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Macroeconomic Effects of Unconventional Monetary Policy in the Euro Area

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Abstract

I find that the Eurosystem can stimulate the economy beyond the policy rate by increasing the size of its balance sheet or the monetary base, that is so-called quantitative easing. The transmission mechanism turns out to be different compared to traditional interest rate innovations: (i) whilst the effects on economic activity and consumer prices reach a peak after about one year for an interest rate innovation, this is more than six months later for a shift in the monetary base that is orthogonal to the policy rate (ii) interest rate spreads charged by banks decline persistently after quantitative easing policies, whereas the spreads increase significantly after a fall in the policy rate (iii) there is no significant short-run liquidity effect after an interest rate innovation, that is additional bank loans are generated by a greater credit multiplier. In contrast, the multiplier declines considerably after an expansion of the Eurosystem's balance sheet.

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1 Introduction

Monetary authorities throughout the world have been responding to the global financial crisis by cutting interest rates to historically low levels and by embarking on a series of unconventional policy actions such as operations that change the composition of their balance sheets, measures that expand the size of the balance sheet or actions that try to guide longer term interest rate expectations. An extensive literature has already investigated the impact of traditional interest rate movements on real activity and inflation.[1] However, little is known about the macroeconomic effects and pass-through of non-standard policies and how they differ from conventional interest rate changes.[2] A better understanding of the transmission mechanism and impact on economic activity is not only essential for policymakers, it is also important to construct theoretical monetary models.

I attempt to address this issue for the Euro area. Notice that the ECB's policy responses to the turmoil were not fully "unconventional" in their essence (Borio and Disyatat 2009). In particular, most policy actions of the ECB in the aftermath of the crisis were aimed at expanding the size of the central bank balance sheet or influencing longer term money market and bank lending interest rates. For instance, there has been a shift from a variable rate tender to a fixed rate tender with full allotment, the pool of collateral accepted for refinancing operations has been enlarged and liquidity to banks has been provided at longer maturities. However, also in normal times, the ECB should have influenced interest rates in credit and money markets without altering its main policy rate (e.g. by changing the signals in its communications). The composition of the balance sheet, in particular the ratio between the volumes of main refinancing operations (MROs) and longer-term refinancing operations (LTOs), has also not been constant over time. In addition, the usual management of liquidity by the Eurosystem should inherently also have resulted in shocks to liquidity offered to banks beyond the overnight interest rate (e.g. changes in the allocated volume of liquidity and errors in the estimation of so-called autonomous liquidity needs).

In this study, the fact that the ECB mainly acted via its regular channels is used to learn more about the (potential) effectiveness of the extraordinary policy measures. More

[1] For instance Bernanke and Blinder (1992) and Christiano, Eichenbaum and Evans (1999) for the United States or Peersman and Smets (2003) for the Euro area

[2] A number of studies have examined the effects of a set of liquidity measures on money market interest rate spreads in the aftermath of the crisis, but not the ultimate impact on the real economy (e.g. Wu 2008; Taylor and Williams 2009; Christensen, Lopez and Rudebusch 2009). An exception is a recent study by Lenza, Pill and Reichlin (2010), who evaluate the macroeconomic consequences of non-standard policy measures in the US, Japan and Euro area by conducting counterfactual exercises based on assumptions regarding how interest rate spreads would have evolved with and without the measures.

precisely, I estimate a structural vector autoregressive (SVAR) model for the Euro area economy with monthly data over the sample period 1999M1-2009M12. SVARs impose very little theoretical structure on the data and can be used to establish some relevant stylized facts. Within this SVAR, I identify three possible sources of disturbances at the supply side of the credit market: (i) innovations to credit supply that are independent of a policy action, labeled as credit multiplier shocks, (ii) credit supply shocks resulting from a shift in the monetary policy rate, and (iii) innovations to credit supply caused by monetary policy actions that are orthogonal to the policy rate. The latter disturbances are labeled as "unconventional" or "non-standard" monetary policy shocks. An inspection of the impulse response functions and time series of the shocks should help to interpret the exact source more carefully and reveal whether the measures taken in the aftermath of the crisis are captured by the estimated innovations, that is a reverse engineering of the underlying impulse. The estimated dynamic effects of these shocks could then be used as a benchmark to learn more about the effectiveness and pass-through of unconventional policies to economic activity and inflation.

Some caution when interpreting the results is obviously required. In the analysis, the effects of a generic series of monetary policy innovations that are orthogonal to the policy rate are estimated. These shocks are a mixture of different actions of which the effects are not necessarily the same. It is also not clear whether the dynamic effects of shocks in normal times are similar as in a crisis period. Nevertheless, it should be useful as a starting point. Furthermore, it is important to stress that I focus on the effects via credit supply or the banking sector, that is the framework does not capture policy interventions that do not affect bank lending directly or indirectly.[3] The Euro area is hence particularly interesting. In contrast to economies where securities markets play a crucial role in the funding of the private sector, borrowing and lending in the Euro area predominantly take place through the intermediation of the banking sector.[4] The non-standard policy measures taken by the Eurosystem as a response to the crisis were also primarily aimed at fueling the banking system. Even the limited outright purchases of covered bonds were intended to improve bank funding conditions (Lenza, Pill and Reichlin 2010).[5]

I find that the identified unconventional monetary policy shocks are characterized by a significant shift in the monetary base or the balance sheet size of the Eurosystem, which

[3] This focus is different from e.g. Gertler and Karadi (2009), who define unconventional monetary policy as "direct lending by the central bank in private markets", which is more applicable to the United States. See also Borio and Disyatat (2009) for a classification of unconventional monetary policies.

[4] Bank loans have in recent years accounted for around 85 percent of the total external financing of the private sector in the euro area (ECB 2008).

[5] Another advantage is that the policy rate did not hit the zero lower bound in the Euro area.

corresponds to so-called quantitative easing policies, and have a significant impact on economic activity and inflation. The time series of the shocks capture very well the measures taken in the aftermath of the crisis. However, also before the crisis, there were significant non-standard monetary policy disturbances, in particular around the 2001 slowdown and the cash changeover in 2002. The results are qualitatively even robust for a sample period which is limited to the pre-crisis period.

When I compare the effects with traditional interest rate innovations, I find similar macroeconomic consequences. Specifically, both shocks have a hump-shaped impact on economic activity and result in a permanent higher level of consumer prices. Hence, both types of instruments can be used for policy purposes. The magnitude of the impact on economic activity is, for instance, similar for a 25 basis points decline in the policy rate or a 10 percent increase in the monetary base which is orthogonal to the policy rate.

The transmission mechanism, however, turns out to be different for both instruments. In particular, the effects of balance sheet policies on output and inflation are more sluggish. Whilst the effects on economic activity and consumer prices reach a peak after about one year for interest rate innovations, this is more than six months later for innovations to the monetary base. Furthermore, bank interest rate spreads increase significantly after an expansionary interest rate innovation, whereas spreads persistently decline after an action which raises the size of the Eurosystem's balance sheet. Finally, there is no significant short-run liquidity effect after an interest rate shock, that is additional bank loans are generated by a greater credit multiplier. In contrast, the multiplier declines significantly for a rise in bank lending which is caused by an expansion in the monetary base. Both features are consistent with a possible stronger risk-taking channel following interest rate shifts (Adrian and Shin 2010; Borio and Zhu 2008).

The rest of the paper is structured as follows. In the next section, I discuss the benchmark VAR model, data and identification strategy that will be used for the estimations. The results are reported in section 3, as well as a number of sensitivity checks, a closer inspection of the source of the identified unconventional shocks and the monetary transmission mechanism. Finally, section 4 concludes.

2 Baseline VAR model for the Euro area economy

2.1 Benchmark specification

The baseline VAR model that will be used for decomposing credit supply innovations into mutually orthogonal components has the following representation:

$$Z_t = \alpha + A(L)Z_{t-1} + B\varepsilon_t \tag{1}$$

where Z_t is a vector of endogenous variables containing the seasonally adjusted natural logarithms of respectively output (y_t), prices (p_t), the volume of bank credit (c_t), the monetary base (b_t), the level of the interest rate on credit (i_t), and the level of the monetary policy rate (s_t). α is a vector of constants, $A(L)$ is a matrix polynomial in the lag operator L, and B the contemporaneous impact matrix of the mutually uncorrelated disturbances ε_t. The VARs in this study are estimated in (log) levels, which allows for implicit cointegrating relationships in the data (Sims, Stock and Watson 1990). A more explicit analysis of the long-run behavior of the various variables is limited by the relatively short sample available.

