus the marginal lending facilities. These last three variables are also considered exogenous.

The complete list of variables used in our equations is reported in Table 4.

Table no. 4 – List of variables

MRO (main refinancing operations): amount demanded by banks (bln euro)	MRO
LTRO (longer-term refinancing operations): amount demanded by banks (bln euro)	LTRO
OT (other operations-fine-tuning): amount demanded by banks (bln euro)	OT
LTRO maturity (days)	LTRO_dur
Maximum duration of LTRO during next 4 days and known on day t (relevant for MRO decision)	Max_dur_1w
Maximum duration of LTRO during next 4 days and known on day t (relevant for MRO decision)	Max_dur_45d
Last day of reserve requirement maintenance period	Last_day
Last day of reserve requirement maintenance period until December 2011	Last_day0_till2011
Overall liquidity (deposit facilities + excess reserves) (bln euro)	Tot_liq
Net repayments to ECB on day t (total repayment minus allotted amount to be settled on day t+1 and known on day t) (bln of euro)	Net_repay(t)
Net repayments to ECB on day t+1 (total repayment on t+1 minus the allotted amount of liquidity to be settled on day t+1 and known on day t) (bln euro)	Net_repay(t+1)
Amount of OT for SMP (Securities Markets Programme) sterilization (bln euro)	OT_SMP
Previous week MRO allotment (bln of euro)	MRO(t-1week)
Repo (official interest rate)	Repo
Expected next 3 month changes in Repo at t-1 [bfinance]	E[ΔRepo](t-1)
EONIA (overnight interbank interest rate)	EONIA
1 week Eurepo (secured interbank interest rate) [*Eurepo*]	Eurepo1w
1 month Eurepo (secured interbank interest rate) [*Eurepo*]	Eurepo1m
3 month Eurepo (secured interbank interest rate) [*Eurepo*]	Eurepo3m
6 month Eurepo (secured interbank interest rate) [*Eurepo*]	Eurepo6m
1 week Euribor (unsecured interbank interest rate) [*Euribor*]	Euribor1w
1 month Euribor (unsecured interbank interest rate) [*Euribor*]	Euribor1m
3 month Euribor (unsecured interbank interest rate) [*Euribor*]	Euribor3m
6 month Euribor (unsecured interbank interest rate) [*Euribor*]	Euribor6m
1 month interbank market risk [*Euribor* and *Eurepo*]	Risk1m
3 month interbank market risk [*Euribor* and *Eurepo*]	Risk3m
6 month interbank market risk [*Euribor* and *Eurepo*]	Risk6m
1 month dollar interbank market risk [$*Libor* and *$OIS*]	URisk1m
3 month dollar interbank market risk [[$*Libor* and *$OIS*]	URisk3m
6 month dollar interbank market risk [[$*Libor* and *$OIS*]	URisk6m
10 yr PIIGS soveraing treasury yield (weighted mean) minus 10 yr Germany bunt	PIIGSspread
Total net cross-border liquidity outflows (TARGET 2) coming from PIIGS banks (interpolated for intramonth days)	ΣPIIGS_T2
Difference between Repo and deposit facility interest rate	corridor
Annual growth of bank loans	gLOAN
Sentiment Eurostat index	Sentiment

Data is from ECB unless the source is indicated in square brackets.

6. THE INTERBANK MARKET RISK AND INTERBANK INTEREST RATES

The equations of the interbank market risk (measured by the spread between Euribor and Eurepo returns) are reported in Table 5. The period considered is Oct 2008 - August 2013; the dependent variable corresponds to the daily change in different maturity risks. Consistently with Figure 1, interbank market risk was found to be positively related to both the corresponding US risk (URisk), and the PIIGS sovereign security risk (the spread between the yield of the 10-yr PIIGS treasury securities and the German bund yield (PIIGSspread)). Changes in risk are also negatively correlated to their own lagged values and the total previous day bank liquidity (Tot_liq_{t-1})

Table no. 5 – The interbank market risk

	ΔRisk1m	ΔRisk3m	ΔRisk6m
const	-0.003**	-0.003**	-0.001
$Risk1m_{t-1}$	-0.024***	-	-
$Risk3m_{t-1}$	-	-0.018***	-
$Risk6m_{t-1}$	-		-0.001***
$URisk1m_{t-1}$	0.0103**	-	-
$URisk3m_{t-1}$	-	0.010***	-
$URisk6m_{t-1}$	-	-	0.005*
$\Delta Risk1m_{t-1}$	0.148**	-	-
$\Delta Risk3m_{t-1}$	-	0.220***	-
$\Delta Risk6m_{t-1}$	-	-	0.181***
$\Delta URisk6m_{t-1}$	-	-	0.075***
$PIIGSspread_{t-1}$	0.0031***	0.0031***	0.0022***
$Tot\_liq_{t-1}/1000$	-0.017**	-0.016***	-0.015***
$adjR^2$	0.066091	0.109609	0.073365
S.E. of regression	0.019920	0.017913	0.021795
DW	1.816670	2.053037	2.084076
n. obs	1252	1205	1182

Period: Oct 2008 - Aug 2013; method: OLS (White)

The interest rates considered in this paper are collected from Eurepo, Euribor and EONIA interbank markets. Since the spread between Eurepo and Euribor corresponds to the measure of the interbank market risk, the empirical analysis was limited to just one market. We selected Eurepo because the so-called "zero bound" downward interest rate has more sense in a secured market where there is no positive risk premium generating a positive bias in the bound itself.

