Working paper

2015-26

THE EFFECT OF ECB MONETARY POLICIES ON INTEREST RATES AND VOLUMES

Jérôme CREEL
OFCE-Sciences Po and ESCP Europe

Paul HUBERT
OFCE-Sciences Po

Mathilde VIENNOT
Paris School of Economics

October 2015

ofce

The Effect of ECB Monetary Policies on Interest Rates and Volumes*

Jérôme Creel
OFCE – Sciences Po & ESCP Europe

Paul Hubert
OFCE – Sciences Po

Mathilde Viennot
Paris School of Economics

October 2015

Abstract
This paper assesses the transmission of ECB monetary policies, conventional and unconventional, to both interest rates and lending volumes or bond issuance for three types of different economic agents through five different markets: sovereign bonds at 6-month, 5-year and 10-year horizons, loans to non-financial corporations, and housing loans to households, during the financial crisis, and for the four largest economies of the Euro Area. We look at three different unconventional tools: excess liquidity, longer-term refinancing operations and securities held for monetary policy purposes following the decomposition of the ECB's Weekly Financial Statements. We first identify series of ECB policy shocks at the Euro Area aggregate level by removing the systematic component of each series and controlling for announcement effects. We second include these exogenous shocks in country-specific structural VAR, in which we control for the credit demand side. The main result is that only the pass-through from the ECB rate to interest rates has been effective. Unconventional policies have had uneven effects and primarily on interest rates.

Keywords: Transmission Channels, Unconventional Monetary Policy, Quantitative Easing, Pass-through, Bank Lending.

JEL codes: E51, E52, E58

* We thank Antonio Afonso, Christophe Blot, Nick Butt, Rohan Churm, Fabien Labondance, Grégory Levieuge, Patrizio Tirelli and seminar participants at OFCE (Paris), ISEG (Lisbon), the 2013 FESSUD annual conference, the 2014 Eastern Economic Association conference, the 2014 ICMAIF conference, the 2014 French Economic Association (AFSE) conference, and the 2014 GDRE Money, Banking and Finance conference for helpful comments. This research project benefited from funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n°266800 (FESSUD). This paper previously circulated under the title "Assessing the Interest Rate and Bank Lending Channels of ECB Monetary Policies". Any remaining errors are our own responsibility.
Email addresses: jerome.creel@sciencespo.fr, paul.hubert@sciencespo.fr (corresponding author), mathilde.viennot@ens.fr. Postal address: 69 quai d'Orsay, 75007 Paris, France. Tel: +33144185427.

1. Introduction

This paper aims at establishing the effect of a fine decomposition of conventional and unconventional ECB monetary policies on both interest rates and volumes in the four largest economies of the Eurozone during the global financial crisis. This issue is topical since Mario Draghi, chairman of the ECB, justified the implementation of some of the unconventional policy tool – the Outright Monetary Transactions - by the disruption of the ECB monetary policy transmission to the real economy in some Eurozone countries. The question also matters theoretically. Unconventional monetary policies should be neutral (apart from signalling effects) except if there is some market segmentation over the following two dimensions: along the term structure (short and long term maturities are not perfect substitute as there are duration preferences) or between countries (there is a home bias in debt holding or risk aversion to some country specific loans or debts). This is the irrelevance result of Eggertsson and Woodford (2003) in perfect financial markets. However, there has been strong empirical evidence against this neutrality in the most recent literature.

One of the pioneering studies about the monetary transmission mechanism is Bernanke and Blinder (1992) showing that the pass-through from the policy rate to lending and deposit interest rates is expected to be positive, whereas the pass-through to lending and deposits volumes is expected to be negative. Before the recent financial crisis, many studies have focused on the monetary transmission mechanism in the Eurozone. Donnay and Degryse (2001) with a SVAR, De Bondt (2005) with a vector error-correction model, Sorensen and Werner (2006) with a cross-country analysis, Sander and Kleimeier (2006) differentiating expected and unexpected monetary policy impulses, assess the pass-through from the policy rate to money market rates or bank interest rates. The literature on the bank lending channel is less numerous than the one on the interest rate channel; Chatelain et al. (2003) and De Santis and Surico (2013) show that bank characteristics play a role in the effect of monetary policy on bank lending.

Many articles have studied the effect of conventional monetary policy in the Eurozone during the worldwide financial crisis. Andries and Lecarpentier-Moyal (2012), Blot and Labondance (2013), Belke, Beckmann and Verheyen (2012), Aristei and Gallo (2012), Gigineishvili (2011), Reziti and Spiliotis (2010), Karagiannis, Panagopoulos and Vlamis (2010), von Borstel, Eickmeier and Krippner (2015) focus on the interest rate channel. However, during the financial crisis, implementing monetary policy became much more complex as the transmission mechanism has been severely impaired by disruptions in the financial markets; as a consequence, the ECB resorted to unconventional measures to provide additional stimulus to the economy. A large literature assesses the effectiveness of such measures[1]. Cordemans and Sola Perea (2011), Abbassi and Linzert (2011), Lenza, Pill and Reichlin (2010), Altavilla, Giannone and Lenza (2014), Ghysels, Idier, Manganelli and Vergote (2014) and Szczerbowicz (2015) focus on the effect of unconventional tools on interest rates. Gambacorta and Marques-Ibanez (2011), Giannone, Lenza, Pill and Reichlin (2012), Darracq-Paries and Santis (2013), Boeckx, Dossche and Peersman (2014) and Andrade, Cahn, Fraisse and Mésonnier (2015) analyse more specifically the bank lending channel. Bonnacorsi di Pati and Sette (2012) study the transmission of monetary shocks affecting Italian banks' balance sheets to the volume and cost of credit to non-financial corporations.

[1] For the US, see Bernanke, Reinhart and Sack (2004)'s indirect evidence or more recently, Fleming, Hrung and Keane (2008), Hrung and Seligman (2011), Krishnamurthy and Vissing-Jorgensen (2011), Thornton (2011), Stroebel and Taylor (2009), Altavilla and Giannone (2014) among others, as well as Joyce, Lasaosa, Stevens and Tong (2011), Joyce (2012) and Butt, Churm, McMahon, Morotz and Schanz (2014) among others for the UK.