All data are monthly and obtained from the ECB Statistical Data Warehouse. I proxy output by industrial production and prices by the HICP. Given the prominent role of bank loans as a source of external finance in the Euro area and the fact that the Eurosystem primarily implemented its non-standard policy actions via the banking system, the benchmark VAR also contains bank credit and the corresponding interest rate. I measure bank credit by the volume of MFI loans to the private sector adjusted for sales and securitization. In particular, this index takes into account the fact that securitization activities could drive a wedge between actual lending and that derived from MFI balance sheet statistics. Similarly, the index corrects for the re-intermediation of loans onto MFI balance sheets without a corresponding rise in actual lending. The latter was for instance the case when markets for several asset-backed securities became illiquid during the financial crisis. For the interest rate on bank lending, I use the constructed composite lending rate of Peersman (2011), which is a weighted average of interest rates charged by MFI's on loans to households, non-financial corporations and non-MFI financial intermediaries (insurance corporations, pension funds and other non-MFI financial intermediaries including investment funds). Furthermore, the policy rate in the VAR is the minimum bid rate of variable rate tenders or the rate applied to fixed rate tenders in the main refinancing operations (MROs) of the Eurosystem, and the monetary base is defined as the sum of banknotes in

circulation and bank reserves (credit institutions current accounts and deposit facility). In section 3.2, I will examine the robustness of the results for alternative specifications of the VAR, as well as alternative variables.

2.2 Identification strategy

In order to identify the structural innovations, I focus on bank lending activities. Whereas this focus makes it easier to disentangle the shocks, a caveat is that conventional and unconventional monetary policy innovations that affect the economy beyond bank lending are not captured. However, borrowing and lending in the Euro area predominantly take place through the intermediation of the banking sector, and non-standard measures taken by the Eurosystem as a response to the crisis were primarily aimed at fueling the banking system. Hence, most monetary policy actions should be captured in the analysis.

Within the VAR model, I identify three possible sources of disturbances at the supply side of the credit market. In particular, credit supply in the Euro area is determined by the Eurosystem and financial intermediaries. On the one hand, credit supply disturbances could hence be the result of shifts in the volume of credit supplied by banks independently of a policy action. I label these shocks as innovations to the credit multiplier, which captures the volume of bank loans that is generated by the financial sector with a specific amount of central bank money. On the other hand, innovations to the supply of credit could be the consequence of monetary policy decisions. I distinguish between two types of such decisions, that is alterations to the policy rate and all other possible monetary policy actions that influence the supply of bank loans.

The baseline set of restrictions to identify the shocks are a mixture of zero and sign restrictions on the contemporaneous impact matrix B of equation (1). More specifically, I use the following set of restrictions:[6]

Identification of different sources of innovations to credit supply

	y_t	p_t	c_t	i_t	s_t	b_t	$c_t - b_t$
Credit multiplier shocks	0	0	$\uparrow^{lagged}$	$\downarrow$	$\uparrow$		$\uparrow$
Interest rate innovations	0	0	$\uparrow^{lagged}$	$\downarrow$	$\downarrow$		
Non-standard policy actions	0	0	$\uparrow^{lagged}$	$\downarrow$	0		

Note: y_t = output, p_t = prices, c_t = credit, i_t = lending rate, s_t = policy rate, b_t = monetary base

[6]Note that the sign restrictions are implemented as $\geqslant$ or $\leqslant$, which implies that a zero impact is also possible. Notice also that, for technical reasons, the zero restriction on the policy rate is implemented as a near-zero restriction. In particular, the immediate impact should be below a threshold of 1 basis point.

First, in line with the traditional literature on the effects of nominal shocks, I assume that there is only a lagged impact of credit supply disturbances on output and consumer prices, that is the contemporaneous impact on both variables is restricted to be zero. In contrast, innovations to output and prices are allowed to have an immediate impact on the volume of credit, the monetary base, the lending rate and the policy rate. This assumption should distinguish shocks that are specific to the credit market from disturbances in the real economy that could also influence the credit market. Despite being a conservative assumption, restraining the contemporaneous impact of nominal disturbances on real variables is considered as being plausible for monthly estimations and allows for comparability with previous results.[7] In section 3.2, I also discuss a robustness check with an identification strategy that does allow for feedback of credit supply disturbances to economic activity and consumer prices within the period, but it turns out that the results are not very sensitive to this assumption.

Second, to differentiate from exogenous credit demand disturbances, I assume that shocks at the supply side of the credit market lead to a negative (or non-positive) co-movement between the interest rate and the volume of credit. In the empirical analysis, the sign restrictions are imposed on the immediate impact and the following four months after the shocks. An exception is the response of the volume of credit, for which the restrictions are only imposed on the third and fourth lag after the disturbances to allow for a possible short-run rise of bank lending after a rise in the lending rate. Giannone, Lenza and Reichlin (2009) find that an unexpected interest rate hike only affects consumer loans and loans for housing purposes negatively on impact, while the component loans to non-financial corporations responds negatively with a lag, but positively on impact (see also Den Haan, Sumner and Yamashiro 2007). Firms could, for instance, still draw on their credit lines at a prespecified rate when the interest rate on new loans increases. Also this assumption does not seem to matter since the immediate response will always be in line with the subsequent months for all three disturbances.

Credit multiplier shocks An innovation to credit supply could be the consequence of a shift in the supply of loans by the banking sector. Consider for instance a shock that makes it easier for financial institutions to securitize their loans. This allows banks to increasingly fund themselves by selling loans in the secondary market and boosts their ability to supply

[7] E.g. Bernanke and Blinder (1992), Bernanke and Mihov (1995), Strongin (1995) amongst others make the same assumption for the identification of monetary policy and other nominal shocks in the US. Several studies even make this assumption using quarterly data, e.g. Christiano, Eichenbaum and Evans (1999) or Peersman and Smets (2003).

new loans for a given amount of central bank money. Other examples of innovations that influence the supply of credit independently of a monetary policy decision are shocks to the risk appetite of banks or disturbances that affect credit derivatives markets. All that is required is that banks are somehow able to obtain extra funding in the market to finance additional loans, which could be either deposits or other liabilities. By definition, such a shock increases the credit multiplier. I further impose the restriction that the ECB reacts to a positive innovation by tightening its policy stance. A policy tightening is consistent with a central bank that tries to stabilize potential output and inflation consequences.

Traditional interest rate innovations Monetary policy disturbances are obviously also expected to affect the supply of credit. The ECB mainly conducts its policy by steering the EONIA. The desired level is typically signalled to the financial markets through either the minimum bid rate of variable rate tenders or the rate applied to fixed rate tenders in its main refinancing operations (MROs). Accordingly, a credit supply disturbance caused by a traditional interest rate innovation is identified as a fall in the policy rate which is passed on to bank lending rates, whilst increasing the volume of credit with a possible lag.

Non-standard policy actions The supply of credit could however also be influenced by other policy actions, such as operations that change the composition of the central bank's balance sheet, actions that try to guide longer term interest rate expectations or measures that expand or reduce the size of the balance sheet or monetary base. I label all policy measures that affect the supply of credit beyond the policy rate as "unconventional" or "non-standard". By construction, these policies are orthogonal to interest rate innovations. In particular, non-standard policy disturbances are identified as credit supply shocks with a zero contemporaneous impact on the policy rate, which is sufficient to disentangle the shocks from interest rate innovations, but also from shocks to the credit multiplier as potential disturbances at the supply side of the credit market.[8]

Some remarks about the identified non-standard policy shocks are worth mentioning. First, unconventional policy actions are only captured by this shock if they affect the supply of credit, that is if they influence the volume of credit and bank lending rates (not necessarily economic activity, which will be determined by the data). In contrast, measures that influence the economy beyond financial intermediaries are not identified, which could for instance be the case for outright purchases of government bonds. The

[8]Notice that there are four credit market variables in the VAR while only three credit market disturbances are identified, as well as two real economy shocks. Hence, all other shocks that influence credit market variables are captured by the remaining innovation, which acts as a "sponge" shock.

same is true for the identified interest rate innovations, for which the results could be compared with other studies that identify monetary policy shocks in a more traditional way. Second, these disturbances could be "demand-induced". In particular, an expansion of credit supply could be driven by additional liquidity that financial institutions obtain from the central bank without augmenting the multiplier. The accommodation of this demand is, however, a policy decision. More importantly, the identifying restrictions require that the central bank does not react to the shock and its potential consequences by keeping the policy rate constant, which is obviously also a policy decision. An example is the surge of the Eurosystem's balance sheet at a given policy rate as a consequence of the full allotment decision in September 2008.

