Monetary policy in changing times

SUMMARY

We evaluate the ECB's monetary policy strategy against some of the underlying economic features of the eurozone, in normal times and during the financial crisis. We show that in the years preceding the crisis the ECB's emphasis on monetary indicators and deliberate avoidance of excessive activism were justified by the underlying macroeconomic conditions that the ECB faced in the eurozone and contributed to avoid more volatile patterns of inflation and economic activity. After the collapse of financial intermediation in late 2008, the strategy of the ECB was to adopt several non-standard policy measures. According to our quantitative evaluation of the impact of the main non-standard policies decided in October 2008 and in May 2009, which notably did not include entering commitments regarding the future path of the policy rate, such measures have significantly contributed to preserving price stability and forestalling a more disruptive collapse of the macroeconomy.

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A monetary policy strategy in good and bad times: lessons from the recent past

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1. INTRODUCTION

During the period between 1999 and 2007 monetary union in Europe built a solid constituency for low inflation. Inflation fluctuated around levels consistent with the ECB's price stability objective, in a context of steady income progression and moderate real fluctuations. The outbreak of the financial turmoil in 2007 and the financial crisis that deflagrated in 2008, however, have led to a rethinking of monetary policy frameworks at the global level. Central banks themselves have occasionally participated in such soul searching. The reflections are still ongoing at the time of writing.

This paper contributes to these reflections. It is divided into two parts which correspond to the pre-crisis and the post-Lehman periods, respectively. The pre-crisis

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evidence and insights serve as a laboratory to reflect on two aspects of the discussion surrounding monetary policy strategies that have been triggered by the crisis: the degree of activism of monetary policy and the search for indicators of monetary and financial conditions to ensure a robust policy. Lack of activism and the existence of a monetary pillar have defined the ECB's strategy in the past and the question is: was this justified? The answer to this question depends in general on the specific constellation of structural economic circumstances that characterize the economy.

Using the structural model of Christiano *et al.* (2010b) – the CMR model – we first show that both supply side and financial shocks have been important drivers of business cycle and asset price fluctuations in the eurozone. The former produced a desynchronization of inflation and real activity, which complicated the appropriate setting of monetary policy. The latter influenced asset price formation in directions that are atypical and interfered with the transmission of monetary policy. We then show that – against those underlying conditions – a forward-looking, pre-emptive strategy focused on short-term inflation developments needs to be balanced by safeguards which insure central bankers against policy myopia. In our policy simulations, reaction to credit developments can represent such a safeguard.

There is no pretence of a universal strategic recipe. The ECB's strategic choices make sense in a eurozone macroeconomic environment characterized by a pro-cyclical supply side and a financial sector prone to leverage cycles. These conditions might not be present everywhere and at all times.

The second part of the paper focuses on the ECB's strategy in crisis times. We concentrate on two aspects that have defined the ECB's crisis management approach and have set that approach apart in an international comparison. These two aspects are: (1) a policy of granting bank counterparties full and unlimited access to liquidity at a fixed rate; (2) an expansion of the menu of maturities for monetary policy operations to longer-term tenors. We discuss also alternative approaches that have characterized the strategy adopted by other central banks during the crisis and that have not been used by the ECB so far, notably the attempt to flatten the 'risk-free' yield curve via forward guidance and large-scale asset purchases. The choice of measures is not independent to the underlying bank-based financing structure in the eurozone or the monetary policy strategy considerations in the pre-crisis period. We find that the ECB interventions were instrumental in averting downside risks to price stability and preventing a larger fall in economic activity.

Our evaluation covers the first phase of the financial crisis and does not consider the sovereign debt crisis which erupted in May 2010 and the ECB's way to deal with it. We leave this analysis for future research.

2. THE ECONOMY AND THE STRATEGY ADOPTED BY THE CENTRAL BANK

In the jargon of Great Moderation analysts, the first nine years of monetary union pose an identification issue. What provided the underpinnings for good macroeconomic performance? Is it just that the eurozone benefited from a very benign constellation of economic shocks and structural economic conditions similar to other advanced economies that facilitated the conduct of policy? In other words: 'Did the economy cooperate?' Or, did monetary policy have a stronger role in steering the economy along a steady path, which would not have been steady otherwise? In other words, 'Did the monetary policy strategy lead the economy?' If it did, what core principles of the strategy were the main ingredients of success? And what would have happened if those principles had not been adhered to? In this section we seek an answer to these questions.

The answers are also crucial for the assessment in the second part of the paper, on the post-Lehman period, especially in understanding which features of the monetary strategy helped in stabilizing the economy and which features could be expected to sustain the economy during the crisis.

2.1. Questions and methodology

Our first question – 'Did the economy cooperate?' – requires structural inference. We generate structural inference using historical shock decomposition. Shock decomposition is a natural by-product obtained when estimating a dynamic stochastic general equilibrium macroeconomic model of the sort proposed by Smets and Wouters (2003, 2007). It serves two purposes, both of which are instrumental in answering our first question if the economy cooperated.

- It helps to dissect the underlying state that policymakers faced at each point in time, in particular to understand whether the sources of fluctuations originated predominantly in demand or supply.[1] The success of policy depends on the composition of fluctuations rather than just on their frequency and amplitude.
- It identifies financial shocks and their impact on the cost of borrowing in the broad economy to assess the viability and efficiency of the monetary policy transmission mechanism at each point in time. This provides an indication of the challenges faced by the central bank. One might legitimately wonder, for example, how a central bank can pursue price stability in a seriously unstable financial environment.

Given the boom and bust phases which characterized asset and credit markets over the period since monetary union, we need a dynamic stochastic general equilibrium (DSGE) model that combines the real, nominal and monetary policy variables that

[1] Financial shocks and shocks associated with banks' liquidity funding could be assigned to demand as they produce positive correlation between inflation and growth, but in the analysis that follows we single them out as a stand-alone category. The reason for this is explained in the second bullet point which follows.

are conventional in New Keynesian analysis with variables that pertain to the markets for liquidity, credit and equity. We use a DSGE model of the monetary business cycle with banks and a money market in the precise version documented in Christiano *et al.* (2010b) – the CMR model. While the model has been used in the past for policy analysis, for example in Christiano *et al.* (2007), the contribution here is twofold. First, it focuses on evaluating monetary policy strategies, similar to Christiano *et al.* (2007), but on the basis of the more complete formulation of the CMR model, which among other things matches financial and credit market developments. As explained in detail in Christiano *et al.* (2010b) it is found that the risk shock is a critical force behind economic fluctuations in the eurozone and the US alike. Christiano *et al.* (2010b) also show that the model outperforms its smaller-scale variants (Christiano *et al.*, 2005; Bernanke *et al.*, 1999) in reproducing key facts for which the three models can generate predictions. Second, the CMR model allows for a fully specified money market, which plays an important role in the study of the financial crisis. The very broad contours of the model are described in Box 1.

For answering our second question 'Did the monetary policy strategy lead the economy?', shock decompositions alone are not sufficient. The strategy has to do with the systematic pattern of monetary policy conduct. In the jargon of quantitative macroeconomics, a strategy is identified by the 'policy rule'. If the central bank's systematic behaviour – the coefficients and the reaction variables – had been different, history would have looked different. So, we try to answer our second question by conducting policy counterfactuals.

Box1: The CMR Model and the Counterfactual Methodology

The DSGE model used to carry out shock decomposition analysis and policy counterfactual simulations is identical to Christiano *et al.* (2010b) – the CMR model – but re-estimated to include data up until 2011Q3. The model builds on the DSGE models by Christiano *et al.* (2005) and Smets and Wouters (2003) and is extended by including a credit market, bankruptcies of enterprises as in Bernanke *et al.* (1999), money holding decisions and a liquidity-creating banking sector. The presence of a profit-maximizing banking sector which extends credit, operates a fractional-reserve-based transformation of base money into deposits and issues short-term securities to finance capital formation allows for including a broad array of monetary aggregates and financial prices in the empirical analysis. The model is estimated using Bayesian methods on data spanning 1985Q1–2008Q3 for the eurozone. The variables treated as observables are 16, covering standard macroeconomic variables, monetary and financial variables such as the stock market, a measure of the external finance premium, credit, M1 and M3, the outstanding stock of refinancing operations with the Eurosystem, and the spread between the 10-year bond rate and the short-term interest rate. The CMR model does well in reproducing the dynamic correlations of macroeconomic, monetary and financial variables observed in the data. As is standard for DSGE simulation exercises, underlying innovations of shocks are assumed to be independent from each other.

Three shocks in credit and liquidity markets are found to be important. First, shocks to the cross-sectional dispersion of borrowers' returns – 'risk shocks' – lead to variations in the uncertainty about the borrowers' credit-worthiness and generate a positive correlation between economic activity, credit and other financial variables. Although this shock affects the dispersion of returns, it has first-order macroeconomic implications and does not rely on second-order perturbation methods. A second relevant shock alters directly the amount of net worth which borrowers can pledge as collateral for their borrowing. Both shocks have a realized and an anticipated 'signal' component of eight quarters[2] with different macroeconomic implications. Anticipated shocks generate expected excess returns that lead to waves of accumulation and decumulation of capital, credit and money that resemble typical economic fluctuations.

The third type of shocks is related to banks' access to complementary forms of funding in the model: the issuance of checkable deposits included in M1, the issuance of other short-term deposits and marketable securities (M3–M1), and central bank refinancing. In particular, it is found that over the recent financial crisis a shock changing banks' desire for central bank liquidity has exerted significant downward impact on economic activity. Excess liquidity is held by banks to withstand unexpected withdrawals of funds and thereby ensure continuity in banking activity. Desire for lower liquidity buffers generates an increase in balance-sheet capacity and loan supply, and leads to an expansion of economic activity and to higher inflation. This impulse is not triggered by central bank decisions to change the policy rate, but finds its source within banks' funding activity itself.

Arguably, there is a big hiatus between the ambition to assess selective elements of the ECB's monetary policy strategy, and the limitations of the tool at our disposal. The gap is apparent when considering the following elements of the ECB's monetary policy strategy.

- First, the Treaty that has laid the institutional foundations of economic and monetary union has instructed the ECB to pursue price stability as its overriding objective, to which any other policy consideration is to be subordinated. The ranking of priorities is clearly lexicographic. This objective has been quantified by the

[2] The length is chosen mainly on the basis of the Marginal Likelihood (ML). In particular, it is found that up to such length the ML increases, at a decreasing rate. Above such value there is little additional impact. In the interest of parsimony, this has been chosen as the relevant length.

Governing Council of the ECB with a range of positive inflation rates below 2% and is not a point target for inflation.

- Second, the Governing Council of the ECB has enunciated that it will aim at maintaining inflation around values not too far below 2% in the medium term. The notion of the medium-term horizon is not pre-set or quantified and is meant to depend on the nature and source of the shocks to the economy. Importantly, it is associated with a steady handed response to the evolution of the economic state and a rejection of fine-tuning.[3]
- Third, in assessing the risks to price stability, the Governing Council gives great prominence to monetary factors, because of their potential threats to price stability over longer horizons. The analysis of money and credit developments is a cornerstone of the strategy, with the monetary pillar providing a way to cross-check the robustness of the policy implications that emanate from standard conjunctural analysis. It is an insurance against policy myopia.

The distance between these strategic principles and standard policy rules is evident. Price stability is a pre-ordered policy priority in the ECB's statutes, but it is only a weighted objective among others in standard policy rules. Also, standard policy rules postulate a reaction to inflation in deviation from a single numerical value. In addition, the medium-term horizon is not a fixed time window in the ECB's strategy, but it has a mechanical element in standard feedback rules. Finally, a two-pillar strategy with the possibilities of cross-checks across different ways to describe the monetary transmission mechanism is difficult to render in analytical terms. To address some of the shortcomings of standard policy rules, we introduce some modifications, but we admittedly fall short of filling the gap.

Our analysis in this section is selective. We mainly concentrate on two elements of the strategy: the medium-term orientation and the role of monetary analysis. The exercise also does not consider the model-consistent optimal monetary policy because it may be of limited importance when a central bank receives a clear mandate to fulfil.

2.2. Empirical issues

We devote this subsection to shock analysis. For this, we need to specify a feedback relationship that connects the short-term interest rate to the economic state. This feedback depends critically on the underlying monetary policy strategy and the way monetary policy is implemented. While the former has not changed since monetary union, the latter has changed in important directions in response to the crisis. In order to fully cover the pre-crisis and the post-Lehman episode, the feedback rule requires being sufficiently flexible to account for the changes in

[3] For a different view on the role that fine-tuning should receive in the monetary policy strategy, see Blinder and Reis (2005) who suggested that the Fed under Chairman Greenspan brought 'a new life' into the idea that the central bank should pursue fine-tuning.

implementation. In October 2008 the ECB changed the modalities of its liquidity provision from variable rate tenders to so-called fixed-rate-full-allotment tenders. It meant that the ECB moved from a policy in which the quantity of liquidity to banks was pre-set, to one in which the interest rate was pre-set, but the quantity of liquidity was provided in unlimited amounts to banks in exchange of collateral.