The literature is much segmented so far: analyses focus either on conventional or unconventional measures, either on interest rates or volumes, and either on the money market, sovereign bonds or loans to NFC. Two types of estimation strategies have been mostly used: event-studies looking at the response to policy announcements, so their implicit focus is on the signalling and confidence channel specifically and the high-frequency response to these announcements, or VAR analyses with the amounts of liquidities provided or securities bought by the monetary authority, so the implicit focus is on the other channels and the lower-frequency response to those policies. This paper contributes to this literature in three ways. First, we assess at the same time the pass-through to interest rates and volumes so as to capture both dimensions of each market. Second, we investigate at the same time the effects of both conventional and unconventional monetary policies, the latter being decomposed at a fine level. Third, the analysis is performed, over the financial crisis sample, for the four largest economies of the Eurozone: Germany, France, Italy and Spain, and at a disaggregated level encompassing sovereign bonds at 6-month, 5-year and 10-year horizons, loans to non-financial corporations, and housing loans to households.

We proceed in two steps. We first identify series of ECB policy shocks, the main refinancing operation interest rate for conventional policy and the amounts spent for each unconventional policy as stated in the ECB's Weekly Financial Statements, at the euro area aggregated level. We do so by removing the systematic component of each series and therefore stripping out their unpredictable component. Using amounts spent rather than announcements suggests that these policies could have been anticipated by market participants. However, we show that this is not the case and that our series of shocks are not predictable. We focus on amounts spent as we are interested in the real effects of unconventional policies, not the high-frequency effects of announcements. To identify unconventional monetary shocks exogenous to anticipation effects, we control for the effects of policy announcements. In doing so, we focus on the transmission channels other than the signalling and confidence channels, and we therefore provide a lower bound estimate of the effects of these policies. Second, we include these 4 estimated series of interest rate and unconventional policy shocks in country-specific structural VARs with 5 additional endogenous variables, namely industrial production, inflation, a proxy variable to control for the credit demand (or bond issuance), interest rates and volumes for each of the five markets considered, as well as oil prices, a composite indicator of systemic stress (CISS) and the Euro Stoxx 50 index as exogenous variables.

The main result is that only the pass-through from the ECB rate to interest rates has been effective, consistently with the existing literature, while the transmission mechanism of the ECB rate to volumes has been weak. Unconventional policies have had uneven effects. It gives support to the break-up of unconventional policies between excess liquidity, LTRO and SHMPP. Excess liquidity has an effect on interest rates in Germany and Spain, and on volumes in France and Spain. In comparison, the impacts of LTRO measures are weaker and concentrated exclusively on interest rates. In contrast, SHMPP measures which were targeted towards peripheral countries have been effective at modifying interest rates in these countries and, to a lower extent, volumes.

One argument to explain the differentiated pass-through of ECB monetary policies lies on the complementarity of these ECB policies. As stated by Mario Draghi, the objective of unconventional policies may have been to restore the transmission mechanism of the conventional policy. So as to shed light on this issue, we look at the effect of conventional policy shocks on unconventional policy tools and vice-versa. A shock to the conventional tool of monetary policy has no effect on any unconventional policies. Regarding the effect of

shocks to unconventional tools on the ECB interest rates, there are only a few instances where the former complements the latter, with excess liquidity and SMHPP policies.

Another argument is that the successful pass-through from the ECB rate to interest rates, which materialized as a decrease in interest rates during the sample period, had a negative effect on the supply side of loans, and offset itself its positive effects on lending volumes. The interest rate channel may be a substitute to the bank lending channel on the supply side when net interest margins deteriorate, and ever more so for larger banks which retain market power. Landier, Sraer and Thesmar (2013) show that a 100 basis point decrease in the Fed funds rate leads a US bank at the 75th percentile of the income gap distribution to decrease lending by about 1.6 percentage point annually relative to a bank at the 25th percentile.

In a context where commercial banks attempt to increase their capital ratios while governments try to reduce their debts, a policy implication of this result would be for central banks to target more directly non-financial corporations or households when implementing unconventional monetary policy or to constrain more effectively bank lending to ensure an operative pass-through towards the real economy.

The rest of the paper is organized as follows. Section 2 presents the theoretical framework, section 3 data, section 4 the identification of policy shocks and section 5 the empirical strategy and results. Section 6 concludes.

2. Framework

This paper is at the crossroads of two evolutions in monetary policy: the first, theoretical, relates to the introduction of financial frictions; and, the second relates to central bank practices and their unconventional measures. These evolutions raise the issue of the transmission channels of monetary policy. Under the classical view of the transmission channel, interest rates impact economic activity by affecting relative prices in the economy (relative prices of capital, of future consumption in terms of current consumption and of domestic goods in terms of foreign goods); this constitutes the interest rate channel and encompasses most mechanisms that are not associated with financial frictions. The interest rate channel is economically significant because of the link between changes in short nominal rates and long real interest rates.[2]

To the extent that consumer and investment spending, and in the first place, durable/capital goods expenditure depend on long rather than short rates, the expectations theory of the term structure holds, so that short rate movements are transmitted to long rates. Nevertheless, many features of the configuration of interest rates during the financial crisis are puzzling from the perspective of the expectations hypothesis.[3] Furthermore, term premia have affected the extent to which changes in short rates are translated into further changes along the yield curve by responding systematically to offset movements in short rates, which is expected to weaken the effect of policy changes. Interest rate channels, due to market segmentation, may well differ in size from one market to another. As regards the conventional instrument of monetary policy, we thus expect a larger transmission mechanism on short-horizon markets than at a longer horizon.

[2] Provided that the central bank affects real interest rates, the impact of monetary policy depends on the interest rate sensitivity of aggregate demand and supply, which may explain the decline of the monetary pass-through during the recent financial crisis.
[3] See Gürkaynak and Wright (2012).