Accordingly, the identified non-standard policy shocks can be considered as a combination of several possible measures aimed at influencing financing conditions and the flow of credit beyond the main policy rate. For instance, as a response to the financial crisis, there has been a shift from a variable rate tender to a fixed rate tender with full allotment, liquidity to banks has been provided at longer maturities and the ECB has expanded its list of eligible collateral. To the extent that the outright purchases of covered bonds have influenced credit conditions of the banking system, these actions should also be captured by the innovations. However, monetary policy shocks that are orthogonal to the main policy rate could also have occurred before the financial crisis. In particular, a specific level of the MRO rate may always be associated with varying monetary conditions. A given policy rate may for instance be associated with a relatively flat or steep term structure of interest rates, which could be influenced by the communication of future policy intentions.[9] Whenever the supply of credit is ultimately affected, such actions are identified as unconventional policy shocks in the estimations. Furthermore, the management of liquidity by the ECB should inherently also have resulted in unconventional policy shocks before the turmoil. More specifically, in its main and longer term refinancing operations, the ECB usually decided on the total amount of liquidity to be allotted. Hence, changes in the allocated volume of liquidity and errors in the estimation of so-called autonomous liquidity needs could have influenced the supply of lending. In particular, excess liquidity allocated by the ECB is not necessarily offered on the overnight interbanking market, it

[9] Remark that communication effects are also an integral part of the transmission mechanism of the non-standard policy measures that were taken following the default of Lehman Brothers. For instance, an announcement that monetary authorities are prepared to engage in operations for certain assets may in itself boost confidence in those assets thereby reducing liquidity premia (Borio and Disyatat 2009). The same argument holds for an announcement that the central bank is prepared to accommodate liquidity shortages in the interbanking market. In this regard, the lengthening of refinancing operations to one year could also be interpreted as a signal of persistent low interest rates.

could also find its way to bank lending. Even the composition of the balance sheet has not been constant over time, that is there have also been shifts in the volume of main refinancing operations versus longer-term operations before the crisis. In the end, a generic series of innovations to bank lending caused by monetary policy actions that are orthogonal to the policy rate is identified. The dynamic effects of these innovations could be used as a benchmark for the effectiveness of extraordinary policies. Once the SVAR is estimated, a closer look at the time series of the shocks should reveal whether the measures taken in the aftermath of the crisis are captured by the innovations. In addition, an inspection of the impulse response functions should help to interpret the source more carefully, i.e. a reverse engineering of the underlying impulse.

3 Estimation results

3.1 Baseline model

The benchmark VAR is estimated for the sample period 1999M9-2009M12. Based on the usual lag-length selection criteria, the estimations include four lags of the endogenous variables.[10] I use a Bayesian approach for estimation and inference. For details, I refer to Peersman (2005) or Uhlig (2005). The prior and posterior distributions of the reduced form VAR belong to the Normal-Wishart family. To draw the 'candidate truths' from the posterior, I take a joint draw from the unrestricted Normal-Wishart posterior for the VAR parameters as well as a random possible decomposition B of the variance-covariance matrix, which allows the construction of impulse response functions. If the impulse response functions from a particular draw satisfy the imposed restrictions, the draw is kept. Otherwise, the draw is rejected by giving it a zero prior weight. Each draw is required to satisfy the restrictions of all three identified shocks simultaneously. Finally, a total of 1000 successful draws from the posterior are used to produce the figures.

3.1.1 Impulse response analysis

Panel A of Figure 1 displays the impulse response functions for interest rate innovations and unconventional policy shocks. To improve comparability, the impulse responses for both shocks are shown within the same panel. Specifically, the shaded (light blue) areas represent the 68 percent posterior probability regions of the estimated responses to a one

[10] Most criteria even suggest a shorter lag length. The results are however robust for different choices of lag length.

standard deviation innovation to the policy rate, whereas the dotted (red) lines those of a non-standard monetary policy action. The impulse response patterns for credit supply shocks caused by traditional interest rate innovations are broadly in line with the pre-EMU VAR evidence on the monetary transmission mechanism (e.g. Peersman and Smets 2003), and the existing evidence for the U.S. (e.g. Bernanke and Blinder 1992, Bernanke and Mihov 1995, or Christiano, Eichenbaum and Evans 1999). An unexpected fall in the policy rate tends to be followed by a temporary rise in economic activity after a few months. The effect on output reaches a peak after one year and returns to the baseline afterwards. On the other hand, consumer prices rise permanently. Interestingly, also unconventional monetary policy shocks that affect the supply of credit have significant temporary output effects and a permanent impact on the level of consumer prices. The pass-through is, however, more delayed. In particular, output and prices only start to rise significantly after about one year, and the peak effect on economic activity is at least six months later than for an interest rate shock.

It is striking how similar the ultimate effects of non-standard policy actions are, despite the lack of a short-run shift in the policy rate. A closer inspection of the monetary base response function suggests that the identified non-standard shocks mainly represent measures aimed at expanding or reducing the size of the central bank's balance sheet, which corresponds to so-called quantitative easing policies. In particular, a one-standard deviation unconventional monetary policy shock is characterized by an increase in the monetary base of approximately 2 percent. In sum, monetary policy can potentially influence economic activity via the supply of bank loans beyond an interest rate shift, that is more than one instrument can be used for policy purposes. The impact on economic activity is for instance similar for a 25 basis points decline in the policy rate and an increase in the monetary base of 10 percent at a given level of the policy rate.[11]

As shown in panel B of Figure 1, also credit multiplier shocks have a hump-shaped output pattern whilst prices rise persistently. A detailed analysis of these disturbances is out of the scope of this paper.[12] Noticeable, however, is the estimated negative endogenous response of the monetary base to a *positive* credit multiplier shock, which suggests that these disturbances are characterized by relatively easy alternative (non central bank)

[11] This finding is in line with Nelson (2002), who finds that real monetary base growth is a significant determinant for economic activity in the UK and US, controlling for the short-term real interest rate.

[12] An analysis of the sources of credit multiplier disturbances, as well as the macroeconomic relevance, can be found in Peersman (2011). In that paper, I examine the consequences of different types of credit market disturbances with a structural interpretation, that is exogenous credit demand, monetary policy and credit multiplier shocks. In contrast to the present study, I also identify exogenous credit demand shocks, but not unconventional policy shocks.

funding opportunities for banks. Hence, to the extent that the financial crisis can be considered as a huge *negative* credit multiplier shock, this response partly explains the significant rise of the monetary base in the aftermath of the crisis. In particular, when bank's funding conditions deteriorate, their capacity to issue loans relative to the amount of liquidity provided by the central bank declines, making them more dependent on the central bank for their liquidity needs.