We tackle the break between the pre-crisis approach and the post-crisis fixed-rate-full-allotment approach by a two-stage estimation procedure. In a first stage, we estimate the CMR model over the pre-Lehman sample period, ending in 2008Q3. For this estimation, we use the following interest rate feedback rule, which we interpret as a money market equilibrium condition:

$$R_t = (\rho R_{t-1} + (1-\rho)[\alpha(E_t\pi_{t+1} - \pi^*) + \beta\Delta y_t + \gamma\Delta M_t] + \varepsilon_t) + \theta\xi_t \qquad (1)$$

The short-term money market interest rate on the left side, identified with the euro overnight index average (EONIA), is determined by two components. The first component in round brackets in (1) reflects the supply of liquidity which is associated with policy intentions: the 'policy rule' proper. Conventionally, this includes the lagged interest rate, the expected gap between GDP inflation and a numerical value consistent with price stability, GDP growth in deviation from its trend, and a white noise policy error, ε_t. In order to capture monetary analysis considerations, we add an extra regressor to this term: excess growth of a monetary indicator, ΔM_t. The second component of (1) is the last term, $\theta\xi_t$, which reflects liquidity demand conditions. It is a function of a latent shock, ξ_t, which itself controls banks' demand for central bank liquidity in the model (see Christiano *et al.*, 2010b). In estimation, the identification of this shock is facilitated by the inclusion of the outstanding stock of central bank liquidity in the set of observables. The values of the estimated parameters for the two subperiods are reported in Table 1.[4]

The degree of coherence between the observed stock of central bank liquidity and the shock to banks' demand for liquidity, the unobserved ξ_t, can be gauged in Figure 1. It plots the actual quarterly growth rate of the liquidity provision (solid line)

Table 1. Parameters on the interest rate feed-back rule

Parameter on	Pre-crisis (1980Q1–2008Q3)	Post-crisis (2008Q4–2011Q3)
Interest rate persistence	0.86	0.83
Inflation	1.79	1.73
Inflation acceleration	0.22	0.28
Output growth	0.49	0.48
Credit growth	0.55	0.26
Banks' demand for CB liquidity	−11.47	0.00

Note: The policy rule in the benchmark model is separately estimated over 1980Q1–2008Q3 and 2008Q4–2011Q3.

[4] The estimated value for banks' demand for central bank liquidity over the post-Lehman period is close to zero, so it was dropped in the post-Lehman counterfactual.

against its simulated growth rate (line with dots) if only the latent bank liquidity demand shock, ξ_t, had been active and all other shocks used in the baseline estimation had been set to zero. It reveals that a large fraction of Eurosystem liquidity growth is explained by variations in the latent liquidity demand shock, ξ_t, which is, however, far from being the only explanatory factor.

In Equation (1), the coefficient θ measures the sensitivity of the equilibrium overnight interbank rate, R_t, to liquidity demand factors. The estimation, in line with the analysis presented in Christiano *et al.* (2010b), reveals that this elasticity is positive, large and highly significant in the pre-crisis period. This provides evidence that, under the variable rate tender regime that was in place before October 2008, shifts in the demand for liquidity in the money market were statistically significant explanatory factors for the observed behaviour of the overnight rate. Overall, as mentioned already, we interpret Equation (1) as a money market equilibrium condition, where liquidity supply factors interact with liquidity demand factors to determine the equilibrium price of overnight liquidity, R_t.

In a second estimation stage covering the post-Lehman period, we fix all the structural non-policy parameters at the values of their posterior modes as estimated in the first stage, and we re-estimate Equation (1) over the crisis data sample comprising the period from 2008Q4 to 2011Q3. In doing so, the initial condition for estimating the model over the restricted post-crisis period is set to coincide with the state of the model at the end of the pre-crisis period. For reasons that we make clear in Section 3, in re-estimating the policy rule, we adopt a signal representation of the policy shock, ε_t. We find that, moving

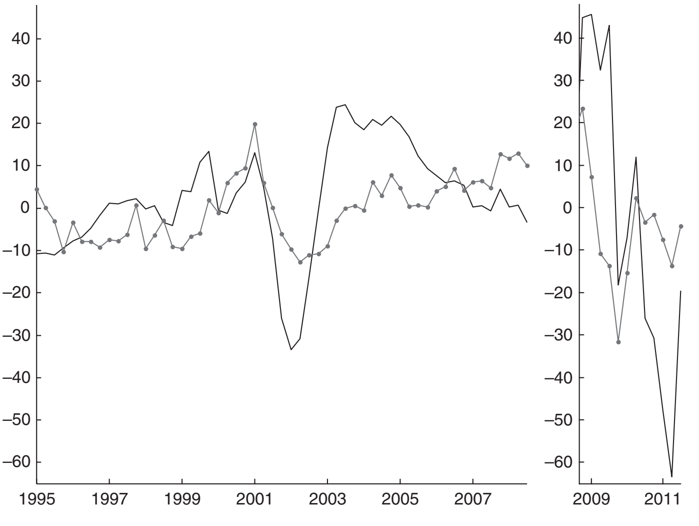

Figure 1. Contribution of the demand for liquidity shock to Eurosystem credit (percentage change)

Note: The solid line indicates the quarterly growth of the stock of Eurosystem refinancing operations in per cent. The line with dots represents the growth rate of the Eurosystem liquidity simulated by the CMR model under the assumption that all shocks but the estimated demand for liquidity shock are set to zero.

from the pre-crisis to the crisis sample, θ drops in absolute terms toward zero and becomes insignificant, so we decided to constrain θ to be zero in the post-Lehman estimation period.[5] This is equivalent to assuming that, under the new allotment procedure, liquidity demand factors are entirely neutralized by policy and become irrelevant.[6]

Before moving to shock analysis, we justify the specific formulation of the policy rule component in Equation (1). First, why do we assume a policy reaction to GDP growth as opposed to a measure of the output gap? Second, why do we include the reaction to credit in order to capture the monetary pillar and the 'leaning against the wind' aspects of the ECB's strategy, as opposed to other monetary aggregates or some measure of asset prices? There are different ways to answer these questions, including extra-model considerations. Here, we report the results of a standard Bayesian model evaluation methodology based on the marginal data density, which measures the relative fit of the model under different specifications of the 'policy rule' component of (1). The results of this exercise over the pre-crisis sample are reported in Table 2. Our baseline specification, assuming reaction to credit and output growth, delivers a clearly superior in-sample fit to those in which the central bank reacts to the stock market or to the output gap. A policy rule that feeds back on credit is also preferred to one which responds to M3 growth, although in this latter case the improvement is small.

2.3. Did the economy cooperate?

For the purpose of the shock decomposition we group the underlying 16 fundamental shocks of the model in three categories: demand, supply and monetary-financial factors. The first group includes shocks that move output and inflation in the

Table 2. Marginal likelihood for different specifications of policy rule

Model variants	Marginal likelihood
Benchmark model	5012.6
Responding to money growth	5010.3
Responding to stock market prices	4993.0
Responding to output gap	4999.6

Note: The policy rule in the benchmark model responds to inflation expectations, output growth, credit growth, and includes an autoregressive component with response to the lagged interest rate. The specification 'Responding to money growth' and 'Responding to stock market prices' replace the response to credit growth with money growth and stock market prices, respectively. The specification 'Responding to output gap' replaces the response to output growth with the output gap.

[5] Our zero-restriction on θ over the crisis sample is supported by marginal data density analysis, which shows that the model in which θ is zero delivers a better fit than the model in which θ is included.

[6] The setup in Del Negro *et al.* (2011) to model the adoption of non-standard measures shares some similarities in that there is a liquidity shock, which captures in reduced form changes in the market for liquidity and is the main driving force of the financial crisis, and there is a policy response to contrast such a shock.

same direction, such as a shock to households' intertemporal preference for consumption and a shock to the government's and the foreign sector's absorption.[7] Supply shocks move output and inflation in opposite directions. These are a temporary shock to total factor productivity hitting intermediate-goods production, an oil price shock and the shock to price mark-ups. The category comprising monetary-financial factors consists of the liquidity demand shock, ξ_t, the monetary policy shock, ε_t, and the 'risk shock'. In the CMR model, shocks to the riskiness of the financial contract come both in the form of contemporaneous unexpected innovations to the risk process itself and in the form of anticipations of the future evolution of the shock (see Box 1). Note that it is mainly the appreciation of risk, that is, the signals, rather than its realization, that turns out to matter most.

Figures 2 and 3 show historical decompositions for GDP growth and inflation, using the posterior modes of the distributions of the coefficient estimates. The break in the continuity of the chart marks the switch in the estimation from the baseline money market interest rate feedback rule to the new fixed-rate-full-allotment regime whereby liquidity demand shocks are offset by construction. We make three observations.

- First, as a matter of regularity, shocks related to aggregate demand (grey bars) follow with a lag the turning points in GDP growth, but rarely coincide with or lead the cycle. This is certainly the case throughout monetary union since 1999.

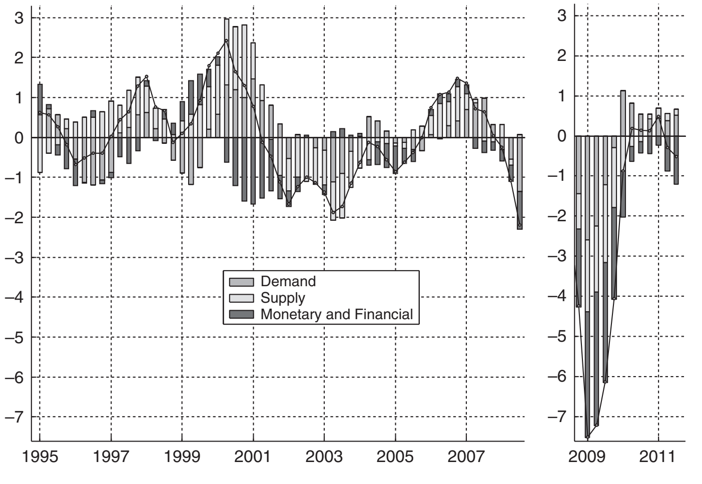

Figure 2. Shock decomposition: GDP growth (year-on-year percentage change)

Note: The solid line indicates the deviation of the year-on-year GDP per capita growth rate from its long-run growth path (1.5%). Each data point is broken down into the contribution from the shocks identified by the model grouped into supply, demand and financial factors.

[7] The CMR model is a closed-economy model. As GDP growth is matched precisely, the net foreign demand component of output and government consumption is also treated as an exogenous shock.

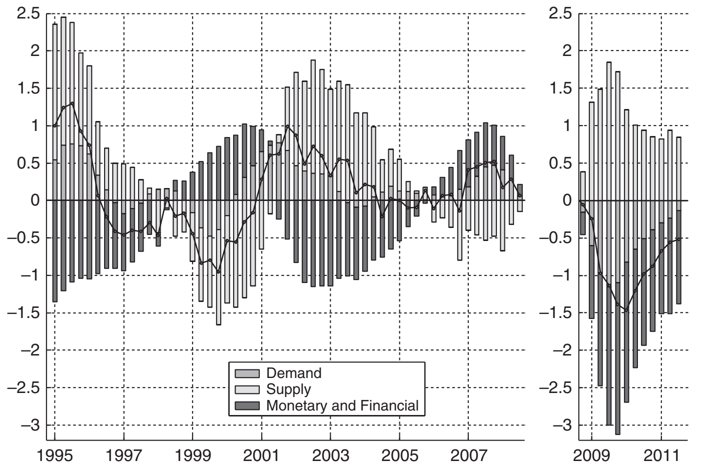

Figure 3. Shock decomposition: inflation (year-on-year percentage change)

Note: The solid line indicates the deviation of the year-on-year GDP inflation from a point numerical definition of price stability (1.9%). See also note to Figure 2.

- Second, monetary and financial factors (black bars) lead or coincide with the peaks and troughs in GDP growth. Except over the dot-com recession and the recent crisis, they tend to dissipate quickly as a determinant of growth, while they introduce long-lasting trends in inflation.
- Third, supply shocks (the white bars) are usually timely indicators and extraordinarily persistent determinants of growth and inflation.

2.3.1. Supply side headwinds. The boom-bust episode of the early years of monetary union offers an instructive story. While financial markets were providing a robust spurt to growth during 1999 and much of 2000, a pro-cyclical adjustment in productivity and mark-ups amplified the cycle. This appears to have contemporaneously damped inflation that would have emerged otherwise. The bust phase that ensued and lasted until 2005 is the mirror image of the same pattern. Pro-cyclical adjustments in productivity aggravated the slump and kept inflation from falling. Such a pro-cyclical supply side represents a challenge for monetary policy.

First, it desynchronizes inflation and economic activity. Provided inflation expectations are well-anchored, synchronization of inflation and economic activity can work as an automatic stabilizer. In booms, higher-than-normal inflation encourages a tighter monetary policy stance that can counter over heating in financial and credit markets and in the broad economy. In busts, a decline in actual inflation can partly offset the cyclical fall in real incomes, and thus sustain demand at a critical point in time. Our analysis indicates that neither of these equilibrating mechanisms seem to have been available in the eurozone in these episodes.

Second, it makes the economic environment more difficult to interpret in real time. A typical demand shock poses little puzzle to a stability-oriented central bank. A timely and determined response to such a shock protects against upside risks to price stability and minimizes the economic volatility that the shock would introduce in the absence of policy action. A supply shock, instead, needs to be interpreted. It is not so much the supply shock *per se* which requires a monetary policy reaction, particularly if the shock is expected to be temporary and to reverse itself before long. Rather, it is the implications that the shock is expected to have for inflation expectations and for the self-sustaining momentum that expectations – once unsettled – can add to the inflation process going forward. If inflation expectations are sufficiently impervious to a supply shock, then monetary policy can afford to lengthen its policy horizon and look through the disturbance. Otherwise, it needs to intervene to stem the transmission of the shock via expectations. In a way, central banks need to be vigilant to the fact that a supply shock might morph into a demand shock, if and when it is allowed to influence inflation expectations. It is this mutation that is most relevant for policy. But, of course, judging whether and when the mutation will happen is fraught with hazards in real time.

We conclude that the supply side 'did not cooperate', and instead blew headwinds which monetary policy had to resist. It applies also to favourable technology shocks, which are expansionary and disinflationary at the same time. Of course, as Blinder and Reis (2005) argue: '[A]n acceleration of productivity gives a central bank a pleasant choice: It can have some combination of lower inflation and lower unemployment than previously planned.' But that apparent blessing can turn into a curse down the road, if – short-sightedly – it induces excessive policy forbearance. This is why the central bank needs insurance against myopia and short-termism, a theme to which we turn below.