In our regressions we assumed that in equilibrium the Eurepo interest rate is given by the value of Repo plus a component negatively related to the banking system liquidity of the previous day. (Eurepo is quoted at 11 am when the amount of liquidity on day t is still unknown). However, in equilibrium (and with no expectations of Repo movements) this negative liquidity effect should not exceed the lower bound of the so-called "corridor" of interest rates (corresponding to the spread between Repo and the ECB deposit facility rate). Even if this constraint is not particularly relevant for the goodness of fit of single equations, it was found to significantly improve their dynamic forecasts. This constraint can be easily imposed by the following representation of the equilibrium liquidity effect:

(1) Eurepo = Repo + (negative) Liquidity effect, i.e. Liquidity effect = Eurepo-Repo = βTot_liq if βTot_liq > -corridor, otherwise = -corridor
(where corridor ≡ Repo–Deposit facility rate)

in formulas:

(2) [β Tot_liq • (β Tot_liq > -corridor) – corridor • (β Tot_liq ≤ - corridor)]

where β is the liquidity equilibrium coefficient, and the logical symbol (x R y) means 1 if xRy is true, 0 otherwise.

Our equations follows an "error correction model" scheme. We explained the change in the Eurepo return on day t as a function of its t-1 disequilibrium level Eurepot-1 – Repot (where the Repo value is taken at day t since its value is known by the previous day), plus the negative liquidity effect:

(3) ΔEurepot = λ (Eurepot-1 – Repot – liquidity effect t-1), therefore:

(4) ΔEurepot = λ (Eurepot-1 –Repot – [β Tot_liq t-1•(β Tot_liq t-1> -corridort) – corridort•(β Tot_liq t-1≤ – corridort)])

Other important explanatory variables we included in the regressions are: (i) net repayments due to ECB on day t and t+1, and already known on t (Net_repay(t) and Net_repay(t+1)); (ii) lagged Eurepo changes; (iii) expectations on future Repo changes from t and t+j months (Et-1[ΔRepot-jm]); (iv) interbank market risk on t-1 (Riskt-1), (v) expected value of Risk for the day t (Et-1[ΔRisk]). All these variables exert an important, although transitory, influence on Eurepo changes and were indicated by our previous analysis. The expected value of Risk is estimated by means of the equations shown in Table 5.

In general:

(5) ΔEurepot = f(t) = α0+ λ(Eurepot-1 – Repot – [β Tot_liq t-1•(β Tot_liq t-1>-corridor) – corridor •(β Tot_liq t-1≤–corridor)]) + α1Net_repay(t) + α2 Net_repay(t+1) + α3ΔEurepot-1 + α4 Et-1[ΔRepot+jm] + α5 Riskt-1 + α6Et-1[ΔRisk]

When significant, the previous coefficient expected signs are: λ< 0, β<0, α1>0, α2>0, α3> or < 0, α4>0, α5≤0, α6≤0.

The risk coefficients (α5 and α6), if significant, should be negative because the higher the interbank risk, the higher the supply of funds on the secured market should be. The effect should also be more relevant for longer maturities.

Since the market expectations on Repo used in this paper come from bfinance, which considers the two and five months forecasts, we used the two month expectations for 1-week, 1-month and 3-month Eurepo maturities and five month expectations for 6-month maturity. We also considered that, in case of 1-week and 1- month maturities, the relevance of expectations depends on the number of days to go before the next ECB meeting. For the 1-week maturity we used weights ranging between 1/7 to 6/7 in the last 6 days before the meeting (w(7)); for the 1-month maturity the weights (w(30))range from 1/30 to 29/30 on the last 30 days.

In order to avoid negative estimations of Eurepo interest rate value, we imposed that fitted Eurepo changes cannot be less than the opposite value of Eurepo on t-1. Eurepot ≥0 implies ΔEurepot +Eurepot-1 ≥0, i.e. ΔEurepot ≥ -Eurepot-1. (In 2004, ECB deposit facility rate became negative, and when including more recent data the constraint should be Eurepot≥ min[0, deposit facility rate]. However the period considered in this paper ends in 2013).

In formulas:

(6) $\Delta Eurepot = f(t)$ if $f(t) > -Eurepot\text{-}1$, $\Delta Eurepot = -Eurepot\text{-}1$ otherwise

There are two econometric solutions for this problem.

The first consists of a non-linear estimation (NLC-OLS) containing the following (constraint) condition in order to exclude negative estimated value:

(7) $\Delta Eurepot = f(t) \bullet (f(t) > -Eurepot\text{-}1) - Eurepot\text{-}1 \bullet (f(t) \leq -Eurepot\text{-}1)$

The second solution uses "censored estimation" with a left censoring (value) series given by -Eurepot-1.