3.1.2 Time series of shocks

To explore the pattern of the disturbances over time, Figure 2 shows the times series of the shocks, as well as the evolution of the monetary base components and the policy rate. More precisely, the light and dark grey areas in panel A show the evolution of respectively the volume of currency in circulation and the volume of bank reserves since the introduction of the euro. The full (blue) line in panel A represents the cumulative evolution of the estimated unconventional monetary policy shocks (a rise implies an expansionary shock). As can be seen, the extraordinary policy measures in response to the crisis are clearly captured by the shocks. Shortly after the collapse of Lehmann, cumulative non-standard monetary policy shocks increased by 8 standard deviations within a period of 8 months. The pattern is also very much in line with the evolution of bank reserves, and to a lesser extent currency in circulation, during that period. However, also before the crisis, there were significant non-standard monetary policy shocks. Specifically, the Euro area experienced a series of expansionary unconventional policy shocks between 2000 and the second half of 2001, which includes the millennium bug and September 11, whereas the stance was rather restrictive during the subsequent slowdown and at the time of the cash changeover in 2002. Also this pattern is very much in line with the evolution of the monetary base during that period, in particular the amount of currency in circulation.[13]

Interestingly, also the endogenous response of the monetary base to the financial crisis is captured by the SVAR. The dotted (red) line in panel A of Figure 2 represents the cumulative evolution of negative innovations to the credit multiplier (a rise implies a fall in the multiplier). The illiquidity of asset-backed securities markets and the deterioration of risk profiles and capital positions of banks during the crisis are identified as a series of negative shocks to the credit multiplier. As discussed in the impulse response analysis, a deterioration of bank's funding conditions make them more dependent on the central bank for their liquidity needs, resulting in a rise of the monetary base. Accordingly, unfavorable

[13] See also Gaspar and Kashyap (2006) for a documentation of this turbulent episode in the ECB's liquidity management.

credit multiplier shocks have clearly contributed to the (double spiked) expansion of the monetary base at the end of the sample period.

On the other hand, the pattern of interest rate innovations is closely related to the evolution of the policy rate over the sample period. Both series are shown in panel B of Figure 2. The policy rate was restrictive around the 2001 slowdown, supportive between 2003 and 2006, and again restrictive between 2006 and the middle of 2007. Tight monetary conditions in the course of 2008 are also identified as a series of restrictive interest rate innovations.[14] As expected, the stance of the policy rate was again expansionary after the collapse of Lehmann, which is illustrated by a 4 standard deviations decline of cumulative interest rate innovations.

3.2 Sensitivity analysis

In this section, I briefly discuss the robustness of the results for alternative measures of central bank money, a VAR with money market instead of credit market variables, an alternative identification strategy and a shorter sample period. Notice first that the results are robust when unemployment is used as an output measure or when core HICP is used as a price measure. Extending the VAR with the European Sentiment Indicator, oil prices or financial market variables such as stock market volatility does also not affect the conclusions.

Central bank money measures Figure 3, rows 1-3 show the impulse responses for some key variables after both monetary policy shocks when respectively the amount of bank reserves, the volume of liquidity providing operations and the overall size of the ECB's balance sheet are used as a proxy for central bank money. As shown in Figure 2, bank reserves fluctuated relatively more than the currency component of the monetary base after the collapse of Lehmann Brothers. On the other hand, there was a decline of currency in circulation and the monetary base in the run-up to the cash turnover in January 2002, which was not the case for the amount of bank reserves. As can be seen from the impulse responses, the macroeconomic consequences of unconventional policy actions that affect the volume of bank reserves are very similar as in the baseline model with the monetary base. Surprisingly, there is no liquidity effect for an interest rate innovation, that is bank reserves even *decrease* after a decline in the policy rate. In section 3.4, this will be analyzed in more detail.

[14] Whereas the financial turmoil started in the summer of 2007, the ECB kept the interest rate at 4 percent, and even raised the policy rate to 4.25 percent in July 2008.

The volume of liquidity providing operations, obtained from the asset-side of the Eurosystem's balance sheet, should better capture policy decisions with respect to bank liquidity provision. However, in contrast to the monetary base, this aggregate does not capture changes of net assets in gold and foreign currency, which could also influence bank lending. In addition, part of the liquidity providing operations return to the Eurosystem in the form of central government deposits and other liquidity absorbing operations by the ECB. The latter also influences the ability of bank lending and is taken into account for the measurement of the monetary base. On the other hand, the overall size of the balance sheet is the sum of liquidity providing operations and all other net assets (mainly gold and foreign currency) on the balance of the Eurosystem. Figure 3 shows that the effects on economic activity and consumer prices are also similar for these two alternative aggregates. In sum, the baseline findings do not depend on the selected measure of central bank money.

A VAR model with money The fourth row of Figure 3 shows the effects for a VAR model with money market variables. More precisely, the VAR is now re-estimated with M3 instead of credit and the 3-month Euribor instead of the bank lending rate. The identified unconventional monetary policy shocks are disturbances to the supply of money which are not caused by innovations to the money multiplier whilst being orthogonal to shifts in the policy rate. The results are again robust, that is non-standard policy measures still have a significant humped-shaped impact on output and a permanent effect on the level of consumer prices. In contrast to the VARs with credit market variables, the timing of the output pattern is now the same for both types of policy instruments.

Alternative identification strategy In the baseline identification strategy, I have assumed that there is no effect of credit market disturbances on output and consumer prices within the month. To be less conservative, I have also re-estimated the VAR leaving both variables unrestricted on impact. An implicit assumption is then that real economy shocks all move the volume of credit and lending rates in the same direction or, in other words, a disturbance that boosts economic activity shifts the demand curve for credit to the right. Again, this does not affect the conclusions of the paper. As shown in the fifth row of Figure 3, the contemporaneous output and inflationary effects are insignificant, while the patterns of the responses are comparable to the benchmark results after a few months.

A shorter sample period Stability tests suggest that the coefficients of the VAR have been rather stable over the sample period.[15] Nevertheless, as a final robustness check, I have also estimated the baseline VAR over a sample period that excludes the enhanced credit support period (until mid 2008). The impulse responses are shown in the bottom row of Figure 3 and confirm the conjecture that unconventional monetary policy shocks also occurred in normal times and had significant macroeconomic consequences. Specifically, the dynamic effects of non-standard policy innovations before the crisis turn out to be qualitatively similar as for the whole sample period. The size of a one standard deviation shock is only smaller, and hence also the magnitude of the effects. Somewhat surprising are the much less precisely estimated effects of traditional interest rate innovations over the shorter sample period, suggesting that the policy response to the recession has improved the identification of conventional monetary policy shocks.

3.3 Inspecting the source of unconventional monetary policy shocks

The results have revealed that the identified non-standard monetary policy shocks are characterized by a shift in the monetary base or the size of the Eurosystem's balance sheet, which corresponds to quantitative easing. Before turning to the transmission mechanism in the next section, I now examine the underlying source of the shocks more carefully.

First, to be sure that the shocks are not capturing deviations between the EONIA and the MRO rate, that is an unconventional policy shock would then just be another "interest rate" innovation within the corridor of the standing facilities, I have re-estimated the VAR with the EONIA as the policy rate instead of the MRO rate.[16] The results are shown in panel A of Figure 4. There is clearly an effect beyond the overnight interest rate. Non-standard policy actions are still characterized by a significant rise in the monetary base having a significant impact on economic activity and consumer prices.

The dominance of innovations to central bank money as the underlying source of unconventional policy shocks is confirmed by the responses of some other variables. Specifically, I have also re-estimated the benchmark VAR by adding each time an additional variable of interest to the block of credit market variables. The identifying restrictions are the

[15] For instance, equation by equation Quandt-Andrews tests for one or more unknown structural breakpoints in the sample cannot reject the null hypothesis of no breakpoints. The cumulative sums of the recursive residuals (CUSUM tests), also indicate that the parameters have been stable over the sample period. Only Chow forecast tests for a specific break in the summer of 2008 do reject stability, in particular for the policy rate and monetary base equations, which is the result of an increased size of the innovations.

[16] Notice that, as a consequences of several unconventional policies, the EONIA has been systematically lower than the MRO rate after September 2008.

same as in the benchmark model and the responses of the additional variables are not restricted on impact. The results for each variable can be found in panel B of Figure 4.[17] First, if the underlying source of the innovations would be a shift in expected monetary policy, for instance due to changes in the communication of the ECB, the spread between the 12-month and 1-month Euribor should decline significantly on impact. Whereas the money market term spread does slightly decline after one month, the contemporaneous response turns out to be insignificant. This suggest that the fall in the spread is rather an endogenous reaction to the shift in the balance sheet than the source of the unconventional policy shock.

The source of the disturbances is also not a change in the composition of the central bank balance sheet. As a response to the financial crisis, the Eurosystem provided for instance more liquidity to banks at longer maturities. However, as shown in Figure 4, the response of the ratio between the volume of main refinancing operations and long-term operations does not change after a non-standard policy shock. Finally, the identified innovations are not an endogenous reaction of central bank money to turbulence in the money market, for instance increased liquidity demand by banks because of an illiquid money market, which is not captured by credit multiplier innovations. In particular, the spread between the 3-month Euribor and the Overnight Index Swap rate, which can be considered as a proxy for financial turbulence, is insignificant on impact and even falls some months after the identified unconventional shocks.