2.3.2. Financial shocks and the transmission mechanism. The efficacy of monetary policy depends on monetary policy actions setting in motion a long chain of adjustments in a whole spectrum of asset prices. Spending decisions and price setting behaviours of the private sector stand at the end of this chain and are influenced by these adjustments. Policy itself is calibrated on reaction patterns and cross-elasticities between the policy instrument and key asset returns that have been observed in the past. But then, any shock or special factor which might disturb or distort those cross-elasticities in directions that are atypical and difficult to quantify *ex ante* can seriously interfere with the policy process. Two examples stand out during the pre-crisis period. First, a monetary policy tightening cycle is less effective in restraining spending if it is offset by an autonomous decline in long-term interest rates and/or in credit spreads. The latter provides the financial stimulus that policy tightening is meant to withdraw. Second, a sharper than expected widening of financial spreads in the early phase of a recession can make credit conditions tighter than a central bank would deem appropriate given the economic state and its likely evolution.

Figures 4 and 5 show that the eurozone had witnessed both examples. While monetary policy was being restricted after 2005 to respond to a resurgence in inflation and

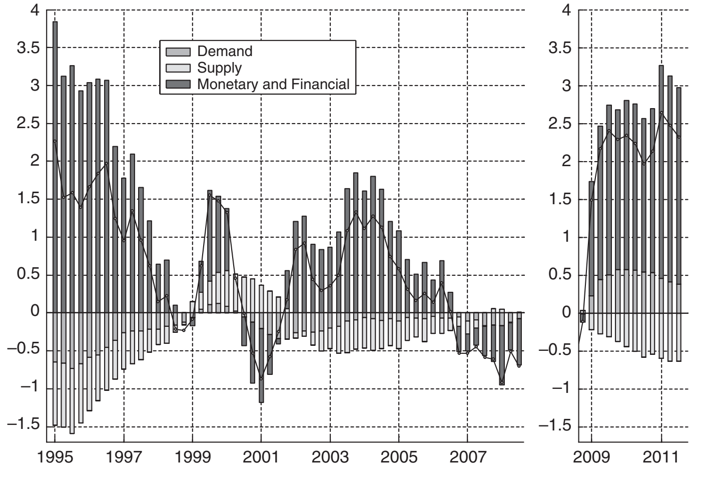

Figure 4. Shock decomposition: 10-year spread (year-on-year percentage change)

Note: The solid line indicates the spread between the 10-year government bond yield and the overnight rate, demeaned. See also note to Figure 2.

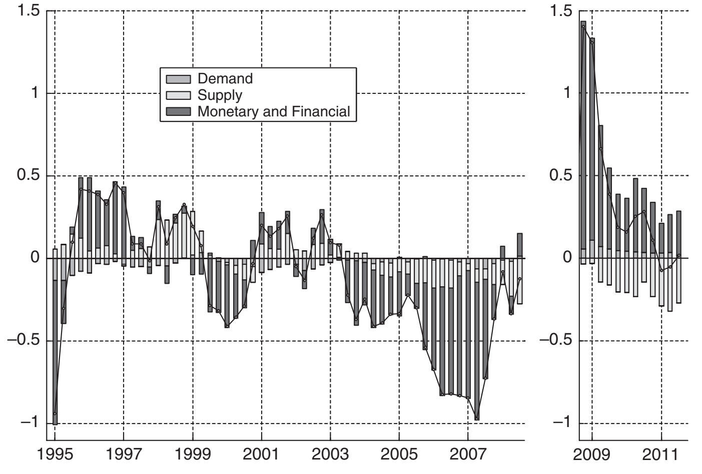

Figure 5. Shock decomposition: credit risk premium (year-on-year percentage change)

Note: The solid line indicates an average measure of the credit spread applied to private borrowers in the euro-zone. See also note to Figure 2.

exuberance in credit markets, financial factors were causing countervailing adjustments in interest rate spreads. Figure 4 shows the response of the spread between the long-term Treasury yield and the short-term rate. While a decline in the spread is typical in tightening phases – as the short-end of the term structure rises whereas the long-end remains relatively stable – the pace of the decline was atypical. At a time in which the price of borrowing short-term was being raised, the terms of borrowing long-term were easing more strongly than usual.

Developments in private credit markets were adding further stimulus. Figure 5 shows that the credit risk premia which firms were required to pay over and above the risk-free rate fell steeply too. Effectively, market rates were falling rather than increasing in response to the monetary policy tightening. Looking inside the group of monetary and financial shocks, which was causing the fall, the main explanatory force was a sharp revision in the appreciation of market and macroeconomic risk.

A more dramatic example of a swing in financial prices interfering with monetary policy occurred starting in the second half of 2008. Despite a series of aggressive reductions in the short-term rate, credit premia whipsawed sharply up. The long-term spread, instead, was kept compressed relative to the overnight interest rate by the ECB's decision to extend the tenors of its loans to banks. We return to these developments in Section 3. Clearly, in the first instance, loosening standards in the credit market made the effective stance more permissive than intended by the ECB. In the latter instance, a poorly functioning financial system impinged on the cost and availability of credit to the private sector and obstructed the transmission of monetary policy stimulus to the economy.

2.4. The role of the strategy in steering the economy

In this subsection we stress-test the ECB's monetary policy strategy in the period before the crisis. The focus is on two dimensions of the ECB's strategy: the medium-term orientation and its emphasis on monetary indicators. Although the two dimensions are strictly complementary, as the latter element reinforces the former, we treat them separately to single out their individual contributions.

2.4.1. Medium-term orientation. Observing monetary policies over the 2001–2003 slump, some commentators remarked on the ECB's more cautious approach compared to the Fed's more active management and it was sometimes chastised as one that did 'too little, too late'.[8] The ECB justified its paradigm on the notion that each central bank should design its policy conduct having in mind the structural and stochastic characteristics of its economy. The ECB's assessment was that a less predictable and more judgemental policy conduct would destabilize the structural economic landscape in the eurozone (see ECB, 2006).

The notion that policy should be tailored to the deep structure of the economy is intuitive. Altissimo *et al.* (2006), Christiano *et al.* (2007) and Trichet (2007) all have drawn attention to the fact that comparatively high price and wage inertia combined with well-anchored inflation expectations in the eurozone call for a steadier course of

[8] See, for example, the article 'Better Late than Never' published in *The Economist* on 5 June 2003. Later, as Chairman Greenspan defined the Fed's standard when confronted by tail events with potentially highly adverse consequences (Greenspan, 2004), the debate evolved into one balancing the advantages and the risks of a 'steady hand versus risk management'.

policy. Here, we will concentrate on how the stochastic properties of the eurozone may have a bearing on its monetary policy and will lead us to broader conclusions on the desirability for a central bank to mechanically react to inflation forecasts – irrespective of the shocks.

To this end, we ask the following two questions. First, what would have been the implications that policymakers could have extracted from stochastic simulations, given the nature of shocks hitting the eurozone economy? Second, would a different type of monetary policy have stabilized the economy better if it had assigned a more prominent role to counter deflation risks? To be sure, it is difficult to know exactly the reasoning behind the policy path selected by a central bank. Therefore, more than the exact quantitative implications, the exercise is meant to offer insights into the relevance of strategic elements of monetary policy. For the exercise we place ourselves back in 1999Q1 and we assume that policymakers were confronted with stochastic simulations of the type shown in Figure 6, which displays the predictive distribution of inflation.

The overall band covers 90% of all possible realizations, and the different shadings mark different percentiles of the distribution. The simulations are based on 20,000 stochastic runs drawing from the estimated model. The left side of the figure shows the distribution that modellers would have obtained drawing from all the shocks estimated in the model. The right side of the figure, instead, excludes supply-side shocks

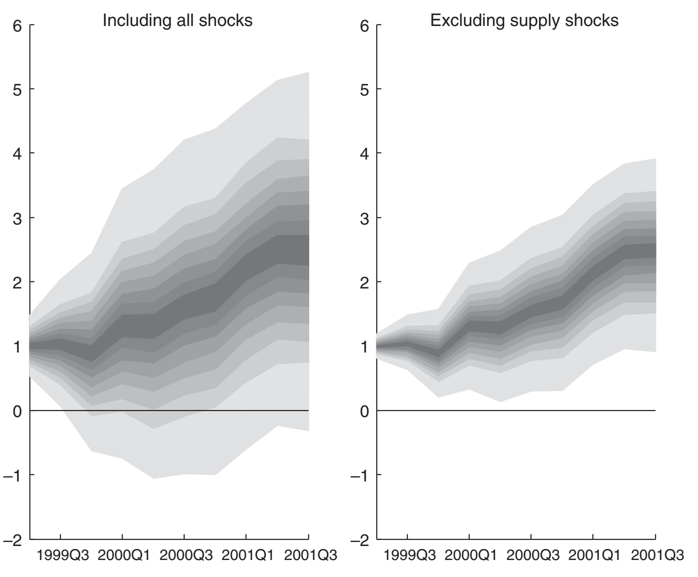

Figure 6. Stochastic simulations: inflation looking forward (year-on-year percentage change)

Note: Predictive distributions for inflation as could have been generated in 1999Q1 by projecting the CMR model forward on the basis of all shocks (left-hand figure) or all shocks excluding temporary TFP shocks, permanent labour-augmenting productivity shocks, oil price shocks, price mark-up shocks (right-hand figure).

from the simulations. For the purpose of this exercise we consider as supply shocks: productivity shocks, oil price shocks and mark-up shocks.[9] Recall that at the time the eurozone was hit by a string of supply-side shocks which were producing rapid disinflation (white bars in Figure 3).

We note two aspects. First, the portion of the distribution in the left panel falling below zero is sizeable. The negative-inflation portion of that distribution – representing the risk of deflation – is about 15%. Second, the range of possible inflation realizations obtained by ignoring supply shocks would have looked more firmly centred around values consistent with the ECB's definition of price stability.[10]

Confronted with the probability of deflation shown in the left panel of Figure 6, we ask: What if the ECB had decided to take out insurance against that risk by reducing its policy rate more aggressively than it did in April of that year? We simulate a policy action which reflects a conventional interpretation of such a risk management strategy in the face of deflation risks. This is not making the comparison to an optimal monetary policy, which would have led to superior model-consistent welfare outcomes. Instead, the focus is on the often advocated risk-management strategy which exploits only available information and can credibly commit an interest rate path only for a limit period of time. The strategy comprises two main elements:

- reduce the policy rate pre-emptively to forestall the risk;
- give forward guidance about the policy path in the near future so that the stimulative impact of the decision on expectations is amplified.

We implement the exercise by postulating that the reduction in the policy rate to 2% decided in 1999Q2 comes together with forward guidance that induces all agents

[9] By disregarding some sources of uncertainty, the predictive distribution mechanically becomes tighter. But the point we want to make is not related to the best unconditional forecast of inflation, or the best way to describe the uncertainty surrounding the point forecast. We are interested in the monetary policy implications of a given expected path of inflation. And we claim that this requires to understand the underlying shocks driving a given inflation path. Also, the central bank can afford to discriminate across different sources of shocks to the extent that long-term inflation expectations are well anchored. Otherwise, as explained above, supply-side shocks may 'morph' into demand shocks.

[10] Many central banks make use of this type of analysis to compute the probability of deflation and inform the policy process. Stochastic simulations of this sort conducted at the Fed in the summer of 2003 triggered a policy debate over the precise interpretation to be given to the results. The FOMC Transcripts suggest that the prevailing view was that it is appropriate to look at the entire distribution (as in the left panel of Figure 6). However, it was also argued that one should discriminate between types of shocks. The complete-shock distribution suggested at the time 28% probability of deflation for the US looking forward, whereas the simulations done by removing supply-side shocks were delivering a much smaller probability, in the order of 8%. At the time of such debate within the FOMC, US productivity was increasing at a robust rate, which in one quarter reached almost 9% annualized. FOMC member Mr Parry remarked: 'This [referring to deflation generated by favourable productivity] may be more like a China version of deflation, where the deflation probability reflects what is happening to productivity.' The reply by staff to this remark was given by Mr Stockton: 'That's right. Certainly, if we created 5,000 stochastic runs of the model to calculate the probabilities, within the 28 percent of cases with deflation there would be many instances in which the deflation was relatively benign. Those would be instances where the deflation was caused by faster productivity growth or beneficial shocks to wage and price setting, with what I would perceive to be less serious consequences for monetary policy.' (FOMC Transcript, 10 December 2002, p. 23).

in the model economy to anticipate a 2% level for the overnight interest rate over one and a half years. As the future rolls on, the signals about future policy remain in place and expectations are systematically confirmed by the actual policy settings. The central bank in this counterfactual is therefore fully credible in its forward guidance. We show the results of the counterfactual exercise in Figure 7. The solid line represents history. The dotted line is the outcome of the alternative strategy.

Note two things. First, as the structural determinants of disinflation were a sequence of favourable supply shocks, both the financial markets (stock market panel) and the economy at large were on a rise, even under baseline policies. Second, as also discussed in Christiano *et al.* (2010a), introducing extra policy accommodation in those conditions would have provided a further boost to asset prices and lending, which in turn would have introduced further inflation and output volatility.

In retrospect, taking into account that downward pressure on inflation may come from supply-side disturbances allows monetary policy to better stabilize the economy. We conclude that a forward-looking, pre-emptive strategy focused on the unconditional expectation of inflation may benefit from safeguards that ensure the central bank against policy myopia. The following subsection offers monetary indicators as possible commitment mechanisms to enforce a steadier hand in policy actions.