The main difference between the two estimation methods is that the first implies that the expected value of a general dependent variable E[y]=f(x) must satisfy the constraint, while in the second, the constraint must be satisfied by the actual value y of the dependent variable.

In this particular case of interest rate estimations, however, one of the regressors is subject to a constraint (the liquidity effect), but Eview 8.1 software does not allow a direct use of uncensored non-linear estimators. We therefore estimated the coefficient β of Equation (5) by iterations. Results are similar to those obtained by the non-linear methods applied to Equation (7) reported in Table 6.

These results correctly show that the equilibrium effect of liquidity is always negative, and its equilibrium coefficient is similar for all maturities (from approximately -6 to -7). As expected, the effect of net repayments to ECB (Net_repay(t) and Net_repay(t+1)) is positive, with repayments on t more important than repayments on t+1. The adjustment coefficient λof the spread Eurepot-1-Repo is negative, and its absolute value varies inversely with maturity. Repo expectations always exert a positive effect on interest rates, while interbank market risk is significant only for 3- and 6-month maturities.

The last column of Table 6 reports the estimated equation of the interbank overnight interest rate (EONIA).

As for Eurepo, it was also imposed for EONIA that the liquidity effect cannot exceed the lower bound of the "corridor" in equilibrium. Some dynamic factors between EONIA and Eurepo are however different.

First of all, the amount of liquidity relevant for EONIA is the one available on day t, and not on t-1, since EONIA is quoted at 7 pm when the amount of liquidity on t is already known. Second, liquidity changes (ΔTot_liqt) are also significant. The liquidity effect was also found to be weaker on the last days of the reserve requirements maintaining period, at least until 2011. The positive coefficients of these days counteract the normal negative liquidity effect. Until 2011, in fact, an important component of the sharp decline in liquidity during the last days was low bank demand and not exogenous tight liquidity conditions. Third, only net repayments on t+1 (Net_repay(t+1)) are significant.

Table no. 6 – Secured interbank rates (Eurepo) and Overnight interbank interest rate (EONIA)

	ΔEurepo				ΔEONIA
	1 week	1 month	3 months	6 months	
const	-0.001	0.001	0.004***	0.005***	0.023***
($EONIA_{t-1}$-Repo)	-	-	-	-	-0.218***
$Eurepo1w_{t-1}$-$Repo_{t-1}$	-0.053***	-	-	-	-
$Eurepo1m_{t-1}$-$Repo_{t-1}$	-	-0.035***	-	-	-
$Eurepo3m_{t-1}$-$Repo_{t-1}$	-	-	-0.026***	-	-
$Eurepo6m_{t-1}$-$Repo_{t-1}$	-	-	-	-0.020***	-
Tot_liq_t/1000 (equilibrium value)	-	-	-	-	-12.293***
ΔTot_liq_t/1000	-	-	-	-	-0.742***
Tot_liq_{t-1}/1000 (equilibrium value)	-6.968***	-6.194***	-6.389***	-7.220***	-
Net_repay(t)/1000	0.257***	0.184***	0.130***	0.125***	-
Net_repay(t+1) /1000	-	-	0.023**	-	0.149***
Tot_liq_t/1000•Last_day0_till2011					1.510***
ΔTot_liq_t/1000•Last_day0_till2011					0.466***
Δ$Eurepo1w_{t-1}$	0.275***	-	-	-	-
Δ$Eurepo1m_{t-1}$	-	0.162***	-	-	-
Δ$Repo_{t-1}$	-	-	-	-	-0.222***
E_{t-1}[Δ$Repo_{t+2m}$]•w(7)	0.101***	-	-	-	-
E_{t-1}[Δ$Repo_{t+2m}$]•w(30)	-	0.048***	-	-	-
E_{t-1}[Δ$Repo_{t+2m}$]	-	-	0.036***	-	-
E_{t-1}[Δ$Repo_{t+5m}$]	-	-	-	0.026***	-
$Risk3m_{t-1}$	-	-	-0.007**	-	-
E_{t-1}[ΔRisk3m]	-	-	-0.610***	-	-
$Risk6m_{t-1}$	-	-	-	-0.006**	-
E_{t-1}[ΔRisk6m]	-	-	-	-0.845***	-
$adjR^2$	0.230	0.230	0.236	0.185	0.512
S.E. of regression	0.033	0.020	0.019	0.023	0.075
DW	2.008	1.958	1.950	2.027	2.030
n. obs	1227	1227	1241	1242	1245

NLC-OLS with White heteroskedasticity-consistent standard errors & covariance;
period: 15 Oct 2008 – 31 Aug 2013, daily data.

Another difference between EONIA and Eurepo equations comes from the day-to-day constraint imposed. For EONIA, the lower "corridor" limit is always binding: the simple interest rate non-negative constraint is therefore not enough.

If g(t) is the unconstrained ΔEONIAt estimation, its constrained estimation must be: g(t) + EONIAt-1 ≥ Repot – corridort. This can be represented as follows:

(8) $$\Delta EONIAt = g(t)\bullet(g(t) \geq Repot - corridort - EONIAt\text{-}1) + (Repot - corridort)\bullet (g(t) < Repot - corridort - EONIAt\text{-}1)$$

The censor estimation method also obtained similar results for EONIA.