In sum, we can safely conclude that the Eurosystem can influence economic activity and inflation beyond the policy rate by adjusting the size of its balance sheet or the monetary base. This conclusion is further confirmed by the estimation of an extended VAR model in the appendix of this paper that explicitly distinguishes between unconventional policy measures that affect the money market term spread and exogenous shocks to the size of the balance sheet.

3.4 Monetary Transmission Mechanism

So far, we have seen that the impact of quantitative easing policies on output and consumer prices is more delayed compared to a decline in the policy rate. Is there a difference in the transmission mechanism of both instruments? To learn more about this, panel A of Figure 5 shows the impact of the two policy shocks on the credit multiplier and the interest rate

[17] Due to space constraints, I only show the impulse response function of the additional variable to both monetary policy shocks. Full results are available upon request.

spread for the baseline VAR. The response of the multiplier is obtained from the responses of credit and the monetary base for each posterior draw, while the interest rate spread is proxied by the difference between the response of the bank lending rate and the MRO rate, as we may expect that the policy rate is pivotal in setting bank's funding conditions.

Consider an increase in the monetary base due to an unconventional policy action. The injection of liquidity results in a rise of credit supplied by banks, reducing lending rates and hence also the interest rate spread charged by banks. The fall in the interest rate spread is implicitly imposed for the first month, but seems to persist for more than two years. The credit multiplier declines significantly in the short run and gradually returns to its initial level after about one year. Hence, the rise in the monetary base is only proportionally transmitted to the volume of bank lending in the long run. In contrast, in case of a policy easing, a traditional innovation to the policy rate results in a significant rise of the interest rate spread charged by banks. More precisely, the interest rate decline of the ECB is passed on to bank lending rates, but less than proportional. The fall in bank lending rates and rise of interest rate spreads boost credit demand and supply, resulting in a relative quick pass-through to economic activity and inflation (as shown in Figure 1 and discussed in section 3.1). In addition, there is hardly a change in the credit multiplier, nor a significant liquidity effect in the short-run.

The different response of the credit multiplier after both monetary policy shocks is particularly interesting. A *potential* explanation is the popular risk-taking channel of monetary transmission. Notice first that, according to traditional textbooks (e.g. Mishkin 2010; Walsh 2010), expansionary monetary policy is expected to have a downward impact on the credit multiplier. Specifically, when interest rates fall, households typically hold more currency relative to interest-bearing bank deposits. As a consequence, less liquidity returns to the financial sector, reducing the ability to supply loans and hence also the credit multiplier. Similarly, a lower interest rate reduces the opportunity cost for banks to hold excess reserves and vault cash, which also lowers the credit multiplier. On the other hand, monetary policy is expected to influence the lending capacity of banks and the credit multiplier via at least two other effects that are part of the risk-taking channel of monetary transmission (Borio and Zhu 2008; Adrian and Shin 2010). First, expansionary monetary policy increases the quality and value of outstanding bank loans through an increase in collateral and the expected associated repayment flows. Accordingly, the value of bank's marked-to-market equity rises leading to an increased balance sheet capacity and risk appetite of the banking system, resulting in greater loan supply. In particular, financial intermediaries will attempt to find ways to allocate their surplus capital. On

the liability side, they take on more debt. On the assets side, they search for borrowers, which expands the credit multiplier. Second, the profitability and risk-taking capacity of financial intermediaries is more directly affected by bank's interest rate spreads. When interest rate spreads rise, the marked-to-market value of equity also increases, leading to more risk appetite of banks and a shift in the supply of credit. Likely, this risk-taking channel of monetary transmission is much stronger for an interest rate shock compared to an innovation in the balance sheet of the central bank. On the one hand, the value of collateral is probably more affected when also the level of the risk-free rate changes. More crucially, the interest rate spread increases significantly after a conventional interest rate fall, whereas there is a significant decline following non-standard policy disturbances (see Figure 5). This channel could hence be a possible source of the substantial difference in the estimated response of the credit multiplier after both monetary policy shocks. Put differently, the same volume of loans is generated by the financial sector for roughly a 0.5 percent increase in the monetary base which also shifts the policy rate, as for a 2 percent rise of the monetary base without an accompanying shift in the policy rate.

Strikingly, as shown in panel B of Figure 5, there seems not even to be a liquidity effect for bank reserves after an interest rate innovation.[18] Such a liquidity effect is often used in the literature to identify monetary policy shocks with sign restrictions (e.g. Uhlig 2005 or Canova and De Nicoló 2002). In particular, these studies identify a monetary policy shock as a disturbance that moves the policy rate and bank reserves in the opposite direction. However, bank reserves turn out to decline in the short run, while the corresponding multiplier increases significantly after a fall in the policy rate. In other words, all additional credit is generated by the banking sector via a rising multiplier.

4 Conclusions

In this paper, I have examined the macroeconomic effects of traditional interest rate innovations and unconventional monetary policy actions on the Euro area economy. More precisely, I have used a structural VAR model to identify three different types of disturbances at the supply side of the credit market: (i) innovations to the supply of credit by banks independently of a monetary policy action, (ii) shocks to the supply of credit due to a shift in the policy rate and (iii) credit supply shocks caused by non-standard monetary policy actions that are orthogonal to the policy rate.

[18] An overview of the early literature on the existence of a liquidity effect can be found in Pagan and Robertson (1995).

I find that more than one instrument can be used to influence the economy. In particular, a policy action which raises the monetary base or the size of the central bank balance sheet for a given policy rate, has a hump-shaped effect on economic activity and a permanent impact on consumer prices. Compared to a traditional interest rate innovation, the pass-through is more sluggish. In addition, the transmission mechanism of both types of policy instruments turns out to be different. Whereas a rise in the balance sheet of the Eurosystem is passed on to bank lending via a decline in interest rate spreads of banks, the spreads increase significantly after a fall in the policy rate. Furthermore, the so-called credit multiplier declines considerably after a balance sheet shock. In contrast, the surge in the volume of credit after an interest rate innovation is mainly created by a rising multiplier. A potential explanation for the difference is a stronger risk-taking channel for an interest rate innovation, a feature which deserves more attention in future research.

The impact and pass-through of the identified unconventional policy shocks should help to learn more about the extraordinary policy measures taken by central banks as a response to the financial turmoil. Some caution is, however, required. A caveat of the analysis is that the estimations are based on a sample period that covers the turbulent period on financial markets, as well as normal times. An implicit assumption is hence that the parameters did not change dramatically as a consequence of the crisis. In addition, the analysis only captures unconventional monetary policy to the extent that the measures influence the banking sector. Hence, a useful extension would be to also include direct lending of central banks in private markets in the analysis.

A Appendix - Two types of unconventional policy shocks

In the paper, I have shown that exogenous shifts in the volume of central bank liquidity are the dominant driving force of the identified non-standard monetary policy shocks in the baseline VAR and have significant output and inflationary effects beyond the current and expected monetary policy rate or the composition of the central bank balance sheet. However, whilst the immediate impact of the disturbances on the money market term spread is insignificant, the distribution of this impact turns out to be negatively skewed (see Figure 4). This suggest that several draws are characterized by a noticeable decline of the spread on impact. In this appendix, I have therefore also estimated an extended VAR model with two different types of unconventional monetary policy shocks. More precisely, compared to the baseline model, the spread between the 12-month and 1-month Euribor is added to the block of credit market variables in the VAR and I now simultaneously identify four possible shocks at the supply side of the credit market. Credit supply shocks driven by disturbances to the credit multiplier and by traditional interest rate innovations are still identified in the same way as in the baseline model. As a first possible unconventional policy shock, I consider a credit supply shock which is characterized by a decline in the money market term spread that is orthogonal to the policy rate. I label this disturbance as a "signaling" shock, which could for instance be the consequence of lending at longer maturities by the ECB or a change in the communication about the future stance of monetary policy. The second non-standard policy shock that could lead to a shift in the supply of credit, labeled as a "balance sheet" shock, is identified as a disturbance to the supply of credit caused by a shock in the volume of central bank money that is orthogonal to both the policy rate and the money market term spread. All restrictions can be summarized as follows:

Identification of two types of non-standard monetary policy shocks

	y_t	p_t	c_t	i_t	s_t	b_t	sp_t	$c_t - b_t$
Credit multiplier shocks	0	0	$\uparrow^{lagged}$	$\downarrow$	$\uparrow$			$\uparrow$
Interest rate innovations	0	0	$\uparrow^{lagged}$	$\downarrow$	$\downarrow$			
Signaling shocks	0	0	$\uparrow^{lagged}$	$\downarrow$	0		$\downarrow$	
Balance sheet shocks	0	0	$\uparrow^{lagged}$	$\downarrow$	0	$\uparrow$	0	

Note: y_t = output, p_t = prices, c_t = credit, i_t = lending rate, s_t = policy rate, b_t = monetary base
sp_t = spread between 12 month and 1 month Euribor

The impulse responses to the three different types of policy disturbances are shown

in Figure A1.[19] As expected, the dynamic effects of the balance sheet shocks are very comparable to the unconventional disturbances identified in the baseline VAR. There is still a hump-shaped impact on economic activity which is more sluggish than the response to an interest rate innovation. Notice that also a credit supply shock which is caused by a decline in the money market term spread that is orthogonal to the policy rate tends to be followed by a temporary increase in economic activity and a more permanent effect on the level of consumer prices. The dynamics are strikingly similar as for a traditional interest rate innovation. Interestingly, the monetary base does not react and the policy rate effectively declines after a few months.

The decline of the credit multiplier and persistent fall in the interest rate spread after a shock in the balance sheet of the Eurosystem is also confirmed by the VAR model with two types of unconventional policy shocks. In contrast, the transmission mechanism for innovations that reduce the money market term spread, in particular the response of the monetary base and the credit multiplier, appears to be very similar as for a conventional interest rate shock. Notice that whereas the spread between the policy rate and the bank lending interest rate remains more or less constant after the signaling shock, the interest margin and profitability of banks should improve due to the decline of longer term money market interest rates. Hence, also the risk-taking effect is probably strong.

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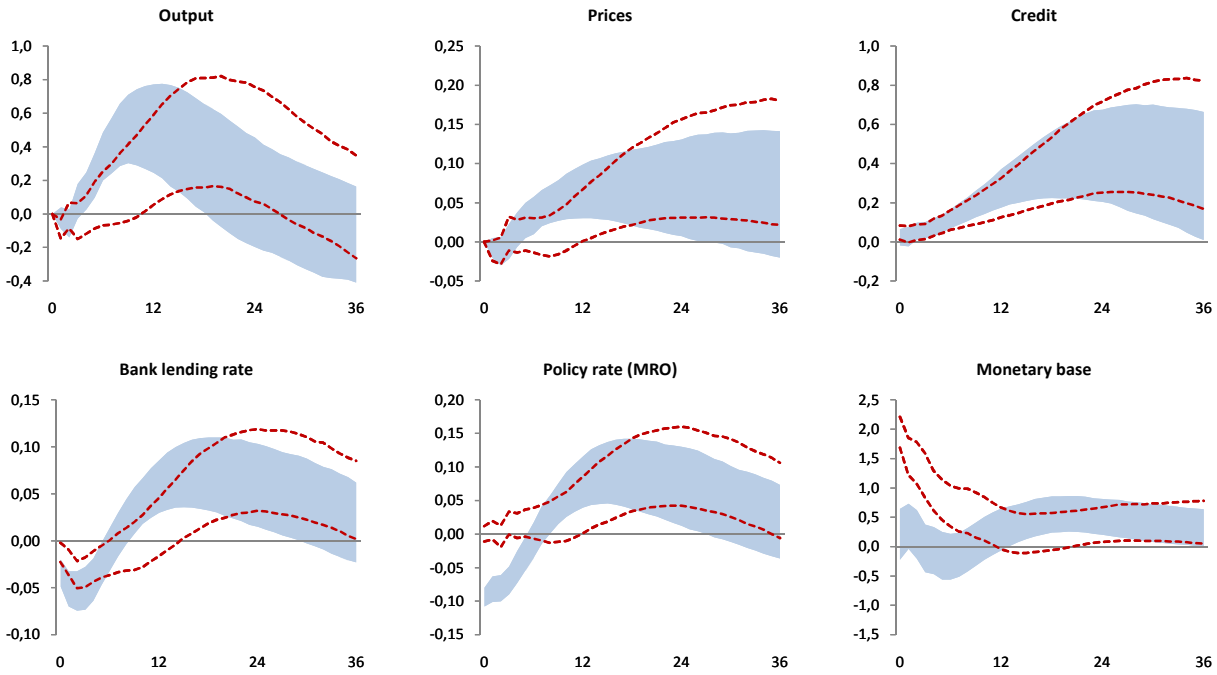
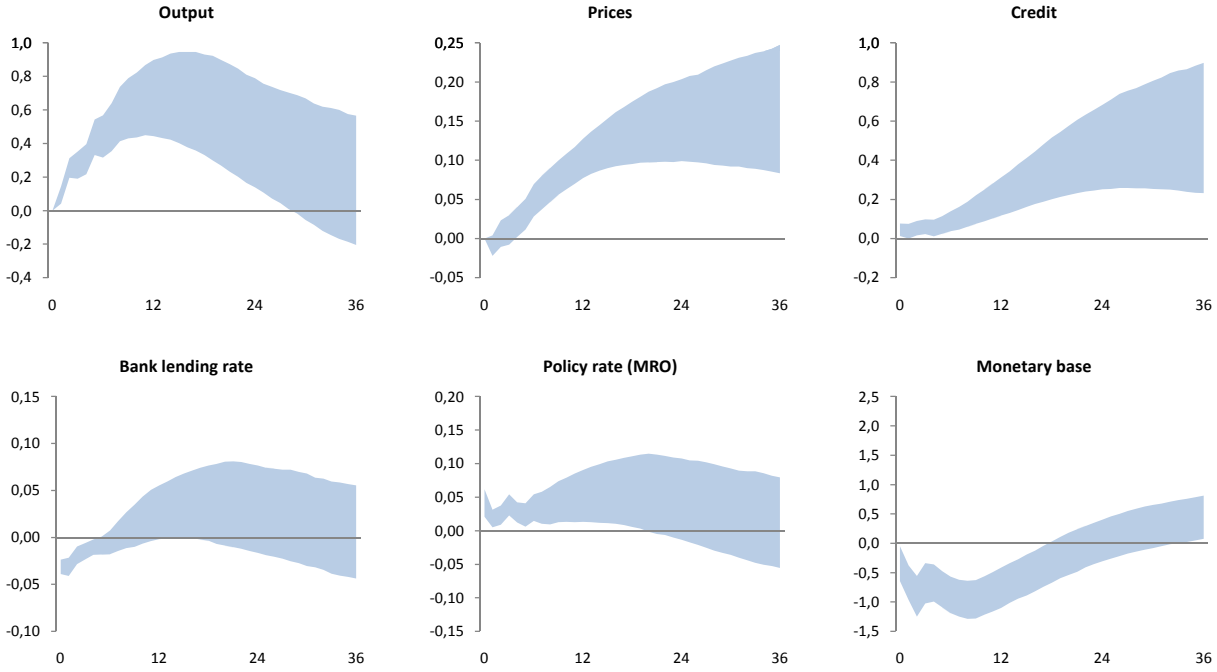
Figure 1 - Impulse responses to different types of credit supply shocks

Panel A: Interest rate innovations and non-standard policy actions



Note: *Interest rate innovations: 68 percent probability regions*
Non-standard policy actions: 68 percent probability regions