The introduction of imperfect information in monetary policy theory has given rise to a credit view which has stressed a distinct role to financial assets and liabilities. For instance, the bank lending channel explains the effects of monetary policy with movements in the supply of bank credit. The essential feature is that the central bank can affect credit supply by financial intermediaries by altering base money, which affects the banks' balance sheet. The monetary policy transmission through this channel may be incomplete thanks to limited liability, credit rationing, or the imperfect substitutability between retail deposits and wholesale deposits or debt on the liability side of banks' balance sheets. Bernanke and Blinder (1988) assume fixed costs of direct financial market participation and banks' incomplete/imperfect information in the market for equity and corporate debt. They show that such structures amplify the effects of monetary policy shocks. However, this amplification will depend on the size of the lending contraction for a given shock: the more interest inelastic is the demand for money, the lower will be this contraction. Consequently, the bank lending channel not only emerges on the equilibrium price of the market – the interest rate set on this market – but also on the volumes, provided one control for the demand for bank credit.

The implementation of unconventional monetary policies hinges on new channels (see Joyce et al., 2011, for a survey): portfolio balance, policy signaling, and default channels. These policies can also help improve the bank lending channel and a complementarity may emerge between conventional and unconventional policies.

After a change in the volume or structure of central bank balance sheet, transmission channels of unconventional policies will be operating provided financial frictions are included. Without financial frictions, the composition of central bank assets is irrelevant in the same sense as in the Modigliani-Miller theorem on the structure of corporate liabilities (Wallace, 1981). Curdia and Woodford (2011) and Gertler and Karadi (2011) propose extensions of DSGE models to quantitative easing measures taken by a central bank under disruptive financial markets or intermediaries. They show that credit policy can improve welfare provided financial disruption is sufficiently high (Curdia and Woodford) or provided an agency problem is introduced between financial intermediaries and depositors (Gertler and Karadi).

Unconventional measures take different forms; consequently, they have different impacts on markets. The purchase of large amounts of debt instruments like QE is expected to impact directly on the sovereign debt market, or on a segment of it, e.g. the market related to the maturity involved in policy measures[4]. We expect that QE policy will produce a reduction in the interest rate and/or an increase in the volume of the sovereign debt market or on the segment targeted by the central banker. We also expect some spillovers on other markets or other segments of the same market, via portfolio changes or confidence effects. Fixed-rate full-allotment operations which gave rise to excess liquidity are targeted towards the money market. Their impact is expected to be small and potentially negative on other markets: excess liquidity is mainly driven by the refinancing needs of banks, either because of low deposits inflows or because of unsecured short run liabilities (ECB Monthly Bulletin, January 2014). Long-term refinancing operations (LTRO) initially fuel excess liquidity. We do not expect a large impact on financial markets, on the volumes and, consequently, on interest rates. The announcement of Targeted LTRO by the ECB in June 2014, which aims explicitly at improving bank lending, gives weight to our expectation of a low impact of LTRO, although some impact of 2011 and 2012 LTRO on sovereign bonds markets could emerge.

[4] OMT measures (not operational yet) involve the purchase of public bonds up to 3-year maturity.

Table 1 – Expected effects of positive monetary policy shocks [5]

	Conventional policy	Unconventional policies
Interest rates	+	-
Volumes	-	+

Although the multiplicity of unconventional measures requires a differentiated study of their respective effects, we will also investigate their aggregate effects. Table 1 summarizes the theoretical predictions of conventional and (undifferentiated) unconventional policies on credit volumes and interest rates.

3. Data

This paper focuses on the monetary transmission mechanism since the global financial crisis in four countries: France, Germany, Italy and Spain. Our dataset goes from June 2007 to October 2014 with a monthly frequency so comprises 89 observations. The monetary transmission mechanism is assessed for conventional and non-conventional tools and on five markets: sovereign debt at three maturities, loans to non-financial corporations (NFC), and housing loans to households.[6]

Conventional monetary policy is measured with the ECB rate for main refinancing operations, whose data over the period is available from the ECB database. We use the ECB's weekly financial statements (WFS)[7] to obtain a fine decomposition of all unconventional policy measures. We have already discussed in section 2.1 about the differentiated objectives of unconventional measures; for this reason, we aim at analysing precisely their effects on interest rates and volumes. Focusing on one type of measure only would not give full credit to the set of measures that the ECB has implemented during the crisis. The simplest unconventional tool is excess liquidity (current accounts – reserve requirements + deposit facility – marginal lending facility, or in WFS terms: item 2.1 – res. req. + item 2.2 – item 5.5). The second set of unconventional tools is Longer-term Refinancing Operations (in WFS terms: item 5.2). The most unconventional instrument is the amount of securities held for monetary purposes, including the Securities Market Program, the 1st, 2nd and 3rd Covered Bond Purchase Programs, and the most recent Asset-Backed Securities Purchase Program (in WFS terms: item 7.1). These data series are taken from the ECB Statistical Data Warehouse, and are expressed in percentage of Euro area (changing composition) GDP. Figure 1 plots the 4 variables. It highlights the differences in the timing and size of measures which require an individual treatment.

For each country (France, Germany, Italy and Spain), the endogenous variables needed for estimating the monetary transmission mechanism include the specific interest rates and their corresponding volumes.

The monetary transmission mechanism is first assessed in the sovereign debt market. Data availability in auctions results has limited the number of countries to only four. Data for new issuances were found on national debt agencies' websites (Agence France Trésor, Banco de España, Banca d'Italia, Deutsche Finanzagentur). After compiling all auctions, we have

[5] A positive conventional monetary policy shock corresponds to an increase in the policy rate, while a positive unconventional monetary policy shock corresponds to an expansion of the central bank balance sheet.
[6] See appendix for data descriptions and descriptive statistics.
[7] https://www.ecb.europa.eu/press/pr/wfs/2015/html/index.en.html

chosen allotments and corresponding yields for bonds with 6-month, 5-year and 10-year maturity. Indeed, these maturities seem to be the most representative of monthly auction amounts[8]. For each country, bonds from 165-day to 210-day maturity are chosen as a proxy for 6-month maturity bonds, bonds from 54-month to 72-month maturity for 5-year maturity bonds and bonds from 114-month to 132-month maturity for 10-year maturity bonds; thus, we escape the problem of disregarding close-to-reference maturity issuances (5 months and 27 days instead of 6 months for example). The allotments are expressed in percentage of euro area GDP.