7. THE BANKING SYSTEM DEMAND FOR LIQUIDITY

The dependent variables considered in our regressions are the net quantity of liquidity the banking system requires from the Eurosystem on days t, corresponding to the so-called "submission of bids" day. In the case of "standard tender procedures", such days precede the corresponding "allotment" days by one, and the corresponding "settlement" days by two days. Only in case of "quick tender procedures" do submission, allotment and settlement occur on the same day.

We divided ECB operations into their three official main groups: MROs (main refinancing operations), LTROs (longer-term operations), and OTs (other operations).

Data are daily, and refer to the period October 2008 -August 2013. Estimations have been limited to the days on which ECB liquidity bids took place. Only values of explanatory variables actually known on day t (i.e. predetermined), are used in our equations. Possible endogenous variables have been replaced by their estimations derived from other equations in order to avoid endogeneity problems.

Apart from simple OLS, we also used both "non-linear constrained OLS" (NLC-OLS), and the "censored regression" method (Censored), but all results are mutually consistent. The equation used in "non-linear constrained OLS" is of the type $y = F(x) \bullet (F(x) > 0)$; the equation used in "censored regression" is $y = F(x)$ with a left censoring (value) series = 0.

The equation for the main refinancing operations (MROs) is reported in Table 7 (second column). Only OLS regression is included since the estimated quantities were always positive.

Demand is inversely correlated to the overall liquidity already held by banks (Tot_liqt-1). It is positively correlated to net repayments already scheduled for t e t+1 (Net_repay(t)+Net_repay(t+1)); the demand for MROs is also even higher than the higher borrowing the previous week (MROt-1week) (which banks have to repay to the Eurosystem on t).

Demand is positively influenced by all variables which indicates difficulties in the interbank market, i.e.: (a) risk of the interbank market (Risk6mt-1), (b) spread between 1-week Eurepo and Repo (Eurepo1mt-1-Repot-1)/corridort-1, (c) total net cross-border liquidity outflows (TARGET 2) coming from PIIGS country banks to the others (ΣPIIGS_T2t-1). The coefficients of these three variables are consistent with the hypothesis that the demand for liquidity is higher when interbank markets do not work well. The demand for MROs is lower in cases where ECB has announced it is offering LTROs within one week, and the impact is stronger the longer LTRO duration (Max_ dur_1wt-1).

The estimation of the demand for longer-term refinancing operations (LTROs) is reported in Table 7 (last two columns). Consistently with the explanations supplied by the ECB and reported in Table 1, the period used in the regressions begins on 15 October 2008. Regular LTROs were however excluded from March 4 to May 10 2010 when the Eurosystem exogenously fixed the supply of liquidity. Since there are three types of LTROs, ("regular" (RLTROs), "supplementary" (SLTROs) and "special" LTROs (STROs)), the possibility that coefficients could depend on the operation type has been taken into account by using dummy variables corresponding to the dates the different types of operations took place (RLTROday, SLTROday and STROday respectively). These dummies have been introduced among regressors both in additive and multiplicative position. When they do not explicitly appear in Table 7,no significant difference appeared between the three types.

The demand for LTROs depends negatively on the overall liquidity already held by banks (Tot_liqt-1), and positively on the net repayments already scheduled for t e t+1

(Net_repay(t) + Net_repay(t+1)). However, Tot_liqt-1 is relevant only for the regular LTRO demand, and more overclose repayments are irrelevant in case of the very long SLTROs. The amount of LTROs is also strongly influenced by the behaviour of the three indicators of interbank market difficulties (Risk6mt-1, (Eurepo1mt-1-Repot-1)/corridort-1 and ΣPIIGS_T2t-1).As for MROs, their coefficients are consistent with the hypothesis of higher demand for liquidity when interbank markets do not perform well. LTRO duration (LTRO_dur) was found to exert a significant positive influence on the demand for SLTROs, whose maturity varies over time. (In the case of RLTROs and STROs, however, duration is fixed: three months for the former, one required reserve maintaining period for the latter). In our regressions the supplementary LTRO duration offered by ECB on day t (LTRO_dur) was in fact found significant at the 1% probability level. In the few cases where two SLTRO operations with different durations took place on the same day, we defined LTRO duration as the greater of the two maturities. The dummy SLTROday added to the regression was found significant and negative, suggesting that, in normal conditions, supplementary operations are somewhat less popular than the others.