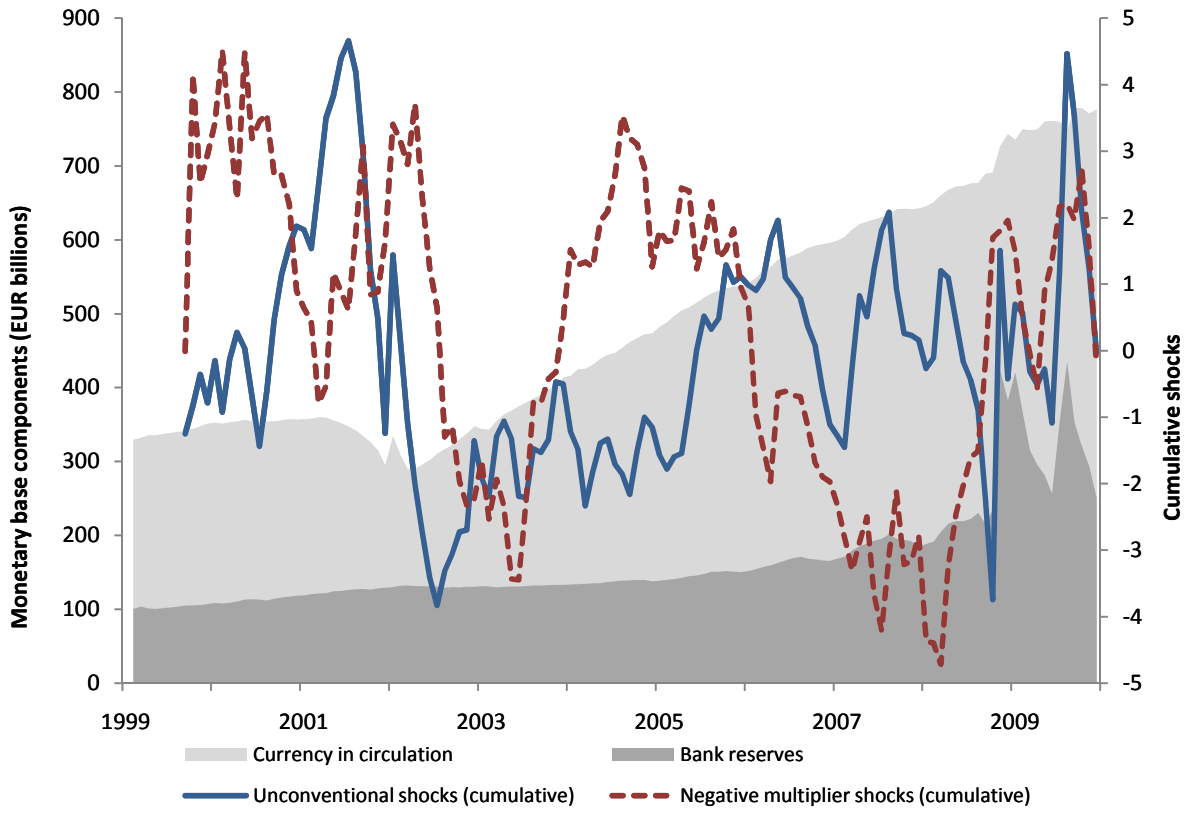
Panel B: Credit multiplier shocks



Note: *Credit multiplier shocks: 68 percent probability regions*

Figure 2 - Time series of shocks

Panel A: Monetary base components, unconventional shocks and credit multiplier shocks



Panel B: Monetary policy rate and interest rate innovations

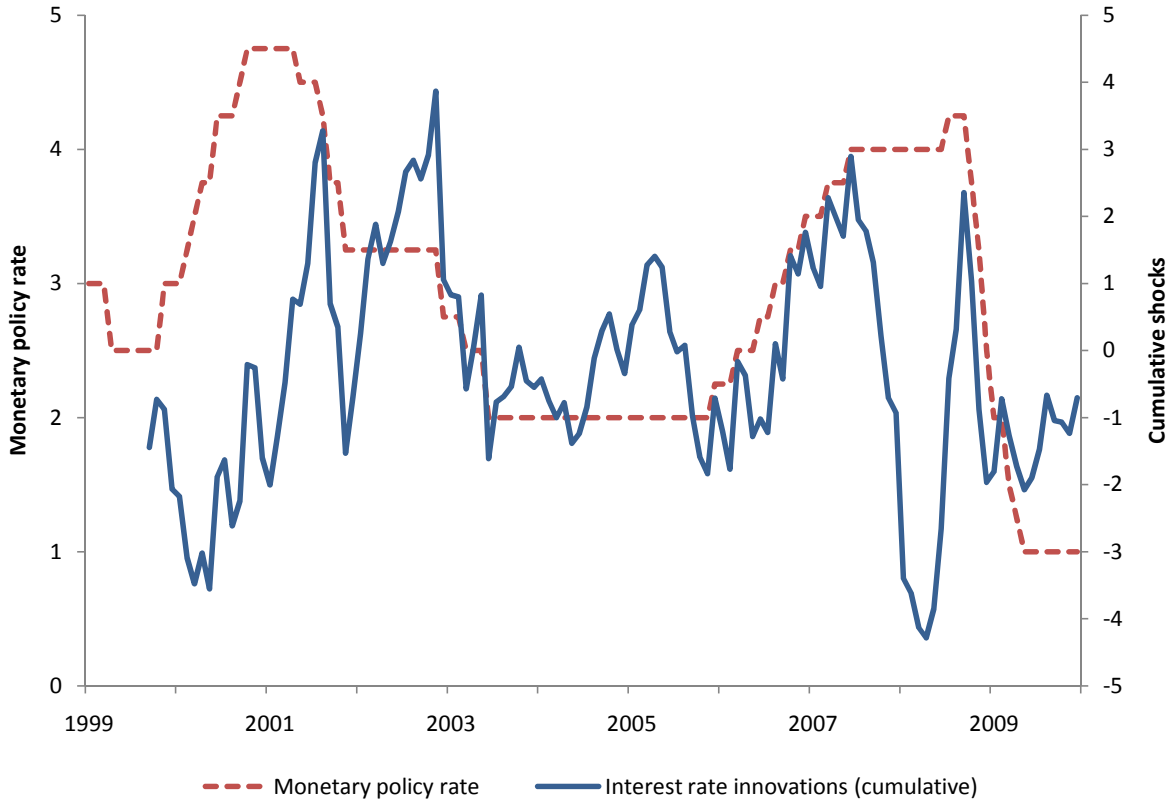


Figure 3 - Interest rate innovations versus non-standard policy actions: sensitivity analysis