For the market of loans to NFC, we take the 'new business' volumes and their corresponding annual interest rates, with 'new business' volumes expressed as a percentage of Euro area GDP. These data were available over the period on national central bank's databases (Banque de France, Banca d'Italia, Bundesbank) or Datastream for Spain.

The lending market to households is usually decomposed between housing loans and cash loans. In each country, cash loans represent a relatively small portion of all loans to households and they are traded at a legal interest rate ceiling which has substantially less variance than interest rates on housing loans[9]. For both reasons, we decided to focus on housing loans whose interest rates vary with policy rates. For each country, we take the 'new business' volume of housing loans and their corresponding annual interest rates. New business volumes are expressed as a percentage of Euro area GDP. These data were available over the period on national central bank's databases (Banque de France, Banca d'Italia) or Datastream for Spain and Germany.

So far, we depicted monetary channels of transmission on the five markets as if their respective volumes were expressed in gross terms or as if they were only supply-driven. Empirical outcomes will be partial, unless we correct the supply of bonds and credit for exogenous determinants or demand-driven factors. New public debt gross issuance does not only respond to a new policy environment (policy rate, GDP change, etc.) but it also stems from former commitments, like debt redemption. Thus, we use debt redemption as a proxy of the lower bound of refinancing needs of government, to net out new issuances of gross debt. Consequently, the estimated monetary channels on sovereign markets are based on a proxy of new issuances of *net* debt. As regards credit to NFC and households, we use BLS surveys to net out credit supply of some drivers of credit demand. Here again, the estimated monetary channels are based on proxies of a *net* supply of credit.

A set of macroeconomic variables is used for the two stages of the analysis, first the identification of common monetary policy shocks and, second, the estimation of country-specific and market-specific monetary channels of transmission. This dataset comprises euro area aggregate data and national data. At the aggregate level, oil prices, the unemployment rate, the CISS, the Euro Stoxx 50, the 10-year euro area average sovereign bond interest rate, private credit growth and the euro/dollar exchange rate are taken from the ECB Statistical Data Warehouse. Oil prices, CISS and Euro Stoxx 50 indices are the same variable for all countries and correspond to Brent crude oil price in euro, expressed in month over month

[8] Together, they represent 25% of the French sovereign debt (9% for 6-month maturity bonds, 8% for 5-year maturity bonds and 8% for 10-year bonds), 32% of the Spanish one (2% for 6-month, 14% for 5-year, 16% for 10-year), 49% of the Italian one (26% for 6-month, 12% for 5-year and 11% for 10-year), 58% of Germany's (21% for 6-month, 17% for 5-year and 20% for 10-year).

[9] In each country, cash loans represent 30% of all loans to households on average over the sample. The variance of interest rates on housing loans is 9 times higher than the variance of interest rates of cash loans in Germany, 3 times higher in Italy, 30% higher in France and 18% higher in Spain.

percentage change, to the Composite Indicator for Systemic Stress, capturing financial instability, and to the stock price index for the major 50 European firms. At the national level, for each country, the consumer price index is available on ECB Statistical Data Warehouse, and the volume of industrial production, used as a proxy for domestic output, is available on Eurostat. Both are expressed in year over year percentage change. We add the stock price index for their major firms: CAC40 for France, DAX for Germany, FTSE MIB for Italy and IBEX35 for Spain. All these are available on ECB Statistical Data Warehouse or Euronext website. Table A in the Appendix provides some descriptive statistics for all variables.

4. Identifying ECB policy shocks

Before estimating country-specific and market-specific structural VARs, we identify for each instrument at the euro area aggregated level ECB policy shocks orthogonal to a wide array of macroeconomic variables. We aim at removing the systematic component underlying the evolution of the four policy instruments so as to retain their unpredictable part. The rationale for this identification is twofold. First, it aims at avoiding endogeneity and, second, it is consistent with the ECB deciding and executing its policies at the aggregate Euro area level.

Our identification of shocks focuses on the actual implementation of monetary policies, although one may argue that the shock happens at the time of the announcement and that most of its effect is therefore realised on the announcement of the policy. However, focusing on announcements with event-studies[10] only measures the signalling and confidence channels on very short time windows. These effects might be offset over the following days. In addition, it does not tell what the actual effects of the policy are, and it only informs about the credibility of the monetary authority. Ultimately, if the effect comes directly on the announcement, this goes against our hypothesis and our identification captures the lower bound of the effect of monetary policies. The fact that our shocks may be anticipated because of the announcements creates another issue. To cope with it, we first control for the systematic responses of monetary policies to announcements and second we assess that our series of shocks are not predictable.
Assuming that the systematic dynamics of Y_t = {ECB rate, EL, LTRO, SHMPP} is driven by policymakers' responses to data in their information set Ω_t, where f(·) is a function capturing their systematic reaction, and that the term ε_t^Y reflects unexpected shocks to the four variables, the model extracting the exogenous shocks can be represented as:

$$Y_t = f(\Omega_t) + \varepsilon_t^Y \quad (1)$$

This equation can be viewed as the reaction function of central bankers, so that in its simplest Taylor-rule form, the information set would only comprise inflation and output, proxied by industrial production. We augment the set of variables that policymakers are likely to focus on with oil prices, the unemployment rate, the CISS, the Euro Stoxx 50, the 10-year euro area average sovereign bond interest rate, private credit growth, and the euro/dollar exchange rate. For each of the 4 policy instruments, we also augment the information set with the remaining 3 policy instruments, making each of the 4 shocks orthogonal to the other policy instruments.[11] The estimated equation for the ECB rate is given in equation (2) whereas the

[10] Alternatives include Instrumental Variables, but there is no obvious relevant instrument to our knowledge or usual VAR sign-restrictions, but they need strong theoretical priors, while our stance here is to let the data speak.
[11] Note that the shocks are not purely independent by construction. However, except shocks to EL and LTRO, they are actually not statistically correlated.