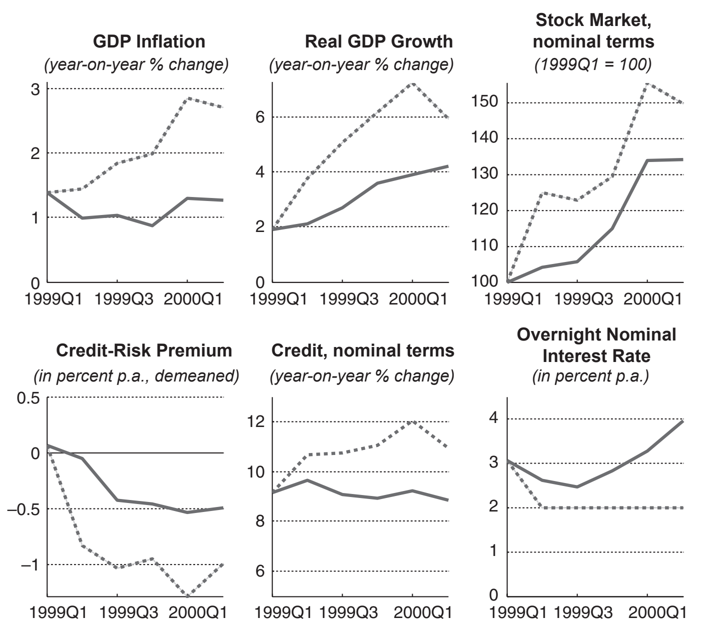

Figure 7. A 1999 policy counterfactual: taking out insurance against deflation

Note: In each panel the solid line indicates history. The dotted line indicates the counterfactual associated with the following policy experiment: the central bank reacts to the risks of deflation displayed in Figure 6 by cutting the policy rate to 2% in 1999Q1 and signalling its intention to keep it at that level until 2000Q2.

2.4.2. Monetary analysis. After the eruption of the financial crisis the question whether a central bank should concentrate on targeting inflation or should also 'lean against the wind' blown by rising monetary and financial imbalances has been put back on the agenda of discussions over the theory and practice of central banking. We want to address the role played by monetary policy in this context, together with the question whether macroeconomic volatility would have increased if the ECB had not relied on its monetary pillar.

This requires rendering the role of the monetary pillar in a model-based exercise which is difficult for essentially two reasons. First, using one single model in this paper, we obviously forfeit one critical side of the monetary pillar approach: its aim to induce robust policy across different specifications of the inflation process. It is the cross-checking aspect of the two pillar strategy as documented in ECB (2003) that we are sure to miss. Second, the policy rule should include the underlying money trend as an indicator of the underlying trend in prices to adequately reflect the ECB's mandate, as explained in Papademos and Stark (2010). Avoiding excess volatility in asset markets is a by-product of the strategic role of monetary analysis.

However, due to the technical complications in estimating and simulating a policy reaction function which feeds back on the underlying trend – as opposed to headline growth rates – of money, in our quantitative exercises we make use of a proxy. Our proxy is the growth rate of bank credit to the non-financial sector in deviation from its long-run trend. This is the reaction variable ΔM_t which we have included in the money market interest rate feedback equation (1). Our choice is motivated by two considerations. The first is that, among all monetary and financial variables possible to define within the CMR model, a reaction to credit delivers the best fit. (see Table 2 above). The second motivation for selecting credit growth as a proxy for underlying money is related to the high correlation between credit and underlying money growth in the eurozone (for an assessment, see Fahr *et al.*, 2011).

We study the contribution of the monetary indicators to volatility using a Taylor-frontier type of approach. Figure 8 shows the inflation-output variability frontier that can be traced out in our model given the shocks that hit the eurozone economy on average. The far-right line with diamonds shows the frontier that is attainable if the feedback rule does not feature a reaction to excess credit growth (the γ coefficient in Equation 1 is zero). Diamonds of a bigger size correspond to a stronger reaction to inflation – with step size of 0.2 to the α coefficients. Starting from lower values of α (upper right corner) and moving down along the line, a central bank would be able to first improve on both dimensions, before entering a trade-off zone between stabilizing inflation and output (bottom right).

Adding a response to excess credit growth in the reaction function would enhance stabilization: it would dampen output volatility without increasing inflation volatility. This is shown by the horizontal lines departing from the vertical line on the right, with increasing reaction to excess credit growth (with step-size of 0.05 in the γ coefficient). The squares mark the maximal response to credit – for any given inflation coefficient

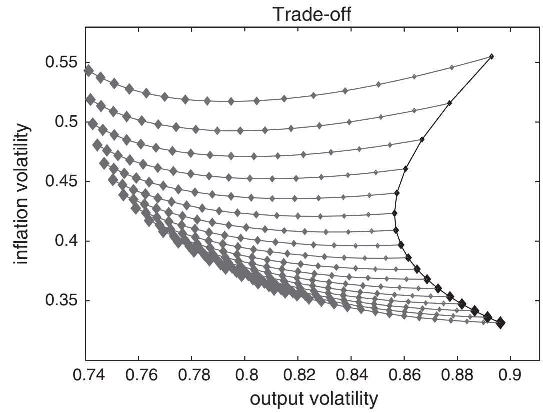

Figure 8. The Taylor frontier with and without the monetary pillar

Notes: Taylor frontiers with a reaction to credit (horizontal lines) and without a reaction to credit (vertical line on the right). Diamonds of increasing size indicate reaction to inflation (credit) of increasing intensity. Squares represent the maximal reaction to credit consistent with a trade-in. The largest response to inflation is equal to a parameter value of 5.

– that would reduce inflation and output volatility without trade-off. Connecting the squares would yield the Pareto improved Taylor frontier available when responding to excess credit growth.

There is a difference between a monetary pillar and a genuine 'lean against the wind' approach. In the latter it is asset prices that a central bank incorporates in its policy framework. Simplifying a great deal, proponents of a 'leaning against the wind' strategy would advocate an unconditional monetary policy response to asset price changes, as is indeed the case in Cecchetti *et al.* (2000). A monetary pillar, by contrast, promotes a form of 'conditional' policy response. The reason is that the equilibrium value of assets – particularly real assets, such as claims on companies and houses – is difficult to compute and is certainly state-contingent. Under a monetary pillar it is the implications for money and credit growth, that is, the policy-relevant implications of an asset price trend which matters. The critical condition that a central bank should ascertain before judging if an asset price trend is policy-relevant is whether the trend is causing and/or is being fed by a concomitant monetary imbalance.

A market bubble that progresses in symbiosis with a credit bubble and generates excess money creation is certainly a policy-relevant event. In general, monetary imbalances are highly correlated with financial imbalances, and the monetary pillar can alert policy to rising imbalances in the monetary sector. In turn, rising financial imbalances are times in which the central bank is called upon to draw its balancing line between short-term risks and its long-term stability objective. In the formulation of those difficult balancing acts monetary analysis can promote a longer-term perspective. It can act as the commitment mechanism to overcome policy myopia.

A monetary pillar is not a universal recipe, but under two specific conditions it can be particularly effective. First, when supply-side shocks are pro-cyclical, macroeconomic booms tend to bring about a surge in productivity and concomitant disinflation. In such a situation a policy reaction to credit growth can offset the tendency to forbearance that a central bank focused only on inflation expectations would otherwise display. We showed in Figure 2 that indeed the eurozone experienced pro-cyclical productivity cycles, whereas the opposite is true in the US (see for example Christiano *et al.*, 2007), where productivity acts as an automatic stabilizer over the business cycle rather than as an amplifying factor as in the eurozone. In those conditions the tendency to forbearance might well be weaker and the need to incorporate monetary analysis considerations in the policy framework might be less prominent.

Second, when the financial system becomes a destabilizing force over the cycle, then a pro-cyclical expansion of finance can indeed magnify macroeconomic instability and call for an offsetting policy reaction. Looking at credit might be a sensible way for a central bank to make that response happen. But excessively pro-cyclical finance is not a fact of nature and can be cured by means other than monetary policy, for example by an effective and timely macro-prudential framework.

3. THE FINANCIAL CRISIS

The initial turmoil and subsequent crisis that swept through financial markets over the past years have posed unprecedented challenges for central banks. Their policy responses have been equally unprecedented and have involved non-standard policies – actions that go beyond adjustments to the policy interest rate. There are many dimensions along which non-standard measures adopted by different central banks during the crisis can be classified. One dimension is related to the aim of non-standard measures, for example flattening of the Treasury yield curve – the 'risk-free' curve – at a time when short-term interest rates have fallen to the zero lower bound versus reduction of abnormally large spreads over and above risk-free rates. Another dimension is related to the degree of active use of the central bank's balance sheet, for example targeted expansion of the balance sheet, versus forward guidance. Another dimension runs along the type of assets exchanged for central bank liquidity, for example sovereign paper versus private financial and/or non-financial papers, and a further dimension is related to the modalities of liquidity provision, for example outright purchases versus collateralized lending.

Irrespective of all these differences, non-standard measures adopted by central banks may actually share stronger similarities than often argued. For instance, when comparing the ECB and the Fed policies, the measures to address liquidity and funding stress adopted by the ECB (see discussion below) and the emergency credit and liquidity programmes adopted by the Fed shared several similarities. Differences were partly motivated by different structures of the financial system across the Atlantic and by the central banks' specific institutional setups, for example, the number of central bank's counterparties and length of the collateral list, including the statutory possibility or limitation to conduct monetary policy operations in private paper.

We have described the entire toolkit of non-standard measures adopted by the ECB until the end of 2009 in Fahr *et al.* (2011). We analyse here a distinct feature of the non-standard measures adopted by the ECB: their focus on improving banks' liquidity and funding. This is motivated by the large role of bank-based financing in the eurozone. From this perspective non-standard measures can be understood as a way to address directly abnormally large spreads over and above risk-free rates and to replace disappearing market transactions between financial institutions.

We focus on the ECB liquidity measures adopted after Lehman's collapse and compare these with non-standard measures adopted by other central banks.

As mentioned before, October 2008 marked a shift in the execution of monetary policy. In conjunction with the ECB's decision to move from liquidity providing monetary operations with variable interest rates to operations at fixed rate with full allotment of banks' liquidity demands – the so-called fixed-rate-full-allotment (FRFA) tenders – the ECB also expanded in June 2009 the array of maturities at which liquidity was being offered to 12 months. Unlike other central banks, such extension in the tenor of liquidity providing operations was not intended to communicate any commitment to a certain path of the policy interest rate. In fact, the interest rate applied to the third 12-month operation conducted in the second half of 2009 was indexed to the average interest rate prevailing in the regular weekly operations during the subsequent 12 months. The measures produced excess liquidity in the money market, which put downward pressure on the overnight interest rate. It drifted down toward the lower limit of the monetary policy corridor.[11]

The exceptional nature of these policies implies that their effectiveness cannot be entirely understood using traditional frameworks. New interpretative tools and benchmarks for appropriate policy will need to be developed before alternative policy responses can be studied thoroughly. We proceed here along two separate routes. The first approach involves counterfactual exercises based on the general equilibrium framework of the CMR. The second approach is intended to 'let the data speak' and generate inference on the basis of as little theoretical structure as possible. The latter is based on an identified VAR approach, where the identification assumptions are designed to capture the specificities of eurozone liquidity policy. It also complements the analysis of Fornari and Stracca (2012), which identifies financial shocks through sign restriction in a panel VAR and evaluates their macroeconomic impact in the eurozone.

[11] The Eurosystem's framework of monetary policy implementation consists of a corridor bracketing the interest rate at which liquidity is supplied in the regular weekly monetary policy operations, the main refinancing rate. The lower bound of the corridor is determined by the rate at which banks can deposit liquidity overnight at the ECB. The upper bound is the marginal lending rate, at which counterparties can borrow funds overnight from the ECB.

3.1. Impact of non-standard measures: counterfactual analysis

The effectiveness of the monetary policy strategy over the financial crisis can be measured by the distance between history and the counterfactual macroeconomic outcome had the ECB not adopted the non-standard policy measures. We rely on the CMR model to run the counterfactuals and concentrate only on two aspects of the policy package implemented between October 2008 and May 2009:

1. The switch to FRFA tender procedures in regular liquidity operations;
2. The expanded spectrum of maturities, from 3 months to 6 months and, as from June 2009, 12 months, at which liquidity has been offered in unlimited amounts in long-term refinancing operations (LTROs).

Our approach based on structural counterfactuals differs from Lenza *et al.* (2010) and Giannone *et al.* (2011). Lenza *et al.* (2010) rely on carrying out two counterfactuals for a number of macro variables within a Bayesian VAR setup by comparing a scenario with policy to one without policy. The no-policy scenario is based on the observed spread between money market rates and the 3-month EURIBOR directly following the collapse of Lehman Brothers in 2008. It is assumed that in the absence of non-standard policy measures the spread would have persisted thereafter and the counterfactual computes the effects on macro variables. It therefore captures a situation in which policy would not have been implemented. The policy scenario captures model-consistent effects on macroeconomic variables from the observed 3-month and 12-month market rates reflecting a situation with implemented policy. The difference between the two counterfactuals is attributed to the non-standard measures. Our framework relies on a DSGE model and therefore should be in principle more robust to the Lucas critique.

3.1.1. Impact of liquidity measures adopted by the ECB. In designing the counterfactuals we face the problem of discriminating the genuine impact of switching to the unlimited provision of liquidity (the FRFA of point 1 above) from the concomitant expansion of the spectrum of maturities at which liquidity was provided in unlimited volumes (point 2 above). In order to discriminate the two, we first quantify the impact of the extended maturity through the long-term liquidity operations in isolation. The basic idea is to exploit the elasticity of the 10-year risk-free interest rate to the overnight interest rate under normal conditions. We reckon that the spread between the 10-year average government bond interest rate and the overnight interest rate would have increased by more than it actually did during the crisis, and we attribute the observed reduced response to the expansion of the spectrum of maturities.

In specific terms, the implementation of the first counterfactual requires the following modelling steps: (a) we assume that in the counterfactual the structural non-policy shocks would have been the same as those identified in the estimation under the new policies during the post-crisis period (as discussed in Section 2); (b) the overnight rate would have evolved according to the feedback relationship described in Equation (1) above, using the coefficients estimated over the post-crisis, including zero elasticity, of the overnight rate to bank liquidity demand shocks. The zero elasticity is the distinct implication of the unlimited provision of liquidity in the model. This counterfactual is meant to simulate a situation in which the ECB provides short-term liquidity in unlimited amounts but does not provide unlimited liquidity in the longer-maturity operations; (c) we make use of the policy shock, ε_t, to generate the same path for the overnight interest rate, but force the 10-year spread to follow past regularities of long-term interest rate adjustments following policy action. Specifically, in a term-structure model, Hördahl *et al.* (2006) show that the response of long-term yields to a monetary policy shock is insignificantly different from zero. This implies that a policy rate change causes a one-to-one change in the term premium of the opposite sign. These results are also consistent with the VAR evidence presented in Section 3.2 below where in reaction to a fall in the MRO rate by 25 basis points the 1-year forward premium increases by approximately the same amount (see Figure 12).