Table no. 7 – Bank demand for MRO and LTRO

	MRO	LTRO	
	OLS	Censored	NLC-OLS
constant	32.350***	34.026***	31.289***
$SLTRO_{day}$	-	-30.292***	-27.611***
Tot_liq_{t-1}	-0.056***	-	-
Tot_liq_{t-1}•$RLTRO_{day}$	-	-0.041***	-0.045***
Net_repay(t)+Net_repay(t+1)	0.111**		-
(Net_repay(t)+Net_repay(t+1)) $RLTRO_{day}$	-	0.389***	0.399***
(Net_repay(t)+Net_repay(t+1)) $SLTRO_{day}$	-	0.176***	0.184***
$MRO_{t-1week}$	0.655***		-
(LTRO_dur-90)•$SLTRO_{day}$	-	0.417***	0.413***
$Max\_dur\_1w_{t-1}$	-0.102***		-
$Max\_dur\_45days_{t-1}$		-0.028***	-0.029***
$Risk6m_{t-1}$	24.815***	35.383***	36.643***
$(Eurepo1w_{t-1}-Repo_{t-1})/corridor_{t-1}$	21.554**	55.710***	57.357***
$\Sigma PIIGS\_T2_{t-1}$	-0.059***	-0.046***	-0.052***
$E_{t-1}[\Delta Repo]$	-28.353***	-	-
$adjR^2$	0.912	-	0.944
S.E. of regression	20.192	16.994	16.874
n. obs	249	130	130

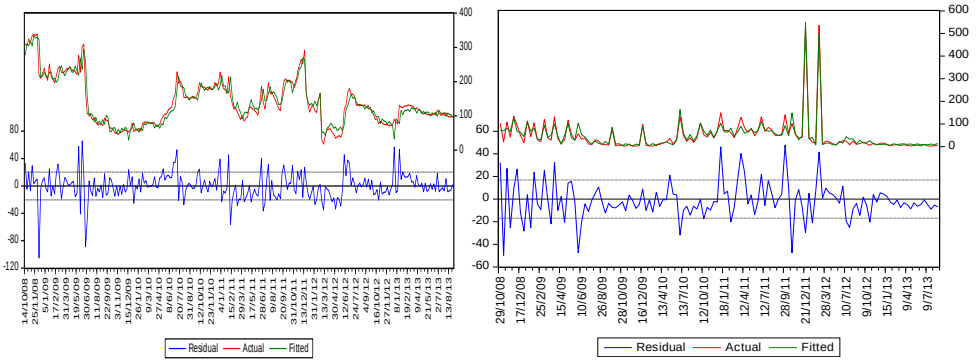
OLS with White heteroskedasticity-consistent standard errors & covariance;Censored: ML - Censored Normal (TOBIT) (Quadratic hill climbing); MRO period: 15 Oct 2008 – 31 Aug 2013, daily data; LTRO period: 15 Oct 2008 – 31 Aug 2013 (only full allotment procedures).

We also examined whether other explanatory variables such as risk were influenced by the type of LTRO, but no significant result emerged.

Another important explanatory variable is the maximum duration of SLTROs announced by the ECB for the next 45 days (Max_dur_45days). Its impact on the demand

for LTROs is negative: since in the period under consideration there was a preference for longer durations, banks preferred to await the announced operations with longer duration.

An outlier was detected in regression residual, corresponding to the first 1-year duration SLTRO of 24 June 2009, when the demand was much higher than in other similar cases. Such high demand might be a consequence of the following ECB official communication of just some days before: "the rate in the first of these operations will be the rate in the main refinancing operations at that time. In subsequent longer-term refinancing operations with full allotment, the fixed rate may include a spread [italics ours] in addition to the rate in the main refinancing operations, depending on the circumstances at the time". This observation was omitted from the sample used in estimations. Using a dummy revealed that demand was in fact about 263 billion euro higher than usual on that date.



MRO LTRO

Figure no. 5 – Demand for MRO and LTRO: actual, fitted and residual values

Estimates of the demand for liquidity resulting from ECB "other operations" (OTs) are shown in Table 8. The operations are both absorbing and providing liquidity (i.e. with a positive or negative sign), and were classified into three subgroups. The first group (OT_SMP) can be considered exogenous since it corresponds to the time deposits employed by ECB to sterilize the previous liquidity inflows caused by the Securities Markets Programme (SMP), whose amount is predetermined and known by banks in advance.

Table no. 8 – Bank demand for "other operations" (OT1) and OT2

	OLS (1)	OLS (1)
constant	-48.957**	19.826*
Tot_liq_{t-1}	-0.786**	-
Net_repay(t)	-	0.349***
Net_repay(t)+Net_repay(t+1)	0.138**	-
OT_SMP_t	-	-0.656***
$(EONIA_{t-1} - Repo_{t-1}) / corridor_{t-1}$	71.222***	32.932*
$adjR^2$	0.882	0.926
S.E. of regression	27.981	15.806
n. obs	38	7

OLS, White heteroskedasticity-consistent standard errors & covariance.

The second group (OT1) includes the liquidity absorbing operations of the last day of the reserve maintenance period, offered by ECB until the end of 2011. Their duration was one day only, and their purpose was to reduce bank idle liquidity costs. They were abolished in January 2012. Their amount is negatively related to the total liquidity already available to banks (Tot_liqt-1), and positively related to the net repayments on day t and t+1 (Net_repay(t)+Net_repay(t)), as well to existing pressures in EONIA market (EONIAt-1-REPOt-1)/corridort-1).