equations for EL, LTRO and SHMPP are of a similar form except that they are augmented with dummies for unconventional policy announcements:

$$i_t = \alpha + \beta_i i_{t-1} + \sum_{k=0}^{3} \beta_{X,k} X_{t-k} + \sum_{p=0}^{1} \beta_{Z,p} M_{t-p} + \sum_{j=0}^{1} \beta_{M,j} P_{t-j} + \varepsilon_t^i \quad (2)$$

where X_t includes inflation and output, M_t the additional macro variables listed above, and P_t the 3 remaining policy instruments. In contrast with conventional policy actions which are not announced in advance, unconventional policies are first announced and then implemented in the following months. We introduce dummies to control for the effects of unconventional policy announcements and so identify unconventional monetary shocks exogenous to anticipation effects. The estimation sample period starts in March 2006 to obtain residuals on the sample period studied: June 2007 - October 2014. Table B in the appendix reports the output of the estimation of equation (2) for the four policy instruments. The contribution of the systematic response to the variables in vectors X, M and P explains 99.7, 98.9, 98.2 and 99.8% of the variance of the ECB rate, excess liquidity, LTROs and SHMPP respectively. The unexplained components, the ε_t^Y residuals (plotted in Figure 2), are considered as the aggregate policy shocks implemented by the ECB. We introduce them in the country-specific structural VARs, which in turn enable us to derive ECB policy shocks that are also exogenous to country-specific and market-specific macroeconomic developments.

Properties of our series of shocks makes the identification approach relevant: residuals are not auto correlated (Table C displays outcomes of the Cumby-Huizinga test), they are unpredictable from macro data over the last 3 or 6 months (Table D shows p-values of a F-test), they have a zero mean and are not correlated together except excess liquidity and LTRO shocks (Table E provides descriptive statistics and correlations of the estimated shock series)[12].

5. The Effects of Conventional and Unconventional Monetary Policies

5.1. A Structural VAR Model

A structural VAR model is used to decompose the aggregate ECB policy shocks into country-specific and market-specific mutually orthogonal components with a structural economic interpretation. We augment a standard VAR for monetary policy analysis including industrial production (IP), inflation (CPI), and (shock to) the conventional policy instrument with the three other aggregate ECB policy shocks, a proxy for bond issuance/credit demand as discussed in section 3 (*mc_d*), new loans' interest rates (*mc_r*) and volumes (*mc_v*) for each market (*m*) and country (*c*). We also include as exogenous contemporaneous variables in the estimation oil prices, the CISS and domestic stock market indices in the vector F_t. For each market, let $Z_t = [IP_t, CPI_t, mc\_d_t, mc\_v_t, mc\_r_t, \varepsilon_t^{SHMPP}, \varepsilon_t^{LTRO}, \varepsilon_t^{EL}, \varepsilon_t^{ECBrate}]'$ represent the (*9* x *1*) vector that contains the endogenous variables at date *t*:

$$AZ_t = a + B \sum_{k=0}^{3} Z_{t-k} + CF_t + DE_t \quad (3)$$

where b_{ij} in the *B* matrix are *(k x 1)* vectors, *F* is the vector comprising the three exogenous contemporaneous variables, *C* their associated parameters, and:

[12] EL and LTRO share similar objectives.

$$A = I_9 \quad (4) \qquad \text{and} \qquad B = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} & b_{16} & b_{17} & b_{18} & b_{19} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} & b_{26} & b_{27} & b_{28} & b_{29} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} & b_{36} & b_{37} & b_{38} & b_{39} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} & \mathbf{b_{46}} & \mathbf{b_{47}} & \mathbf{b_{48}} & \mathbf{b_{49}} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} & \mathbf{b_{56}} & \mathbf{b_{57}} & \mathbf{b_{58}} & \mathbf{b_{59}} \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & b_{66} & b_{67} & b_{68} & \mathbf{b_{69}} \\ b_{71} & b_{72} & b_{73} & b_{74} & b_{75} & b_{76} & b_{77} & b_{78} & \mathbf{b_{79}} \\ b_{81} & b_{82} & b_{83} & b_{84} & b_{85} & b_{86} & b_{87} & b_{88} & \mathbf{b_{89}} \\ b_{91} & b_{92} & b_{93} & b_{94} & b_{95} & \mathbf{b_{96}} & \mathbf{b_{97}} & \mathbf{b_{98}} & b_{99} \end{bmatrix} \quad (5)$$

The reduced-form errors E_t = [e_t^{IP}, e_t^{CPI}, $e_t^{mc\_d}$, $e_t^{mc\_v}$, $e_t^{mc\_r}$, e_t^{SHMPP}, e_t^{LTRO}, e_t^{EL}, $e_t^{ECBrate}$]' combine the structural innovation to a given variable with the contemporaneous responses to the other variables. The recursive identification assumption postulates that the structural errors are independent, and that reduced-form errors are related to structural errors through a lower triangular *D* matrix. This means that the covariance between the reduced-form errors is attributed to the structural error of the variable ordered previously in Z_t, and that the structural error is uncorrelated to the reduced-form errors of the preceding variables. This recursive identification therefore depends on the ordering of the variables in the Z_t vector.

In our benchmark VAR, we assume that shifts in industrial production and inflation produce a contemporaneous change in policy variables and in market prices and volumes. The latter two also react contemporaneously to policy variables, while by construction policy variables react to innovations to market prices and volumes only with a lag. This is consistent with the institutional framework and decision-making constraints which, at a monthly frequency, introduce delays in the monetary reaction to changes on financial and loans markets. Concerning the relative position of the policy variables, we assume that the unconventional interventions react with a lag to the ECB interest rate consistently with the prevalence of the conventional instrument over unconventional ones.

The structural VAR analysis is performed with $k = 3$ lags, and with a small sample estimator because the number of observations is small. The variance-covariance matrix is estimated with a small-sample degrees-of-freedom adjustment: the small-sample divisor used is *1/(T-m)* instead of the maximum likelihood divisor *1/T*, where *T* is the sample size and *m* the average number of parameters in each of the equations. All the eigenvalues lie inside the unit circle, so our VAR model satisfies the stability condition to interpret impulse–response functions.