In order to replicate the 'standard' sensitivity of the 10-year term spread to policy action, we re-simulate the model conditioning on two variables: the overnight rate and the term spread. In the first counterfactual, the overnight rate is kept fixed at its observed path, while the spread is forced to increase by about 75 basis points relative to the observed path over the simulation horizon. This conditioning is met by using both the unexpected and the expected component of the monetary policy shock process. This is the reason why, as mentioned already in Section 2, the baseline estimation over the post-Lehman sample period is conducted on the assumption that agents receive signals on the size of the policy shock. The horizon for which agents receive these signals is set to six quarters, given the fact that the ECB provided three LTROs with one year duration each, starting at the end of 2009Q2. This overlapping structure yields a total length of six quarters. Our implicit assumption, similar to the one in Lenza *et al.* (2010), is that the differential path for the 10-year spread relative to historical regularities is entirely due to the launch of the three 12-month long-term operations over the second half of 2009. In sum, we interpret this counterfactual as simulating a situation in which the ECB would not have supplied LTRO liquidity with a 12-month maturity, but provided unlimited liquidity at fixed rate with weekly maturities.

The second counterfactual exercise tries to answer the question: what would have happened if the demand for liquidity had not been satisfied unboundedly by the Eurosystem? We simulate the admittedly extreme case in which the Eurosystem would have continued its pre-crisis liquidity provision characterized by variable rate tenders, with the amount of liquidity offered to banks determined on the basis of 'liquidity needs' by banks – rather than unlimited liquidity as done by the ECB during the crisis. The liquidity needs cover the minimum reserve requirements, the public's demand for banknotes and autonomous variations in the accounts held by some governments at their national central banks. In the pre-crisis period, such estimated liquidity needs were the main reference statistic used by the Eurosystem to calibrate the pre-set volume of liquidity supplied in the weekly refinancing operations.

Specifically, the implementation of the second counterfactual is designed as follows: (a) we assume that the structural non-policy shocks would have been the same as those identified under the new policies over the post-crisis period, as in the counterfactual described above; (b) we re-simulate the model over the post-crisis period assuming that the value of θ is equal to the value estimated using the pre-crisis sample, unlike in the baseline post-Lehman sample estimation and unlike the counterfactual above; (c) we shut down the policy signals and assume that the liquidity provision by the ECB grow at the average growth rate of the 'liquidity needs'.

The results of the two scenarios are portrayed in Figure 9. The difference between the solid line and the dashed line is a measure of the impact of the shift to a fixed-rate-full-allotment procedure for auctioning liquidity including the effects of the lengthened maturity. The difference between the solid line and the dotted line is instead a measure of the pure impact of the lengthened maturity, under the assumption that the ECB would have provided liquidity in unlimited amounts, but only at short tenor.

According to the counterfactual exercises, the maximal impact of the non-standard policy interventions was associated with the switch to FRFA tender procedure (the

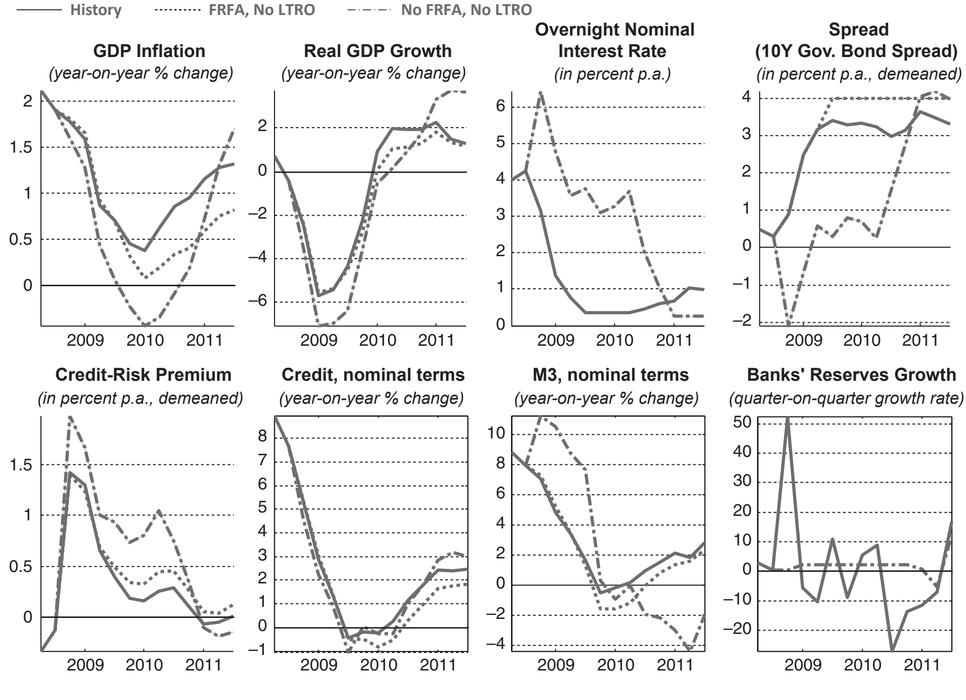

Figure 9. Post-crisis counterfactual: FRFA and long-term refinancing operations

Note: In each panel the solid line indicates history. The dotted line indicates the counterfactual associated with FRFA in the main refinancing operations, but no longer-term operations. The dashed line indicates the counterfactual associated with a variable-rate-tender policy (no FRFA) in all refinancing operations including refinancing operations at longer maturities.

dashed lines). Had the unprecedented increase in the demand for liquidity following the financial collapse not been accommodated by unlimited liquidity supply from the central bank, this would have pushed the money market rate strongly upward. The ECB measures have prevented deflation and contained the fall in economic activity.

The model generates an endogenous upward adjustment in M3 growth in parallel to the shift in the demand for liquidity. This is due to the increase in the demand for short-term deposits included in M3 but not in M1. Unlike the overnight deposits included in the definition of M1, these deposits are remunerated at an interest rate that is closely indexed to the overnight rate. As the latter increases sharply in the model simulations, these other forms of deposits become an attractive form of wealth allocation, which explains the surge in M3.

As a caveat to the analysis, the presence of the corridor in the ECB operational framework implies that the overnight market rate would have been occasionally capped by the upper bound of the corridor, which, however, is not enforced in the simulations. This assumption does not seem unreasonable, however. Without the full allotment tenders, banks would have either systematically borrowed from the ECB at its marginal lending facility and borne the stigma that this implies, or borrowed at the prevailing market rate, which would have been much higher than the rate charged at the lending facility. We assume that banks would have chosen to avoid the stigma attached to the marginal lending facility and to borrow at the market rate.

The extension of the maturities up to 12 months, captured by the difference between the solid and the dotted line in Figure 9, contributed to limiting the deflationary impact of the crisis, albeit to a smaller extent.

3.1.2. Alternative non-standard measures. When assessing the ECB's non-standard measures an obvious question is: What is the difference compared to policies adopted by other central banks? Focusing on the US, and limiting the analysis to strategic aspects in line with the aim of this paper, a difference between the ECB's and the Fed's non-standard measures stands out: the focus in the US on flattening the 'risk-free' curve via forward guidance and large-scale asset purchases of Treasuries (often labelled quantitative easing, QE). These two measures have not been employed by the ECB. In the US they were intended to provide additional policy accommodation when the policy rate is constrained by the zero lower bound. The expected impact of these measures on economic activity and inflation rested on the presence of spillover effects on overall financial conditions faced by households and firms. In other words, they relied upon a well-functioning transmission mechanism – as it would be the case for standard monetary policy in the absence of the zero lower bound.[12]

As discussed above, the stress faced by the banking system in the eurozone coupled with eurozone bank-centred lending implied that the chain of reactions across asset

[12] See Chung *et al.* (2011).

prices and financial conditions normally set in motion by a change of 'risk-free' rates was not working properly in the eurozone. This represented a challenge for standard monetary policy and in turn for possible measures aimed at flattening the risk-free curve. These considerations can probably largely explain the preference accorded by monetary policy in the eurozone to non-standard measures focused on addressing directly spreads over and above risk-free rates and on taking up intermediation directly. Additional considerations were probably related to large cross-country heterogeneity in eurozone financial conditions (not addressed here) and the fear that forward guidance may not be correctly understood as a conditional commitment by the public. The notion that the central bank will be patient in removing policy accommodation in the future notwithstanding inflation rates possibly rising above the numerical objective may be difficult to convey to the public. The major challenge for a central bank once inflation rates rise above the desired objective consists in managing inflation expectations and preventing their unanchoring. In that case, the central bank may need to rapidly withdraw policy accommodation to regain control of inflation expectations. However, at that point it may become hard to explain to the public that such a policy is perfectly consistent with the very notion of the original commitment to maintain interest rates low, which was part of the forward guidance communication. Any misunderstanding between the central bank and the markets can limit the flexibility of the central bank and endanger its credibility.[13] Finally, when comparing non-standard measures across central banks, it should be noted that the policy rate in the eurozone remained well above the zero lower bound.

Forward guidance and QE are usually understood as strictly intertwined, although their relationship is interpreted in the literature in different ways. At one end of the spectrum it has been argued that large-scale purchases of longer term Treasuries are neutral, but may help to make forward guidance more credible (Eggertsson and Woodford, 2003). At the other end of the spectrum it has been argued that within a general equilibrium model large-scale asset purchases can be found to have an independent effect, but such an effect is largely amplified by the commitment to hold the short-term nominal interest rate at the zero lower bound (Chen *et al.*, 2011). On the empirical side, Bauer and Rudebusch (2011) find that almost half of the impact on long-term Treasury yields associated with the Fed's asset purchases may come from the signalling effect that lowered expected future policy rates.

Notwithstanding their interaction, we analyse QE and forward guidance separately, implying that the impacts in our simulations may be largely overlapping. Starting with

[13] The challenge inherent in forward guidance is well described by Walsh (2009), who argues that instances in which central banks have made explicit use of forward guidance have been characterized by a mixed communication in which the central bank is 'simultaneously promising to keep interest rates low for an extended period while also promising to prevent inflation from rising. … In fact, the point of committing to low rates in the future is precisely because this will generate expectations of inflation. … it is inconsistent to commit to low interest rates and stable inflation' (see p. 13). Thus, rather than promising higher future inflation, policymakers seem to be concerned that inflation expectations remain anchored.

QE, we ask what could have been the impact in the eurozone had it been implemented in a similar size compared to that in the US. Given the uncertainty surrounding the channels through which asset purchases may affect yields and given the lack of their detailed inclusion in our structural model, we take the impact that QE may have had on US financial conditions from available studies.[14] They suggest that the Fed's purchases may have lowered long-term Treasury yields and corporate bonds by about 50 basis points. We make the assumption that this is fully reflected in a decline of equal size in the economy-wide financing conditions, which in the CMR model are captured by the premium. One way to put this effect into perspective is to measure the change in the policy rate in the model that would be necessary in order to generate such a change in the premium. It would normally require a cut in the policy rate of about 250 basis points. This falls in the same ball park as the rule of thumb for the US suggested by Chung *et al.* (2011), who argue that a 50 basis point decline in bond yields would correspond to about a 200 basis point cut in the federal funds rate.

Note that in light of our previous discussion regarding the malfunctioning of markets and the stress in the banking system that disrupted the normal transmission mechanism, this is an extreme assumption. However, given the difficulty to measure the degree of impairment of the transmission mechanism in a simple way in the model, this assumption allows to compute an upper bound of the possible effect of QE had it been implemented in the eurozone. Under the assumption that the impact on the premium declines over just more than two years,[15] Table 3 shows the results. For reference, it compares the impact with the one found in the FRFA counterfactual described above.

Turning to forward guidance, as already discussed, it is not clear whether it represents an independent instrument with respect to QE or whether their effects are largely overlapping. However, we analyse it separately to illustrate the hazards that the central bank may face in the exit phase in case it needs to counteract rising inflationary

Table 3. Impact of non-standard measures: QE and FRFA

	Inflation		GDP growth	
	Average effect over 2009–2010	Peak effect	Average effect over 2009–2010	Peak effect
QE	0.5	0.7	0.5	1.6
FRFA	0.6	1.0	1.0	2.1

Notes: The effect of fixed-rate-full-allotment (FRFA) by the ECB is reproduced from Figure 9. QE refers to quantitative easing as described in this section. Both inflation and GDP growth are measured as value in current quarter over value of previous four quarters of the GDP deflator and real GDP, respectively. The table displays the average and peak effect over the reference period.

[14] See for instance Gagnon *et al.* (2011), Chung *et al.* (2011) and references therein quoted.

[15] As the premium is measured as a spread above the expectational component of risk-free rates, the effect is likely to be temporary, see also Chung *et al.* (2011), who argue that the decline in the spread of mortgage rates over Treasury yields is likely to be temporary.

pressures and is bound by an explicit commitment about the future path of the policy rate. Given the modelling framework we have adopted, this implies that QE and forward guidance are likely to measure the same effects and therefore they should not be summed up. Again, the simulations are computed assuming a well-functioning pass-through of risk-free rates throughout the financial system, which however was not available to monetary policy in the eurozone.