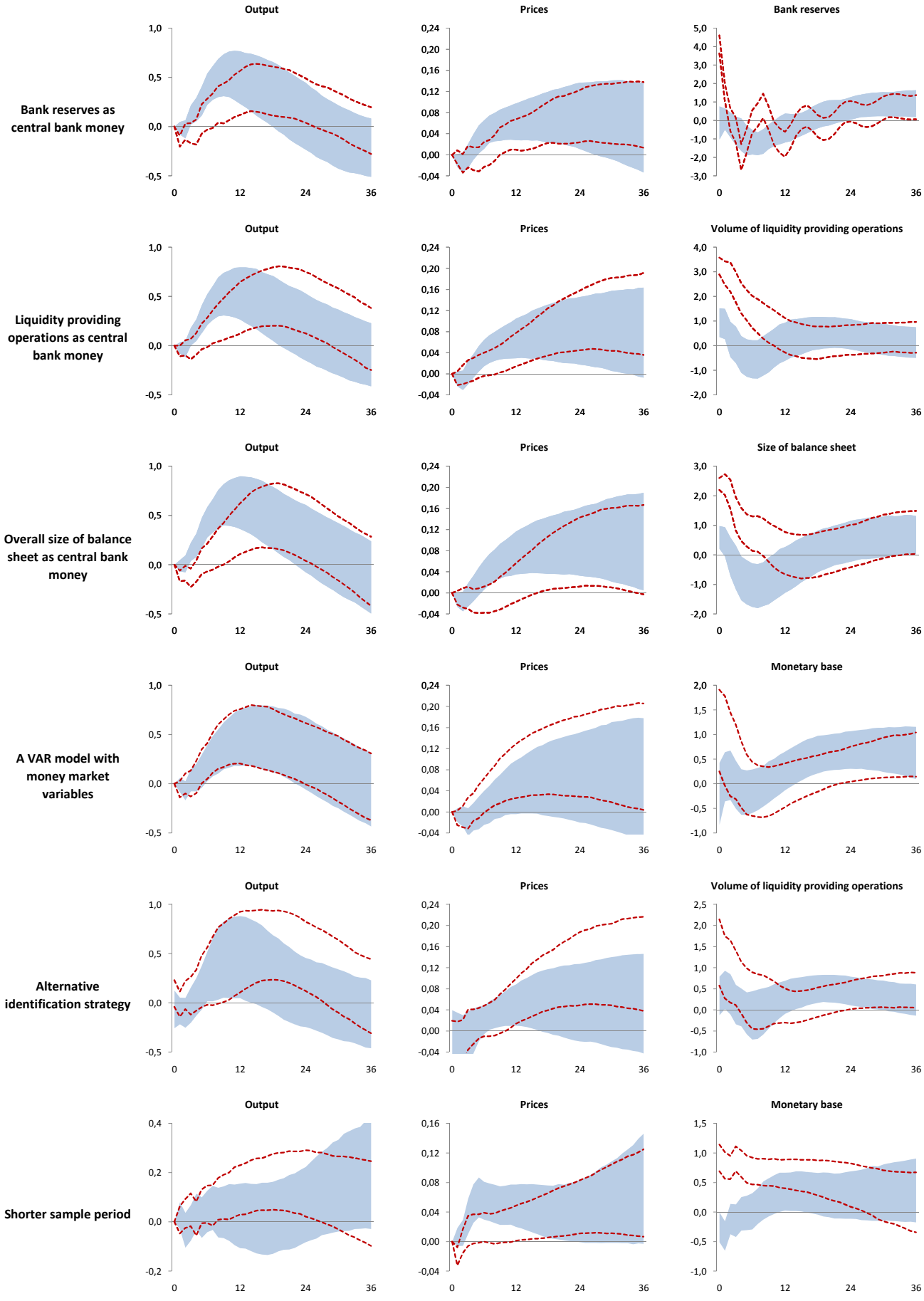
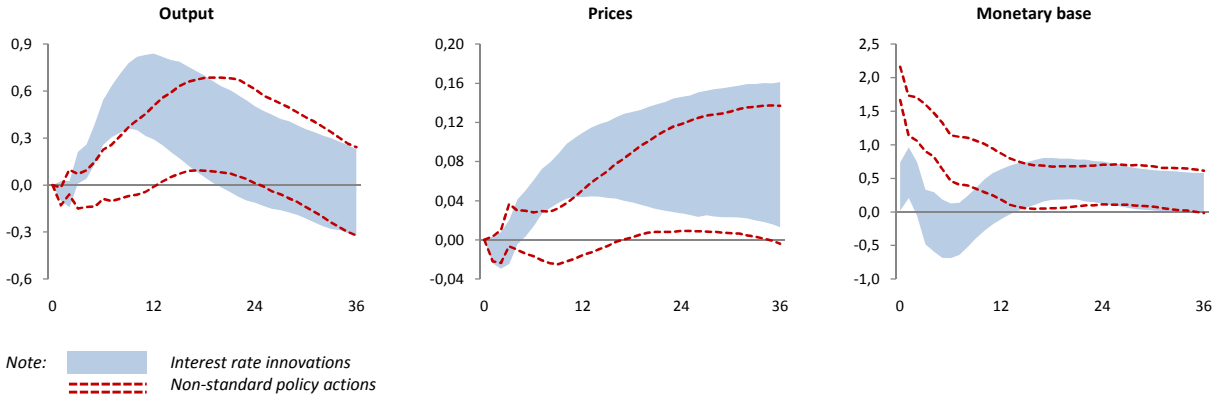


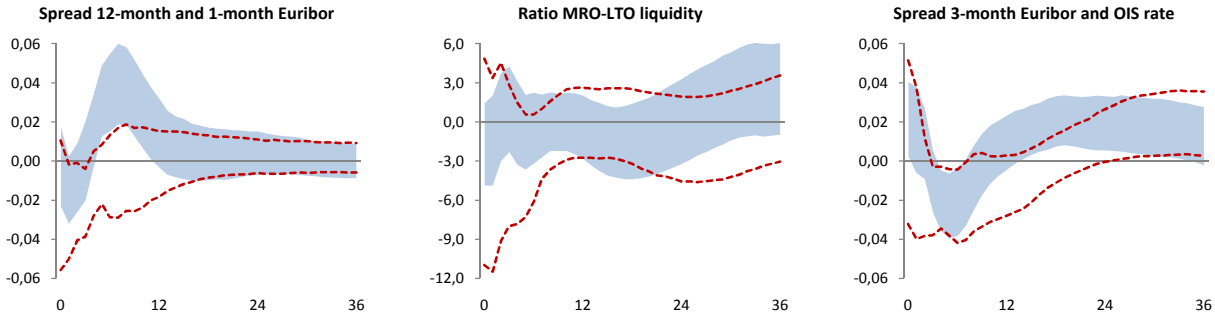
Figure 4 - Inspecting the source of unconventional monetary policy shocks

Panel A: VAR with EONIA as the policy rate



Note: *Interest rate innovations*
Non-standard policy actions

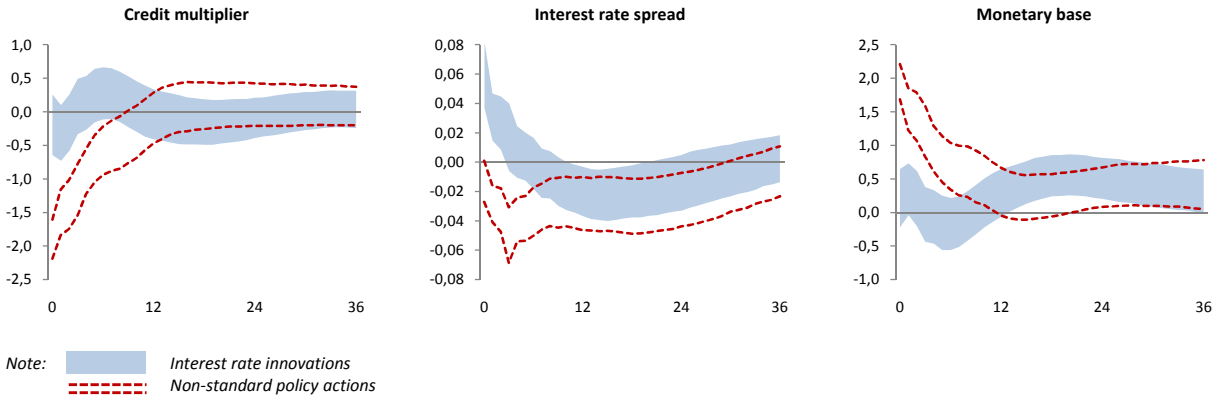
Panel B: Impulse responses of other variables



Note: *Interest rate innovations*
Non-standard policy actions

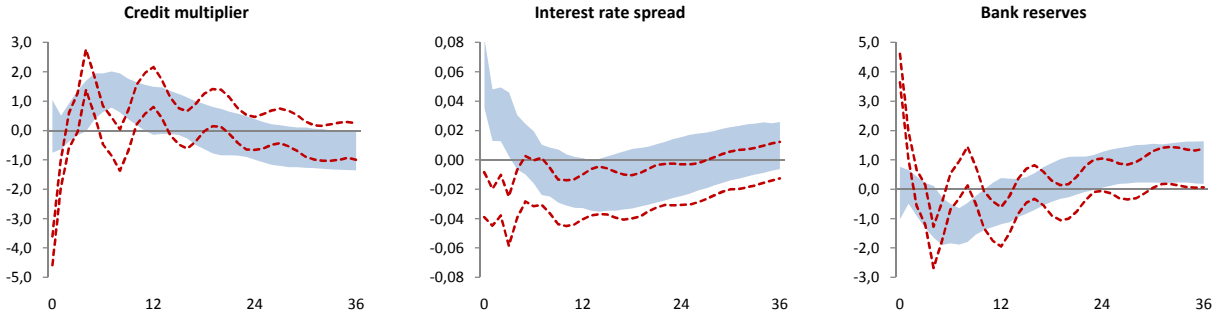
Figure 5 - Transmission mechanism of conventional and unconventional monetary policy

Panel A: Baseline specification



Note: *Interest rate innovations*
Non-standard policy actions

Panel B: Bank reserves as central bank money



Note: *Interest rate innovations*
Non-standard policy actions

Figure A1 - A VAR with two types of unconventional monetary policy shocks