Figure 2 confronts ECB aggregate policy shocks, as discussed in section 4, with an alternative identification approach of country- and market-specific ECB policy shocks. The latter stem from the estimation of the model described in equation (3) where $\bar{Z}_t$ = [IP_t, CPI_t, mc_d_t, mc_v_t, mc_r_t, $SHMPP_t$, $LTRO_t$, EL_t, $ECBrate_t$]' substitutes for vector Z_t. The differences among the country- and market-specific ECB policy shocks are substantial; they show that this alternative identification approach is not suitable to an investigation into the country- and market-specific channels of transmission of a *common* monetary policy shock. Moreover, the differences between, on the one hand aggregate and, on the other hand, country- and market-specific policy shocks show that the former identification approach gives unique outcomes; it gives support to the choice of identifying aggregate policy shocks as in section 4.

5.2. Impulse Response Functions

Figure 3 plots the impulse responses of interest rates to a one-S.D. innovation (a 0.08 percentage point increase) in the ECB interest rate, for Germany, France, Italy and Spain (rows) and for sovereign bonds at 6-month, 5-year and 10-year horizons, loans to NFC, and housing loans to households (columns). The pass-through from the ECB interest rate to market rates is significant and positive as expected for all countries on the markets for loans to NFC and loans to households, though it is a bit less significant on the latter than on the former type of market. The impacts on the NFC markets last 6 months in Germany, France and Italy and a bit longer in Spain. The length of impact is also close to 6 months on the market for housing loans, except in France where it last beyond 12 months. In contrast with the former markets, the pass-through on sovereign-debt markets is less significant and an opposition between Northern and Southern countries of the Euro area emerges: there is no pass-through in Germany and France, whereas it is positive and significant in Italy, at the 3 different maturities, and in Spain, temporarily at the 6-month maturity. Figure 4 plots the impulse responses of volumes to a one-S.D. innovation in the ECB interest rate. We would expect volumes to be negatively correlated to an increase in the ECB interest rate but we obtain mixed results. First, there is very scarce and temporary evidence of a pass-through. Debt at 10-year horizon in Germany, debt at 6-month horizon in Italy and NFC and housing loans in Spain show short-lived evidence. Second, the pass-through is very low, except for NFC loans in Spain where the elasticity is close to 2. Third, there are also unexpected positive impacts, in Italy and France.

Figure 5 presents the impulse responses of interest rates to a one-S.D. innovation (a 0.16 percentage point increase in terms of Euro Area GDP) in excess liquidity. There is evidence of a pass-through from unconventional policies to interest rates over our sample in Germany on the market for housing loans and in Spain on the market for NFC loans. Both last more than 6 months. In Italy, there is no such pass-through. In France, one can interpret the (statistically weak) positive response of interest rates on sovereign bonds at 10-year horizon as a portfolio balance effect. Excess liquidity would induce demand for high-yield bonds. Figure 6, which plots the impulse responses of volumes to a one-S.D. innovation in excess liquidity, shows that French public debt at 10-year horizon reacts positively and temporarily to the shock on EL. In Germany and Italy, there is no evidence of a pass-through from EL to volumes. In contrast, Spain shows evidence of a relatively strong pass-through for NFC loans, with a maximum elasticity above unity.

Among the four countries studied, Spain once again emerges as the most beneficial one of LTRO measures, but only in terms of market rates. Figure 7 presents the impulse responses of interest rates to a one-S.D. innovation (a 0.32 percentage point increase in terms of Euro Area GDP) in LTROs. The impact on the market for NFC loans in Spain is significant, negative and lasting 6 months. The same impact is weaker in Germany, where evidence also points to temporary and significant rises in interest rates, on the 10-year bond market and on the market for housing loans. In France and Italy, there is no pass-through from LTRO on interest rates. Figure 8 plots the impulse responses of volumes to a one-S.D. innovation in LTROs, and does not show any evidence of a pass-through. LTRO measures thus have had only limited impact in the Euro area.

Figure 9 presents the impulse responses of interest rates to a one-S.D. innovation (a 0.04 percentage point increase in terms of Euro Area GDP) in SHMPP. The shock introduces a discrepancy in impact between, on the one hand, Germany and France, and on the other hand, Italy and Spain. In the former countries, we find a statistically weak but positive

impact of SHMPP on interest rates, for sovereign bonds at 6-month horizon and NFC loans in Germany, and for sovereign bonds at 5 and 10-year horizon in France. In the latter countries, IRFs show evidence of statistically significant negative impacts on sovereign bond markets, at 6-month and 5-year horizon in Italy and 6-month and 10-year horizon in Spain. This discrepancy in impact can be interpreted as reflecting the discrepancy in context: peripheral countries, like Spain or Italy, have been hit by the sovereign debt crisis, with growing spreads *vis-à-vis* the German Bund, whereas core countries, like Germany and France, have to some extent benefited from the crisis via their role of safe havens, evidenced by a negative trend in their bond yields. Evidence about the impact of the same policy on volumes is weaker than the impact on interest rates. Figure 10 plots the impulse responses of volumes to a one-S.D. innovation in SHMPP. In Italy and Spain, there is some evidence of an increase in volumes on sovereign bond markets, but it is very short and weakly significant. In both countries, weak evidence also points to a different reaction of the housing loans markets: loans increase in Italy and decrease in Spain. In Germany, SHMPP has a short negative impact on volumes on public debt at 6-month horizon whereas in France, the sovereign bond market at 5-year horizon reacts positively in the short run.

In summary, IRFs show that the conventional interest rate channel has been at work in the 4 countries, but conventional monetary policy has only had a weak effect on volumes. IRFs for unconventional policies show that they have had quite different effects. It gives support to the break-up of unconventional policies between excess liquidity, LTRO and SHMPP. Excess liquidity has had a pass-through on interest rates in Germany and Spain, and on volumes in France and Spain. In comparison, the impacts of LTRO measures have been weaker and concentrated exclusively on interest rates. In contrast, SHMPP measures which were targeted towards peripheral countries have been effective at modifying interest rates in these countries and, to a lower extent, volumes.