The simulations are carried out in incremental steps. First, to calibrate the extent of forward guidance to be used in the simulations we assume a version of the risk management approach discussed in Section 2.4.1. In particular, at the outburst of the financial crisis the central bank fears that a very bad outcome may occur and its action may become constrained by the zero lower bound. In light of our previous discussion, we approximate this situation by assuming that in 2008Q4 the central bank carries out stochastic simulations focusing on adverse 'demand' shocks. We concentrate on the realization of shocks underlying inflation developments that fall in the lower part of the predictive inflation distribution. The outcome is displayed in the upper panels of Figure 10 by the dotted line. To show more clearly that the interest rate would need to become negative according to the feedback rule estimated in the model, we

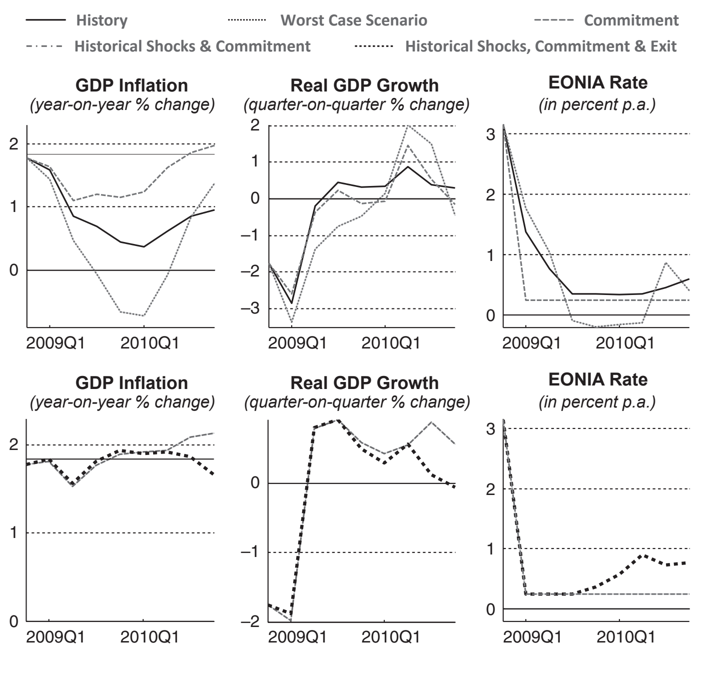

Figure 10. Post-crisis counterfactual: forward guidance

Note: In the panels the solid line indicates history. In the upper panels the dotted line indicates the counterfactual associated with assuming that adverse shocks in the lowest percentile of the predictive distribution would have occurred. The dashed line indicates the counterfactual associated with bringing immediately the EONIA down to low levels and committing to maintain it there for some time. In the lower panels the dashed line is the outcome in case the shocks that are estimated to have occurred in reality do materialize but the policy commitment is maintained. The thick dotted line is the outcome in case there is a policy 'surprise', that is, the tightening occurs earlier than originally expected by markets.

do not enforce the lower bound in the simulations. For comparison, the figure displays also the historical path followed by the EONIA (see solid line).

Second, to counteract such adverse developments the simulation assumes the central bank moves immediately to the zero lower bound (considered here to be 25 basis points) and commits to remain there for a period of time (considered here to be 7 quarters). The length of the period is determined such that it is sufficiently long to ensure that, if there is the bad realization of shocks as envisaged by the dotted line, inflation nevertheless remains close to the objective. The outcome is illustrated by the dashed line in the upper panels of Figure 10. Assuming that this commitment is fully credible, the results are consistent with the finding in the literature that forward guidance about the future path of interest rates can in general be effective in forestalling deflationary risks.[16]

In a third step we simulate a situation in which the actual realization of the non-policy shocks turns out to be less severe than initially expected. We assume that the realization of shocks is the one that actually hit the eurozone (as identified by the model) instead of the one used in the steps before. The outcome based on historical shocks while at the same time maintaining the policy commitment to low rates is represented by the dashed line in the lower panels of Figure 10. This can be interpreted as a situation where monetary policy maintains interest rates low despite a less adverse macroeconomic evolution in order to make good on past promises. The rise in inflation is explained by the realization of less adverse shocks while the interest rate is maintained at the lower bound.

The final step shows the outcome in case the central bank reneges on its commitment (dotted bold line in the lower panels of Figure 10). This makes monetary policy an independent source of start-stop dynamics with the economy plunging again into recession. Overall, the analysis suggests that possible complications arising at the time of exit are an essential dimension to consider when designing the preferred types of non-standard measures to adopt in the face of a financial crisis. In addition, the simulations disregard that the supportive effect of forward guidance in the model rests on a well-functioning transmission mechanism, which was not the case in the reality of the eurozone.

3.2. A VAR analysis

Our second approach for assessing the non-standard measures undertaken by the ECB is based on a structural VAR. Advantages and drawbacks of this approach are well known. The main advantage in our context is that it imposes very mild theoretical description: VAR results are therefore data-driven and not model-dependent.

[16] See Eggertsson and Woodford (2003). Levin *et al.* (2010) show, however, that depending on the persistence of the shocks and output elasticity to the interest rate forward guidance may not be sufficient to preserve macroeconomic stability even under commitment.

The main drawback is that a VAR is a reduced-form model: as such it cannot be used to perform a counterfactual analysis. Our VAR results should therefore be interpreted as simply shedding some light on the way in which non-standard policies have been transmitted to the rest of the economy. A general problem in assessing the effectiveness of non-standard measures in the eurozone is that these measures are unprecedented.

To rely on consistent series of central bank liquidity, we estimate the model from January 1999 until December 2011, at monthly frequency.[17]

The VAR includes standard macroeconomic variables, such as HICP inflation, detrended industrial production, the Purchasing Managers Index (labelled 'PMI' in the figures) and the rate of growth of loans to the private non-financial sector. To study the effects of non-standard measures on the macroeconomy, we additionally include indicators of financial distress: (a) the 3-month EURIBOR-OIS spread (BnkSpr); (b) the spread between short-term loans to non-financial corporations and the 3-month EURIBOR ('Loan Spr'); and (c) a measure of implied volatility in the eurozone stock market, the VSTOXX. For policy, we include the MRO rate, the spread between the MRO and the rate on the deposit facility ('MRO-DEP'), and central bank liquidity allotted in liquidity providing operations ('LiqTot'). Finally, we use market-based measures of expected future interest rates and inflation: the 1-year forward spread and the 10-year break-even inflation rate ('BEIR').[18] Overall, our VAR includes 12 variables. Given the relatively short available sample period, we estimate it using Bayesian methods and a Minnesota prior.[19] We include 10 lags in the specification.

A key step in our analysis is the identification of the shocks, where we follow Bernanke and Mihov (1998). Starting from a block of 'policy variables' – the MRO rate, the spread between the MRO rate and the rate on the deposit facility, and the total amount of liquidity – we specify a simple model of central bank liquidity to identify both a standard policy shock and a non-standard policy shock. The policy block is

[17] The volatility of the data we use tends to increase over the crisis period. This would be a problem for our standard VAR, if it induced heteroscedasticity in the variance of the shocks. As a robustness check, we also estimated the model on the January 2007–June 2010 sample. The impulse response results were broadly in line with those over the full sample, but uncertainty bands were considerably larger.

[18] More precisely, the following variables are included in the VAR: (1) inflation, measured as year-on-year log-difference of the eurozone HICP; (2) industrial production, measured in log-deviation from a quadratic trend; (3) the Purchasing Managers Index (in logs); (4) the annual growth rate of bank loans to the private sector, adjusted for sales and securitization (index of notional stocks); (5) the implied volatility of the Dow Jones Euro Stoxx 50 Price Index (in logs); (6) the 3-month spread between the EURIBOR and the Overnight Index Swap rate (for 1999, when OIS rates are not available, the 3-month yield on German government bonds is used instead); (7) the spread between the rate on bank loans (with maturity of up to 1 year) to non-financial corporations and the 3-month EURIBOR; (8) the MRO rate; (9) the spread between the MRO rate and the rate on the deposit facility; (10) the outstanding amount of ECB liquidity-providing operations (in logs); (11) the 1-year forward spread, namely the spread between the 1-year ahead overnight rate (implicit in the term structure of German government bonds) and the MRO rate; (12) the 10-year break-even inflation rate (extended backwards to the pre-2004 period in which index-linked bonds were either unavailable or very illiquid using fitted data from Hördahl and Tristani, 2012).

[19] The tightness hyper-parameter is set to 0.1; the weight parameter is set to 0.5.

ordered after all standard macroeconomic variables and also after our indicators of financial distress. This is consistent with the frequently used assumption that monetary policy can react to all these variables and indicators contemporaneously, but they are only affected by policy with at least a lag of 1 month. After the policy block, we include our measures of expected future interest rates and inflation. This choice allows these variables to react to policy shocks contemporaneously.

Concerning non-standard policy measures, we mainly focus on the decision to adopt a fixed-rate-full-allotment policy in liquidity operations and on the changes in the size of the interest rate corridor surrounding the main policy rate. We also analysed a second VAR to study the effects of the extension in the maturity of liquidity providing operations, but the results were statistically insignificant and are therefore not reported.

3.2.1. The short-term model. To identify the standard and non-standard policy shocks we start from two observations. First, the expansion of the ECB balance sheet was purely demand-induced at the given rate on refinancing operations, but the full allotment policy was in itself a policy decision. Second, changes in the rate on the deposit facility, for given MRO rate, can have macroeconomic impact through two channels. The first channel operates through changes in banks' opportunity cost of holding excess reserves: *ceteris paribus*, a reduction of the deposit rate would thus entail a higher cost of excess reserves. The second channel works in conjunction with the full allotment policy and the availability of vast amounts of reserves. In these circumstances, lowering the deposit rate permits a larger fall in the overnight money-market rate, compared to the level of the main policy rate.

The identification of the two policy shocks is based on the following simple model of the market for central bank money. First, we assume that the MRO rate is set independently of banks' liquidity needs. This reflects the fact that the MRO is the main indicator of the ECB policy stance. Any shock to banks' demand for ECB reserves is therefore implicitly accommodated without triggering changes in the intended policy rate. If we use u to denote the portion of our VAR residuals which is orthogonal to the VAR residuals in the non-policy block and ε to denote the structural shocks of the policy block, we can therefore identify the standard policy shock ε_{P} as

$$u_{\mathrm{MRO}} = \varepsilon_{\mathrm{p}}$$

Our second identification assumption exploits the fact that excess reserves are only remunerated at the rate on the deposit facility. They therefore carry an opportunity cost equal to the spread between the MRO rate and the rate on the deposit facility. Total reserves include required reserves and excess reserves. For simplicity, we abstract from this distinction and simply allow for total reserves to be sensitive to the MRO-deposit rate spread. The residual component is a liquidity demand shock ε_{d} due to factors not explained by our VAR. We therefore write

$$u_{\mathrm{LiqTot}} = -\beta u_{\mathrm{MRODep}} + \varepsilon_{\mathrm{d}}$$

where β is an elasticity parameter to be estimated.

Finally, we acknowledge that the central bank has the additional policy tool of modifying the spread between MRO and deposit rates. We postulate a generic 'reaction function' which depends on the state of the economy, but assume that this is independent of other liquidity market shocks. The reaction function residual can then be interpreted as a second, 'non-standard' policy shock ε_{s}:

$$u_{\mathrm{MRODep}} = \varepsilon_{\mathrm{s}}$$

Note that the model implies that total liquidity innovations are related to structural shocks in the following manner

$$u_{\mathrm{LiqTot}} = \varepsilon_{\mathrm{d}} - \beta \varepsilon_{\mathrm{s}}$$

so that an unexpected increase in liquidity can result from either a non-standard policy shock to the spread between MRO rate and deposit rate, or from a positive liquidity demand shock. By assumption, liquidity demand shocks are perfectly accommodated at an unchanged opportunity cost.

In our estimates, we find β to be insignificantly different from zero. An increase in the spread between the MRO rate and the rate on the deposit facility does not reduce the demand for liquidity. This suggests the existence of other channels through which changes in the size of the interest rate corridor affect the demand for liquidity, including a signalling channel and a precautionary savings channel.

The signalling channel implies that, *ceteris paribus*, a widening of the corridor due to a fall in the rate on the deposit facility may be interpreted as an indication that further reductions in the MRO rate may occur in the future. The existence of this channel is consistent with the finding in our impulse responses that the MRO rate indeed falls one year after the shock to the spread between the MRO rate and the rate on the deposit facility.

The precautionary savings channel is related to the fact that a wider corridor also implies a higher spread between the rate on the marginal lending facility and the MRO rate. The rate on the marginal lending facility is a penalty rate. An increase in its level, therefore, may encourage banks to increase their precautionary demand for excess reserves, so as to avoid any recourse to the marginal lending facility over the future.

As a robustness check, we also studied the implications of a slightly more involved model allowing for the distinction between excess reserves and total reserves. Overall, results turn out to be very similar, but are characterized by larger uncertainty.

3.2.2. Impulse response analysis. To gauge the overall performance of the VAR, we first look at its implications in terms of two benchmark shocks: an increase in the spread between 3-month EURIBOR and overnight swap rates – the financial credit spread – which we interpret as indicative of the financial crisis; and a standard policy tightening, which is comparable to existing results in the literature. The first shock is identified recursively, under the assumption that any innovation in the spread which is not correlated with innovations in macroeconomic variables is a structural 'spread shock'. All impulse response graphs report the mean response over 30,000 draws from the posterior parameter distribution, together with the 16th and 84th percentile of the distribution.