The last group of "other operations" (OT2) are the fine-tuning instruments ECB employs in the case of temporary shortage or excess of liquidity. Their duration is very short and demand is positively influenced by the amount of day repayments (Net_repay(t)) and pressures in EONIA market. Demand however is negatively related to the amount of liquidity absorbed on t by time deposits (OT_SMPt).

8. THE RELEVANCE OF ECB LIQUIDITY INTERVENTIONS: SOME SIMULATIONS

Up to the first months of 2014, Trichet's distinction between "standard" and "non-standard" measures was a guideline for ECB policy. "Non-standard measures … aim to remove the major roadblocks"; "the measures must address a problem of significant magnitude to warrant exceptional action". The "non-standard measures, by their nature, are temporary to the extent that they have to be strictly commensurate to the degree of dysfunctionality of markets that is hampering the transmission mechanism. Trichet (2010)". The distinction was also noted by Cohen-Setton and Dorfmeister (2013), "While standard measures [i.e. interest rates and communication policy] are aimed at addressing the overall monetary stance, non-standard measures (initially called enhanced credit support) are designed to restore adequate liquidity and the proper functioning of financial markets".

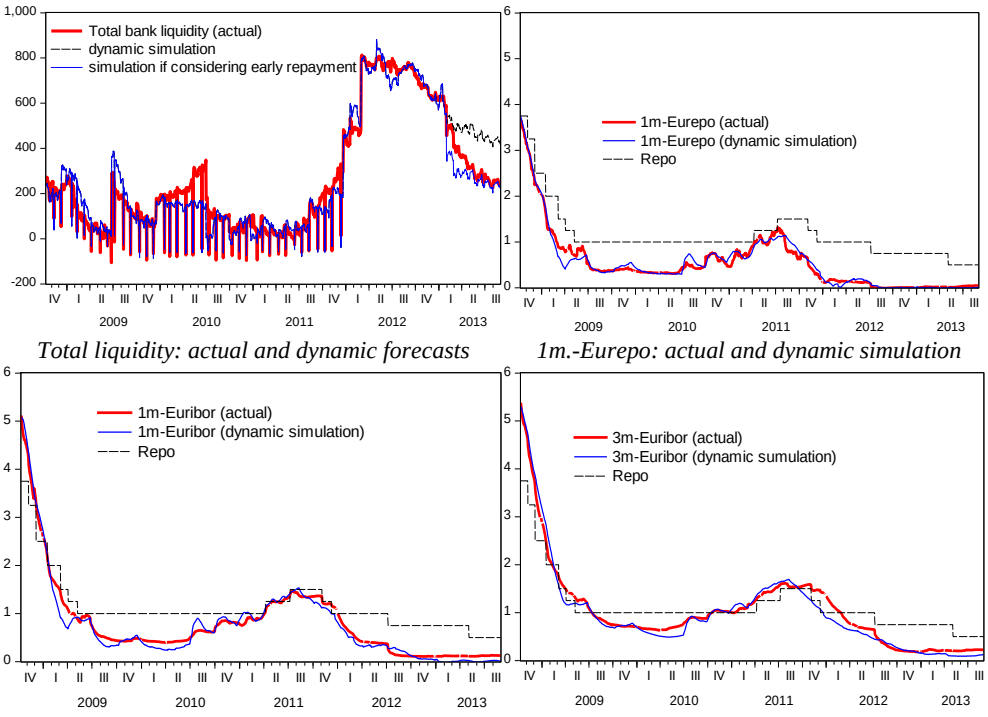
This section examines three main questions. First, it aims to identify what the paths of liquidity and interest rates would have been if the ECB had not taken non-standard measures. Secondly, it assesses whether the non-standard measures were consistent with demand for liquidity by the banking system. Thirdly, it assesses whether the non-standard measures were sufficient to meet demand for liquidity by the banking system.

The last regressions seem to confirm that ECB policy was consistent with its target since interventions increased banking sector liquidity: the levels of interest rates and risk are negatively influenced by liquidity, while a high level of risk increased the demand for liquidity and, in a full allotment regime, the amount of liquidity too. Moreover, from time to time ECB activated "supplementary" longer-term financing operations (SLTROs), with long durations that were particularly appreciated by banks during the worst crises 2008-2013.

In order to bring into focus the impact of ECB non-standard policy on liquidity operations, we ran some simulations by using the model presented in Figure 4 where parameters come from the equations reported in previous tables.

Before starting the simulation, however, we checked whether our model is a good approximation of reality by comparing the actual trend of the main endogenous variables with their so-called dynamic forecasts in the period Oct-2008-Aug-2013. The exogenous variables entering the model are: the Repo (the official interest rate), its expectations, the exogenous components of liquidity, the timing and types of ECB intervention, the interbank market risk and PIIGS countries sovereign spread.

Results obtained for the 1 month Eurepo, for 1 and 3month Euribor (an important benchmark for the cost of credit to firms as well to households) and for bank liquidity are reported in Figure 6.