In the following, we discuss about the relevance of our identification approach and of main results. First, we discuss about the introduction of sign restrictions and, second, about restrictions on the linkages between conventional and unconventional policies. Third, we show results stemming from a unique monetary policy stance, mixing the conventional and the 3 unconventional measures.

5.3. Isolating the direct effect of policy variables on rates and volumes

The structural VAR model already introduces short-run restrictions, with the Cholesky decomposition in the D matrix of equation (3), but it does not introduce sign restrictions. Sign restrictions in VAR estimations of monetary policy channels of transmission have been common in the literature since Faust (1998). For instance, Uhlig (2005) argues that sign restrictions help reconsider the impact of monetary policy shocks on output. Although Faust (1998) imposes sign restrictions on impact, Uhlig (2005) extends sign restrictions to several periods after the monetary shock and concludes that monetary shocks in the US have no clear-cut impact on output. The relevance of sign restrictions can be assessed by the estimates of the direct effect of policy variables on market rates and volumes from equation (3). They consist in the country- and market-specific estimated coefficients b_{46}-b_{49} (impacts of policy variables on volumes) and b_{56}-b_{59} (impacts of policy variables on interest rates) in the B matrix. By construction, interest rates and volumes cannot respond on impact (i.e. contemporaneously) to shocks to the policy variables since they are ordered before in the Z vector.

Results are reported in Table 2. They show that the sum of coefficients is in most cases not significantly different from zero. Consequently, the introduction of sign restrictions in the structural VAR discussed in this paper would not fit the data. The evaluation of the reliability of sign restrictions thus supports the choice of not introducing such restrictions.

5.4. Isolating the cross-effects of policy variables

The empirical literature has pointed out that unconventional monetary policy measures may impact directly on conventional policy (see, e.g. Krishnamurthy and Vissing-Jorgensen, 2011). The introduction of some restrictions in the direct relationships between different types of monetary policy must be discussed. The reliability of such restrictions can be assessed via the country- and market-specific estimated coefficients b_{69}-b_{89} (impacts of ECB rate on unconventional policy variables) and b_{96}-b_{98} (impacts of unconventional policy variables on ECB rate) in the *B* matrix of equation (3).

Results reported in Table 3 show a very clear picture. A shock to the conventional tool of monetary policy has no statistically significant impact on unconventional policies, whatever the latter is, whatever the market and whatever the country. Regarding the direct effect of shocks to unconventional tools on the ECB interest rates, there are only a few instances where the former complements the latter, 2 related to excess liquidity, 5 related to SMHPP and none related to LTRO.

5.5. Squaring the preceding results with a unique policy stance variable

Although our results point to different outcomes across the different monetary policy instruments, a simpler model in which all instruments are summarised into a single one is worth investigating. If this model gives similar results overall – an effective interest rate channel and an impact of ECB monetary policy on some specific market's volumes - it will weaken the approach of this paper to deal with a detailed description of ECB monetary policies.

The new environment of monetary policy, with the growing importance of unconventional measures because of the zero-lower bond on the conventional instrument, has urged research on the assessment of the overall monetary stance and led to the computations of "shadow rates" as single measure of conventional and unconventional policies. Wu and Xia (forthcoming) have used their shadow rate to gauge the macroeconomic effects of US monetary policies during the crisis. We first identify shocks to their shadow rate for the Euro area using the same method as for the previous policy measures, so estimating equation (2) without the *P* vector. Second we measure the impact of ECB monetary policy on the 20 markets under study. Estimates stem from equation (3) in which the shadow rate substitutes for the 4 policy variables, so the model is a 5-equation VAR.

Results reported in Figures 11 and 12 show that contrary to our former results, the interest rate channel vanishes. The only exception is the market for loans to NFC in Spain. As for the impact of ECB monetary policy on volumes, most impulse responses are not statistically significant. When they are, they give counter-intuitive outcomes: volumes increase (temporarily) in Germany (NFC loans) and Italy (5-year sovereign bonds and NFC loans). We check that these outcomes are not sensitive to an identification approach without sign restrictions. Results reported in table 4 show that the shadow rate has no direct impact (at the 1% level) either on interest rates or on volumes in all markets studied. Sign restrictions would not fit the data.

In summary, the use of an overall stance of ECB monetary policy does not give the same results as with detailed stances of monetary policies, which we interpret as a support towards the approach we follow.

6. Conclusion

This paper aims at establishing the effect of a fine decomposition of conventional and unconventional ECB monetary policies on both interest rates and volumes in the four largest economies of the Eurozone during the global financial crisis. We first identify series of ECB policy shocks, the main refinancing operation interest rate for conventional policy and on amounts spent for each unconventional policy as stated in the ECB's Weekly Financial Statements, at the euro area aggregated level, by removing the systematic component of each series. Second, we include these four estimated series of interest rate and unconventional policy shocks in country-specific structural VARs with five macro variables.

The pass-through from the ECB rate to interest rates has been effective, consistently with the existing literature, whereas the transmission mechanism of the ECB rate to volumes has been weak. Unconventional policies have had uneven effects. It gives support to the break-up of unconventional policies between excess liquidity, LTRO and SHMPP. Excess liquidity has an effect on interest rates in Germany and Spain, and on volumes in France and Spain. In comparison, the impacts of LTRO measures are weaker and concentrated exclusively on interest rates. In contrast, SHMPP measures which were targeted towards peripheral countries have been effective at modifying interest rates in these countries and, to a lower extent, volumes.

This paper focuses on the effects of ECB monetary policies on low-frequency interest rates and volumes. Further research may be directed towards a cross investigation of higher-frequency event-studies allowing to capture the confidence and signalling channels with lower-frequency analysis allowing to capture the channels of transmission to macro variables. It would permit to estimate in a single framework both the effects of monetary policy actions and announcements.

References

Abbassi, P. and T. Linzert (2011), "The effectiveness of monetary policy in steering money market rates during the recent financial crisis", *European Central Bank Working Paper Series*, 1328.