A 1 percentage point increase in the spread between the 3-month EURIBOR and the overnight swap rates (the BnkSpr variable in the graph) is displayed in Figure 11. Consistently with the developments between 2009 and 2011, the shock is very persistent: the spread falls by two thirds after 6 months, but remains at these higher levels for the following 6 months. The pass-through to lending rates for non-financial firms takes a few months, but is then completed with an increase of more than one-to-one relative

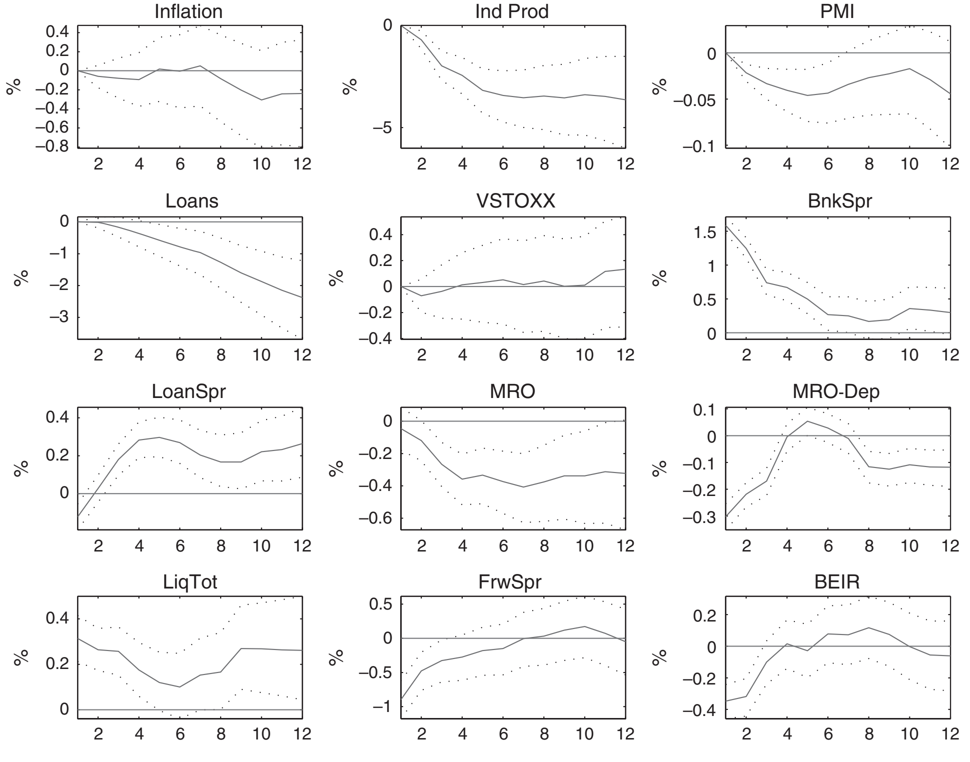

Figure 11. Impulse responses to a 1% increase in the interbank spread

Note: In each panel the solid line indicates the median response, the dotted lines refer to the 16th and 84th percentile of the posterior distribution of the impulse responses. Legend: 'Inflation' is the year-on-year log-difference of the HICP; 'Ind Prod' is log-industrial production in deviation from a quadratic trend; 'PMI' is the Purchasing Managers Index (in logs); 'Loans' is the annual growth rate of loans adjusted for sales and securitisation; 'VSTOXX' is implied stock market volatility (in logs); 'BnkSpr' is the spread between the 3-month EURIBOR and the 3-month overnight index swap rate; 'LoanSpr' is the spread between the rate on bank loans to non-financial corporations and the 3-month EURIBOR; 'MRO' is the MRO rate; 'MRO-Dep' is the spread between the MRO rate and the rate on the deposit facility; 'LiqTot' is the outstanding amount of ECB liquidity-providing operations (in logs); 'FrwSpr' is the spread between the overnight rate in 1 year and the MRO rate; 'BEIR' is the 10-year break-even inflation rate.

to the EURIBOR rates, as can be seen from the spread between loan rates and the EURIBOR rate (labelled LoanSpr). As a result, there is a persistent increase in the demand for central bank liquidity after the shock. Consistently with the developments in October 2008, the increase in liquidity is also smoothed by a temporary reduction in the spread between the MRO rate and the rate on the deposit facility together with a reduction of the MRO rate by 40 basis points after 6 months. Nevertheless, loans fall by 2% after one year, and industrial production declines by up to 4%. This shock is therefore quite consistent with the assumption that the shock to the EURIBOR-overnight swap rates played a significant role in the recession of 2008–2009.

Figure 12 reports impulse responses to a standard expansionary policy shock, that is, a 25 basis points cut of the MRO rate. The shock is quite persistent and produces mildly expansionary effects. The Purchasing Managers Index, the amount of loans and industrial production increase slowly and significantly after three quarters. The effects of the shock on inflation are statistically insignificant, but the break-even inflation rate increases slightly for a few months.

We now turn to the analysis of non-standard shocks. Figure 13 illustrates the response of the economy to an increase in the spread between the MRO rate and the rate on the deposit facility (labelled MRO-DEP). For a given MRO rate, this shock

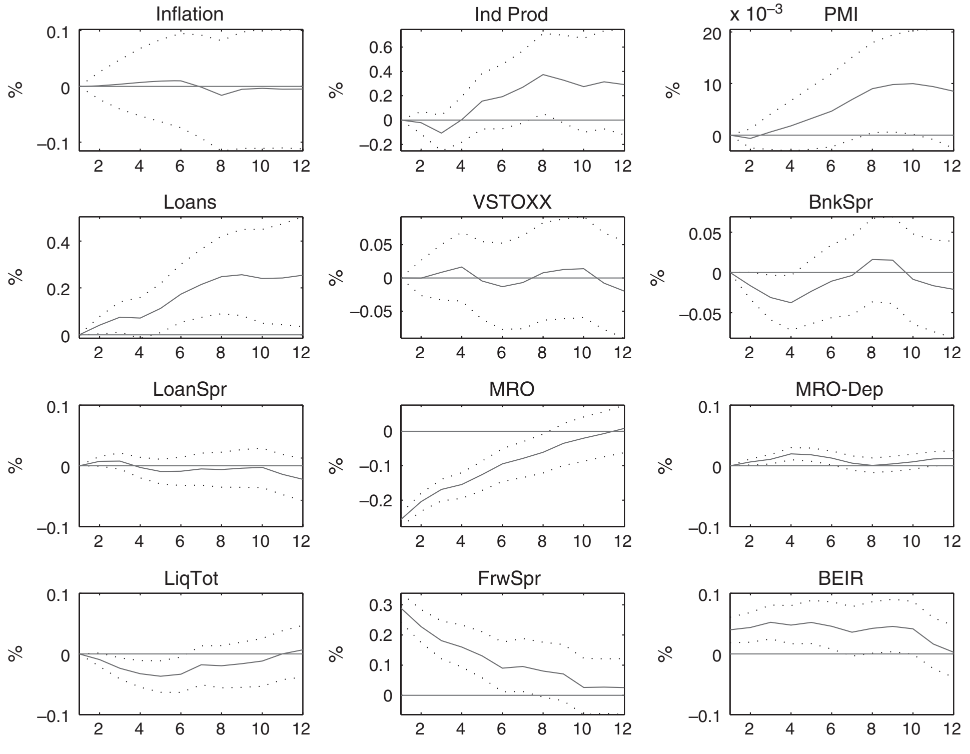

Figure 12. Impulse responses to a standard policy shock

Note: In each panel the solid line indicates the median response, the dotted lines refer to the 16th and 84th percentile of the posterior distribution of the impulse responses. Legend: see note to Figure 11.

represents a fall in the rate on the deposit facility which is not correlated with contemporaneous increases in the amount of central bank liquidity. It is therefore most closely related to the widening of the ECB corridor that occurred in January 2009. The shock has two effects. On the one hand, it has a direct impact on the demand for central bank liquidity: it increases both the opportunity cost of borrowing at the MRO rate and the cost of borrowing from the marginal lending facility, in case of unexpected liquidity shortages. The first effect should lead to a reduction in the demand for liquidity; the second effect to an increase. The impulse responses suggest that the second channel tends to prevail, leading to a slight increase in central bank liquidity (labelled LiqTot). On the other hand, the shock permits a fall in the EONIA which reduces refinancing costs on the overnight market and is expansionary for banks able to obtain liquidity from the market and not forced to rely on central bank funding. Overall, the impulse responses show that the net effect of the shock is expansionary. Loans increase persistently and the spread between loan rates and the EURIBOR rate falls. Industrial production and, to a lesser extent, inflation increase significantly after a few months. Such expansionary effects may also operate through expectations of future cuts in the MRO rate, which falls significantly one year after the shock.

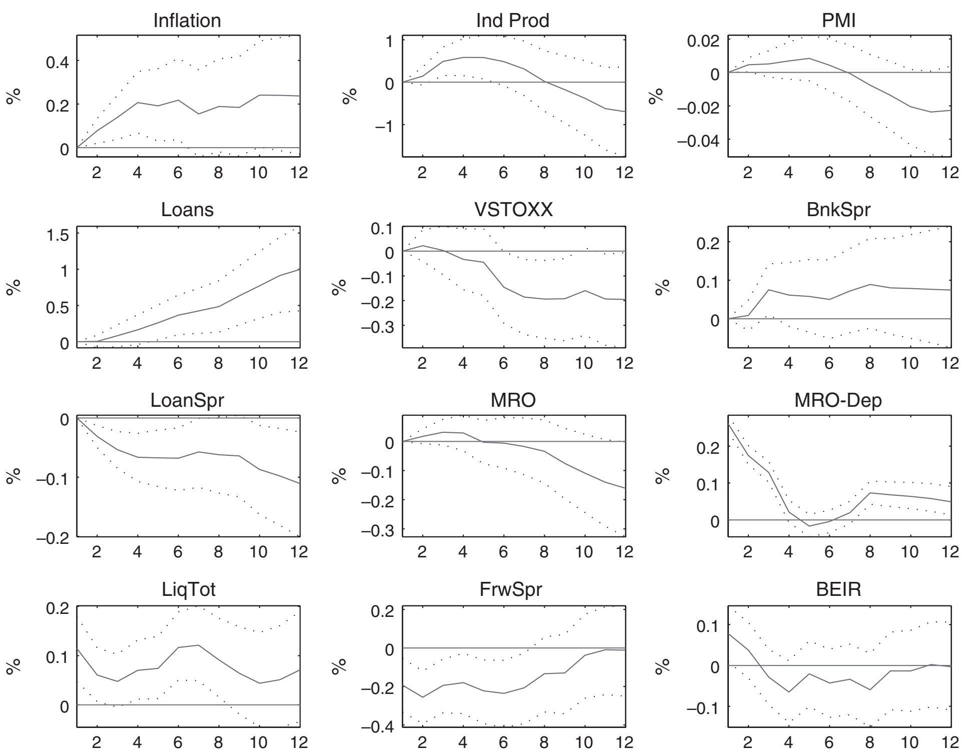

Figure 13. Impulse responses to an exogenous fall in the rate on the deposit facility

Note: In each panel the solid line indicates the median response, the dotted lines refer to the 16th and 84th percentile of the posterior distribution of the impulse responses. Legend: see note to Figure 11.

Figure 14 illustrates the response of the economy to a liquidity demand shock, signalling stress in the banking sector, which is fully accommodated by policy. The shock to total liquidity (LiqTot) is standardized to the increase in total ECB liquidity that occurred in October 2008. Figure 14 suggests that the ECB's full-allotment policy acted as a shock absorber, in the sense of preventing a fall in the amount of loans. Nevertheless, the shock is accompanied by a persistent increase in interbank spreads and by a short-lived increase in the spread between loan rates and the EURIBOR rate. It also leads to a large, though only marginally significant slowdown in industrial production, and it produces no significant effects on inflation, even if break-even inflation rates increase slightly for a few months.

All in all, the VAR results assign an important role to financial shocks – namely shocks that affect the spread between EURIBOR and overnight index swap rates – in explaining the 2008–2009 recession. They are also broadly consistent with existing results on the effects of a standard policy shock. Concerning non-standard policy, the VAR results are consistent with the hypothesis that the ECB's measures played a non-negligible role in helping the banking sector absorb the financial shock and in supporting the expansionary impact of the interest rate reductions.

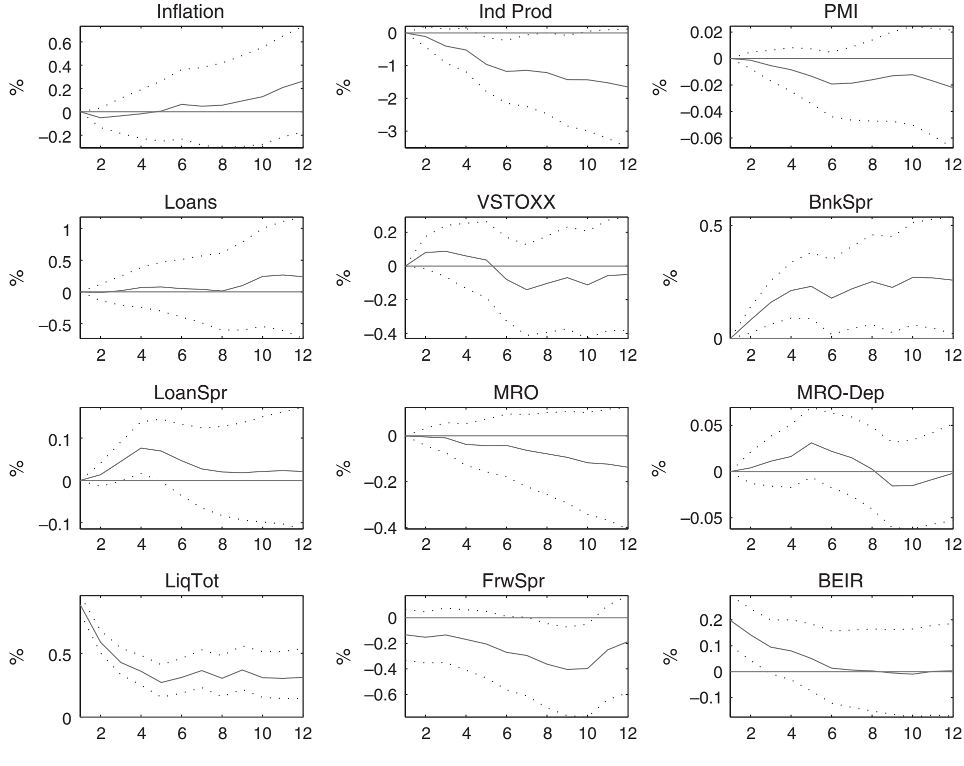

Figure 14. Impulse responses to a liquidity demand shock

Note: In each panel the solid line indicates the median response, the dotted lines refer to the 16th and 84th percentile of the posterior distribution of the impulse responses. Legend: see note to Figure 11.

4. CONCLUSION

The financial crisis has set in motion at a global level a process aimed at rethinking the monetary policy frameworks. We investigate some features of the ECB's monetary policy strategy and the ECB's monetary policy response to the financial crisis.