Total liquidity: actual and dynamic forecasts *1m.-Eurepo: actual and dynamic simulation*

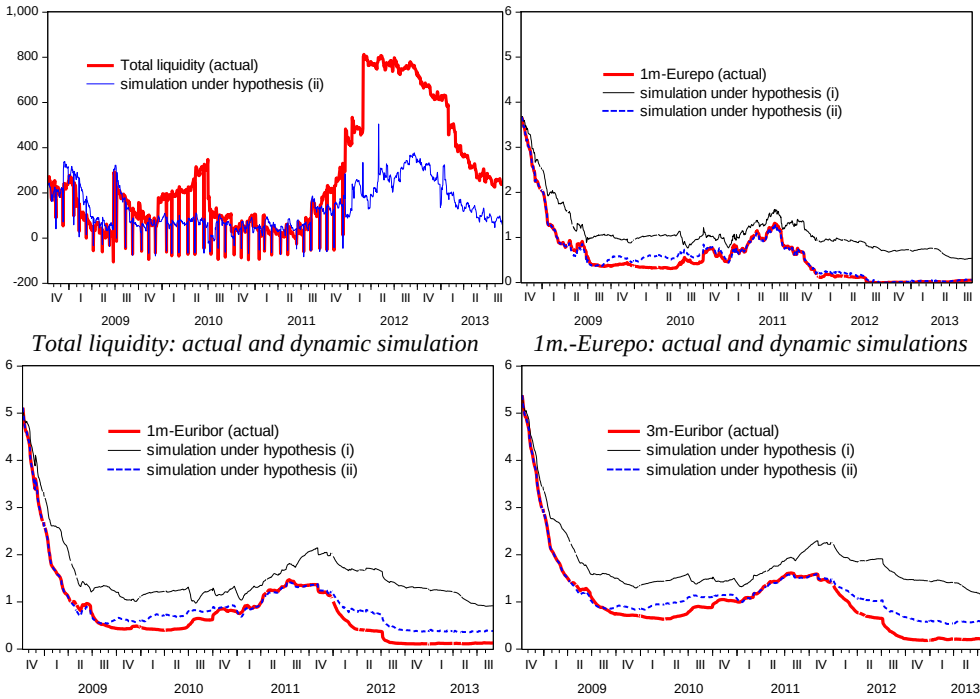
1m.- Euribor: actual and dynamic simulation *3m.- Euribor: actual and dynamic simulation*

Figure no. 6 – Dynamic forecasts and actual values: bank liquidity and interbank interest rates

All equation parameters derive from the non-linear OLS with constraints estimators, but results are also very similar when censored estimators are used. The dynamic forecasts of all variables are closely connected to their actual values, which suggests that our model is a reliable approximation of what really happened in 2008-2013. For the year 2013, forecasts include not including the (negative) "early repayments"[2]. (considered exogenous) of the 2-years supplementary LTRO of Dec.2011 and Feb. 2012. Of course, when the negative effect of early repayments is considered, actual and dynamic forecasted liquidity trends are much more similar.

After this satisfactory result, we compared the actual movements of liquidity and interest rates with their actual values under alternative hypotheses of ECB behaviour. In particular we investigated their plausible dynamics in two cases: (i) bank liquidity exogenously maintained at zero (as it was until 2008), and (ii) the actual allotment procedure but without SLTROs.

The results are reported in Figure 7. They show that if liquidity had been maintained at zero, Eurepo, and particularly Euribor, would have been much higher than they actually were. They also show a significant positive impact of the SLTRO: without them, liquidity would have been lower and interest rates higher in periods of stress.



Total liquidity: actual and dynamic simulation *1m.-Eurepo: actual and dynamic simulations*

1m.- Euribor: actual and dynamic simulations *3m.- Euribor: actual and dynamic simulations*

(a) = Total liquidity maintained at 0; (b) = no use of supplementary LTRO operations

Figure no. 7 – The effect of alternative monetary policies on liquidity and interbank rate

In other words, ECB employed in the years 2008-2013 its non-standard measures in cases of interbank risk and liquidity stress, and chose the type of intervention most attractive to a banking system aiming to increase its liquidity every time. This suggests a high degree of consistency between ECB's targets and non-standard measures. Such measures, however, increased liquidity only when banks demanded this. Until 2013, standard measures were used to prevent a severe credit crunch and to restore the monetary policy transmission mechanism, the ECB's objectives main for their use, but not to encourage banks to increase their lending to firms and households.

9. CONCLUSIONS

The consequences of the financial crisis would have been more serious if the ECB had not taken a number of unprecedented non-standard monetary policy measures. ECB response actually improved the condition of financial markets in the Eurozone. The results of our empirical analysis in fact confirm the consistency of ECB non-standard measures with the demand for liquidity by the banking system. Levels of interest rates and risk are negatively influenced by liquidity, while a high level of risk increases the demand for liquidity. So in a full allotment regime, a high level of risk decreases interest rates. It is significant that ECB also activated from time to time "supplementary" longer-term financing operations (SLTRO), which banks found a very attractive way of funding, particularly in the worst periods of crisis. From an econometric point of view, our estimation

and simulations have shown that including institutional constraints is important for obtaining reliable results. Moreover a previous knowledge of the variables the banking system really considers relevant for its liquidity management is a fundamental tool in deciding the regressors to include in the various equations.