One lesson from the pre-crisis period is that a strong focus on expected inflation over an insufficiently long horizon may exacerbate boom-bust behaviour. This paper argues for a more medium-term orientation of monetary policy strategies focused on an analysis of the various sources of inflation developments and their medium- and long-term implications. A second lesson is that monetary policy strategies benefit from granting a strong role to monetary and credit developments, especially if business cycle fluctuations are driven by supply and financial developments.

The great recession has led to an unprecedented use of non-standard monetary policy tools. We discuss some of the non-standard policy measures the ECB has taken to address the malfunctioning in financial markets and to address stress in the banking system. We focus on the full allotment of liquidity by the ECB at fixed rates and the extension of maturity of this liquidity. We find that these measures were effective in averting downside risks to price stability and containing the fall in economic activity. An important lesson from the financial crisis experience is therefore that by taking on a financial intermediation role in markets that are impaired, central banks can complement their more traditional interest rate policy and improve the transmission of policy signals to the real economy. A comparison with policies adopted by other central banks suggests that focusing on flattening the 'risk-free' curve, when the policy rate is constrained by the zero lower bound, may be an effective stabilization tool. It requires, however, that the central bank can rely upon a well-functioning transmission mechanism that permits normal spillover effects on financial conditions faced by households and firms. Monetary policy in the eurozone faced, instead, an impaired transmission mechanism and the policy rate was not at the zero lower bound. Overall, our analysis suggests that the liquidity measures adopted by the ECB have been designed to suit the specificities of the eurozone context. We leave to future research the period that witnessed the intensification of the sovereign debt crisis in the eurozone and the monetary policy response to those developments.

Discussion

Romain Rancière

PSE

This article addresses a very important question: how does monetary policy change when financial conditions drastically change, affecting the supply of credit and that of liquidity? The evaluation of non-standard monetary policy tools is done within the framework of a DGSE model augmented with financial frictions. While the article analyses both tranquil times and crisis time, the main contribution regards the analysis of ECB policy in crisis times. The structural estimation approach allows comparing the historical path of some key variables – inflation, GDP, credit, risk-premia – versus the counterfactual paths in the absence of non-standard policies such as fixed-rate-full-allotment (FRFA) or long-term refinancing operation (LTRO). The paper makes a convincing case that non-standard policies have prevented deflation, mitigated the recession and reduced risk-premia. Yet a key puzzle emerges: these policies have had virtually no effect on nominal credit. This puzzle presents a challenge both from a modelling perspective and from a policy perspective. How shall we understand that in a model where financial frictions are keys, alternative policies have so little impact on the volume of available credit. From a policy perspective, how shall we justify using policies that improve considerably banks' balance sheets if they do not result in additional credit to the economy? Is there nothing central banks could do or should do to reduce the credit crunch problem?

A weakness of the article and more generally of that line of research is that crises are exogenous. These models ignore the possibly that tranquil times policies can plant the seed for future crisis by fostering risky credit boom and asset bubbles. The disconnect between normal times and crisis times also explains why potential moral hazard issues associated with crises policies are ignored. A related topic for future research is to understand how these non-standard policies redistribute resources in the economy: between agents (e.g. between creditors and debtors) or between sectors (e.g. between the financial and the non-financial sector). Finally, the rise of public debt also raises some challenges for monetary policies that have yet to be fully understood and modelled.

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This thoughtful and rich paper is a prototypical exercise in both the science and the art of monetary policy analysis (Clarida *et al.*, 1999). By 'science' I mean the use of advanced techniques in dynamic general equilibrium theory and Bayesian econometrics to: (i) formulate conditional forecasts on the evolution of the aggregate economy; (ii) assess the role of different sources of fluctuations in contributing to the volatility of selected key variables; (iii) produce counterfactual exercises to evaluate the role of monetary policy in shaping the behaviour of inflation of output. By 'art', in this case, I mean the difficult attempt to reconcile the predictions of an internally consistent model with the true observed practice of monetary policy at the ECB since the onset of its mandate.

To preview, the paper makes, in its essence, an impeccable use of scientific techniques to rationalize monetary policy decisions that appear, sometimes, the product of art as opposed to science (with both terms being used in the specific sense clarified above).

Many researchers in monetary policy theory often refer to two alleged Achilles' heels of the ECB policy framework. The first is the lack of so-called forward-guidance, namely an active use of communication policy to manage agents' expectations optimally. The second is the use of the so-called monetary pillar. In a nutshell, this paper is an extensive counter-argument to the benefits of the former, and a passionate, well-documented, praise of the latter. For the sake of brevity, I will henceforth focus my comments only on the first part, that is, the critical assessment of forward guidance.

Consider the following example studied in the paper. In the early 2000s the eurozone economy experienced a period of reduction in inflation. Employing their estimated DSGE model the authors suggest that there are three main determinants of the movements in inflation in the eurozone: (i) mark-up shocks; (ii) oil shocks; (iii) productivity shocks.

Notice that all shocks originate on the supply side of the economy. A close inspection of one of the historical decompositions produced in the paper (one of the main 'scientific tools' used in the analysis) indicates that the disinflation period of the early 2000s was mainly caused by a boom in productivity.

Is this credible? A study by a group of ECB economists (Gomez-Salvador *et al.*, 2006), using a descriptive analysis, indicates that labour productivity growth in the eurozone in the period 2000–2005 was 0.5%, well below the 1.5% experienced in the US in the same period. In general, the study points to a decline in average labour productivity growth in the eurozone since the mid-1990s throughout the 2000s.

Suppose, however, that, despite appearing counterfactual at first pass, we take for granted that a productivity boom was the likely source of disinflation in that period in the eurozone. We therefore ask: what should monetary policy do in response to a productivity boom? Recent developments in monetary policy theory provide us with a counterintuitive answer to this question: the central bank should lower the nominal interest rate.[20]

The intuition behind this prescription is the following. Suppose the central bank features an objective function that penalizes both the variability of inflation and of the output gap.[21] A rise in productivity generates a fall in inflation (due to higher production efficiency exerting a downward pressure on firms' real marginal costs) but, simultaneously, also a fall in the output gap. The latter is the result of movements in productivity affecting the potential level of output. In this context it is optimal for the central bank to lower the nominal interest rate and, in an environment with nominal rigidities, generate a reduction also in the real rate of interest, which in turn stimulates both inflation and economic activity. This policy prescription is counterintuitive because it is the opposite of traditional stabilization

[20] This prescription emerges within the context of a baseline dynamic general equilibrium model featuring nominal rigidities, forward-looking price setters and imperfectly competitive goods markets. See Woodford (2003) and Clarida *et al.* (1999).

[21] See for instance Woodford (2003) and Galí (2008) for textbook illustrations of how such an objective function can be derived from first principles in a microfounded New Keynesian model, in order to reflect a unique mapping to households' welfare.

interventions aimed at 'leaning against the wind'. But it is entirely consistent with the first principles of the model.

What did the ECB actually do in response to the alleged productivity-driven disinflation? The data indicates that the Ionia rate (the reference short-term interest rate for the ECB policy) rose continuously from 1999:Q3 to late 2001, in stark contrast to what standard theory prescribes. Hence a first question arises: why was the ECB policy so different from what basic theory prescribes? The paper remains elusive on this point. What the paper does is, in fact, to develop a more subtle point. In order to downplay the usefulness of forward-guidance in monetary policy, the authors perform a counter-factual analysis, and ask: what would have happened if instead of raising the nominal interest rate, the ECB had taken a commitment to keep rates unchanged through the end of 2001? They show that this commitment behaviour would have generated a destabilizing simultaneous boom in inflation and real activity.

The authors skilfully refrain from noticing, however, that recent theory has taught us something different. In the context of a standard New Keynesian model (sometimes labelled as the workhorse model for monetary policy and business cycle analysis) forward guidance is a feature of optimal policy behaviour in response to supply shocks of a different nature. Namely, so called cost-push shocks. The reason being that such shocks (unlike productivity ones) generate a meaningful trade-off between the goal of stabilizing inflation and the one of stabilizing the output gap. When this trade-off is binding, forward guidance helps because it allows an optimal management of expectations.[22]

Existing theory does not at all prescribe that forward guidance should be the optimal response to productivity shocks. Hence, it may not be surprising that the result produced by the model is what the authors define as a 'disastrous' policy, that is, an apparently spiralling rise in inflation. Forward guidance in the presence of productivity shocks is simply an 'artistic' policy prescription. This is an example of what, using an excess of synthesis, I would define as indulging in 'using science to justify art'.

The same example illustrates a pitfall of the analysis emerging throughout the paper: the lack of a rigorous metric to assess the performance of alternative policies. This metric should comprise two pillars. First, computing the model-consistent optimal policy. Second, evaluate the welfare costs of implementing alternative deviations from the optimal benchmark, for example, via simple policy rule prescriptions. In the instance illustrated above, the resulting boom in inflation is accompanied also by a large acceleration in output growth (noticeably, not necessarily in the output gap): how far from the optimal outcome is this? There is no metric in the paper to answer this question.

For the approach of the paper to be fully 'scientific', then, it should at least (i) show the model consistent output gap; (ii) compute the model-consistent optimal monetary

[22] See, e.g., Woodford (2003) and Clarida *et al.* (1999).

policy conditional to a productivity boom. This would allow us to answer the following question: is the optimal response to productivity shocks different in the current model – which features a rich, and very welcome, structure with financial imperfections – relative to the standard (and admittedly simple) New Keynesian model? This would be the only rigorous way to possibly justify why the ECB increased rates (as opposed to decrease them, as simple theory would prescribe) in the early 2000s, despite the evidence (if we take the authors' estimates literally) that disinflation was driven by a productivity boom in that period.

More generally, there is a subtle scepticism against forward guidance that emerges throughout the paper. The following sentence is illustrative: 'One way to interpret the ECB avoidance to enter commitments is related to exit considerations and the fear that the conditionality may not be correctly understood by the public'. This view is recurrent in the paper, and raises at least two objections/remarks.

First, the authors' view seems inconsistent with the same structure of the model (the 'science part') that informs their analysis. As that model is strongly rooted in rational expectations, it is well known that it would strongly favour forward guidance if only the central bank were allowed to conduct policy optimally, rather than via simple rules as done here.

Second, the scepticism against forward guidance seems in stark contrast with the policy conduct of the Federal Reserve since the onset of the recent crisis.[23] During this period it has become increasingly clear that zero lower bound (ZLB) is a constraint of more significant relevance for the conduct of monetary policy than previously appreciated. I do not obviously mean to imply that the ECB should necessarily conduct policy like the Fed.

But for a researcher it is of independent interest (and somewhat puzzling) to realize that while the recent Fed policy contains striking similarities with the textbook application of lessons learnt from the most recent academic literature on the ZLB (e.g., Eggertson and Woodford, 2003), the ECB policy does not. For this state of affairs either implies that one of the two policy institutions is making some error (unless one concedes that the underlying economic conditions are significantly different); or that the recent monetary policy literature is ill-oriented. At this stage it is difficult to answer this question, but it is a major achievement of this paper to be so provocative in this respect.

Panel discussion

Gianluca Benigno asked the authors to elaborate on the policy trade-offs in the model. Thierry Tressel first noted that 'leaning against the wind' in the eurozone is more dif-

[23] See for instance the statement from the 9 August 2011 FOMC meeting establishing a formal embracement of forward guidance: 'The Committee currently anticipates that economic conditions … are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013.'

ficult than in the US as in the former there may be a credit boom in one country but not in the others (aggregate credit might not rise sharply). Second, regarding LTROs, he felt that it is important to understand the counterfactual but was not too convinced that one could assess it in the authors' model. Richard Portes was puzzled by how supply shocks are identified in the paper. In particular, he noticed that the main shock in 2009 was a productivity shock and that there was no oil shock. If this was really the case, he wondered what kind of productivity shock it was. Second, he asked if the Fed's current policy stance is likely to lead to a take-off in inflation. Refet Gürkaynak added that the authors should also illustrate as a counterfactual what the implications would have been for the eurozone if the ECB had adopted the policies of the Fed. He argued that the counterfactuals in the paper do not really allow one to conclude that the alternative policies would have been bad at the time. He contended that using the US counterfactual could provide a more direct and obvious comparison. Tommaso Monacelli's opinion diverged from that of Gürkaynak. Specifically Monacelli thought that the most natural approach is to make comparisons with optimal policy derived from the model which accounts for the innate structural characteristics of the region. He said that the Fed's conduct of policy currently appears to be consistent with theory while he could not understand the ECB's strategy. Perhaps an analysis of the eurozone's optimal policy could reveal why their tactic was so different.

Referring to Monacelli's analysis, Stephan Fahr explained that it would be a good idea not to lower interest rates after a productivity boom in order to help foster stability rather than boom-bust cycles. Fahr welcomed Monacelli's point about looking at optimal policy but also considered the extent to which this was possible given the size of the model. Picking up on Michael Devereux's point about the Fed having a dual mandate of full employment and inflation containment, Fahr told the panel that the dimensions along which comparisons could be made between the policies of the Fed and those of the ECB would be restricted given the ECB's primary objective of price stability. Massimo Rostagno stated that although evaluating optimal monetary policy might be interesting from an academic perspective, it would be difficult in their study and moreover not very useful for the line of work they are involved in (namely presenting facts and inferences on the basis of the empirics to policymaking bodies). Next, he stressed that the central bank has a problem when inflation is not pro-cyclical and in particular is systematically counter-cyclical like in the eurozone. As to Ranciere's comment pertaining the the lack of credit reaction, Rostagno disagreed as this does not find support in the analysis. More importantly, the analysis showed that non-standard measures have provided substantial stabilisation of inflation and economic activity. Nevertheless, Rostagno completely agreed with Ranciere's comments pertaining to LTROs (the paper completely abstracts from what the LTROs might have averted, particularly the 3-year LTROs). He drew attention to the point that the model considers the absolute lower bound of the effect of the LTROs and the FRFA switch made in 2008.

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