The importance of European Central Bank liquidity interventions that aimed at facilitating the transmission of the interest rate policy and enhancing the flows of credit to the real economy has been highlighted in recent policy debates. Reduction of refinancing concern of the euro-area banking system and a long-term liquidity planning horizon was expected to encourage banks to provide credit. However, disruption of the financial sector in fact prevented the complementary transmission channel, aimed at stimulating lending, from functioning correctly. The dynamics of the demand for credit have become more complex, as the non-financial sector attempted to pay debts resulting from previous over high income expectations.

In implementing adjustments, it is important to acknowledge that there is a limit to what monetary policy can do. The partial ineffectiveness of monetary policy on the real sector shows that "it cannot substitute for measures that tackle the underlying problems, promoting the necessary balance sheet repair and structural reforms" (BIS, 2014, p. 92).

We conclude with some considerations on the monetary policy perspective.

The Basel III international regulatory framework introduced new liquidity regulations for managing liquidity risk and may impact on the effectiveness of ECB operating procedures. Monetary policy operations could affect banks' regulatory liquidity ratios, since the reserves are part of banks' portfolio of highly-liquid assets. Basel III could thus potentially influence interbank market behaviour. The timely identification of the effects of these developments on the money supply will be an important contribution of monetary analysis[3].

Application of expansionary monetary policy in the post-crisis period is a vexed question. Borio (2009) warns of negative side effects of this policy in the crisis resolution phase, and calls for the incorporation of the financial cycle theory into policy. The purchase of government debt by a central bank implies the coordination with the public sector of all matters concerned with debt management operations. "As their balance sheets expand and they take on more financial risks, central banks risk seeing their operational independence and anti- inflation credentials come under threat in the longer-term"[4].

Interesting empirical evidence shows that in normal recessions, a more accommodating monetary policy in the downturn does lead to a stronger recovery. However, in downturns associated with a financial crisis this result is no longer statistically significant. The benefits of accommodative monetary policy appear to be "short-lived".

Unconventional monetary policy only existed as a theoretical concept and had never been tried before the financial crisis and recession. It therefore needs to be examined very carefully and to be applied only in specific circumstances, taking into account its limitations. Otherwise, prolonged accommodation may have unwelcome side effects such as distorting market signals, masking balance sheet weaknesses, misallocating credit and encouraging excessive and unwelcome risk-taking. Accommodation may in fact increase risks to the central bank itself.

It is clear that monetary policy is no substitute for reforms in the labour market and fiscal regulations, but critical aspects of political economy do need to be taken into account. The widespread perception in society that certain liquidity measures may be to the advantage of the financial sector should not be overlooked at the current European economic conjuncture. And lastly, as long as underlying structural problems remain unsolved, repeated rounds of unconventional monetary policy measures by the ECB could affect the crucial aspect of central bank credibility.

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Appendix
List of Abbreviations

BASEL III	Third Basel Accord (international regulatory framework for banks)
BI	Bank of Italy
BIS	Bank For International Settlements
CDS	Credit Default Swap
EBA	European Banking Authority
ECB	European Central Bank
EFSF	European Financial Stability Facility
EMU	Economic and Monetary Union
EONIA	Euro Overnight Index Average
ESM	European Stability Mechanism
EURIRS	Euro Interest Rate Swap
IMF	International Monetary Fund
LCR	Liquidity Coverage Ratio
LTRO	Long-term refinancing operations
MRO	Main Refinancing Operations
NSFR	Net Stable Funding Ratio

OIS	Overnight Index Swap
OLS	Ordinary Least Squares
OMT	Outright Monetary Transactions
OT	Available Stable Funding
REPO	Repurchase Agreement
RLTRO	Regular Long-term Refinancing Operations
PIIGS	Portugal, Italy, Ireland, Greece and Spain
SLTRO	Supplementary Long-term Refinancing Operation
SMP	Securities Markets Program
STRO	Special Term Refinancing Operation
TARGET2	Trans-European Automated Real-Time Gross Settlement Express Transfer
VAR	Vector autoregression

Notes

[1] The data used in this paper and all implemented Eviews-8.1 codes are available on request.

[2] A measure of early-repayments can be obtained by comparing the actual open market operations OMT with their value obtained by the recursive formula described in Section 5: OMTt = OMTt-1 + MRO, LTRO and OT allotments with settlement on t, minus the previous operations matured on t and the OT sterilizations , plus the increase in the amount of covered bonds purchasing program.

[3] The European Banking Authority report December 2013 Art. 509(1) finds: "Evidence of a shift of euro refinancing into vLTROs which may reflect banks' increased demand for longer-term refinancing beyond the 30-day LCR threshold. At the same time, this shift towards vLTROs is also likely to reflect precautionary demand for Eurosystem credit in the context of the financial crisis".

[4] Central bank financed with short-term claims, "shorten the debt maturity profile of the consolidated public sector balance sheet, which comprises the central bank and the government. This raises the sensitivity of the debt service burden to changes in short-term interest rates." Borio (2009) Bank for International Settlements.