Altavilla, C. And D. Gianonne (2014), "The effectiveness of non-standard monetary policy measures: evidence from survey data", *Working Papers ECARES*, 2014-30.

Altavilla, C., D. Giannone and M. Lenza (2014). "The Financial and Macroeconomic Effects of the OMT Announcements", *Working Paper ECARES*, 2014-31.

Andrade, P., C. Cahn, H. Fraisse and J.S. Mésonnier (2015). "Can the Provision of Long-Term Liquidity Help to Avoid a Credit Crunch? Evidence from the Eurosystem's LTROs", mimeo Banque de France.

Andries, N. and S. Lecarpentier-Moyal (2012), "La crise financière a-t-elle affecté la transmission de la politique monétaire sur les prêts aux sociétés non financières dans les pays de la zone euro ?", Paper presented at *Congrès de l'AFSE 2012*.

Aristei, D. and M. Gallo (2012), "Interest Rate Pass-Through in the Euro Area during the Financial Crisis: a Multivariate Regime-Switching Approach", *Università di Perugia, Quaderni del Dipartimento di Economia, Finanza e Statistica*, 107/2012.

Bachmann, R. and E. Sims (2012), "Confidence and the transmission of government spending shocks", *Journal of Monetary Economics*, 59, 235–249.

Beirne, J. et al. (2011), "The impact of the Eurosystem's Covered Bond Purchase Programme on the primary and secondary markets", *European Central Bank Occasional Paper Series*, 122.

Belke, A., J. Beckmann and F. Verheyen (2012), "Interest Rate Pass-Through in the EMU: New Evidence from Nonlinear Cointegration Techniques for Fully Harmonized Data", *Discussion Papers of DIW Berlin*, 1223.

Bernanke, B., and A.S. Blinder (1988). "Credit, Money and Aggregate Demand", *American Economic Review*, 78(2), 435-39, May.

Bernanke, B. and A. Blinder (1992), "The Federal Funds Rate and the Channels of Monetary Transmission", *American Economic Review*, 82(4), 901-921.

Bernanke, B., V. Reinhart and B. Sack (2004), „Monetary Policy Alternatives at the Zero Bound: An Empirical Assessment", *Brookings Papers on Economic Activity*, 2004(2), 1-78.

Blot, C. and F. Labondance (2013), "Business lending rate pass-through in the Eurozone: monetary policy transmission before and after the financial crash", *Economics Bulletin*, 33(2), 973-985.

Boeckxx, J., M. Dossche and G. Peersman (2014), "Effectiveness and transmission of the ECB's balance sheet policies", *CESifo Working Paper Series*, No. 4907, June.

Bonaccorsi di Patti, E. and E. Sette (2012), "Bank balance sheets and the transmission of financial shocks to borrowers: evidence from the 2007-2008 crisis", *Bank of Italy Economic Working Papers*, 848.

von Borstel, J., S. Eickmeier and L. Krippner (2015), "The interest rate pass-through in the euro area during the sovereign debt crisis", *CAMA Working Paper*, 15/2015.

Butt, N., R. Churm, M. McMahon, A. Morotz and J. Schanz (2014). "QE and the bank lending channel in the United Kingdom", *Bank of England Working Paper*, 511.

Chatelain, J.B., M. Ehrmann, A. Generale, J. Martínez-Pagés, P. Vermeulen, and A. Worms (2003), "Monetary Policy Transmission in the Euro area: New Evidence from Micro Data on Firms and Banks", *Journal of the European Economic Association*, 1(2-3), 731-742.

Cordemans, N. and M. de Sola Perea (2011), "Central bank rates, market rates and retail bank rates in the euro area in the context of the recent crisis", *National Bank of Belgium Economic Review,* (1), 27-52.

Darracq-Paries, M. and R. De Santis (2013), "A Non-Standard Monetary Policy Shock: the ECB's 3-year LTROs and the shift in credit supply", *European Central Bank Working Paper Series*, 1508.

De Bondt, G. (2005), "Interest Rate Pass-Through: Empirical Results for the Euro Area", *German Economic Review*, 6(1), 37-78.

Degryse, H. and M. Donnay (2001), "Bank Lending Rate Pass-Through and Differences in Transmission of a Single EMU Monetary Policy", *Katholieke Universiteit Leuven Center for Economic Studies – Discussion Papers*, ces0117.

De Santis, R. and P. Surico (2013), "Bank Lending and Monetary Transmission in the Euro Area", *Economic Policy*, 28, 423–457.

Faust, J. (1998). "The robustness of identified VAR conclusions about money". *Carnegie-Rochester Conference Series in Public Policy* 49, 207–244.

Fleming, M., W. Hrung and F. Keane (2010), "Repo market effects of the term securities lending facility", *FRB of New York Staff Report*, 426.

Gambacorta, L. and D. Marques-Ibanez (2011), "The bank lending channel: Lessons from the crisis", *BIS Working Papers*, 345.

Giannone, M. Lenza, H. Pill and L. Reichlin (2012). "The ECB and the Interbank Market", *Economic Journal*, 122(564), F467-F486.

Gigineishvili, N. (2011), "Determinants of Interest Rate Pass-Through: Do Macroeconomic Conditions and Financial Market Structure Matter?", *IMF Working Paper*, 11(176).

Ghysels, E., J. Idier, S. Manganelli and O. Vergote (2014). « A high frequency assessment of the ECB Securities Markets Programme", *ECB Working Paper*, 1642.

Gürkaynak, R.S., and J.H. Wright (2012). "Macroeconomics and the Term Structure." *Journal of Economic Literature*, 50(2), 331-67.

Hrung, W. and J. Seligman (2011), "Responses to the Financial Crisis, Treasury Debt, and the Impact on Short-Term Money Markets", *FRB of New York Staff Reports*, 481.

Joyce, M., A. Lasaosa, I. Stevens, and M. Tong (2011). "The financial market impact of quantitative easing", *International Journal of Central Banking*, 7, 113-161.

Joyce, M. (2012). "Quantitative easing and other unconventional monetary policies: Bank of England conference summary," *Bank of England Quarterly Bulletin*, 52, 48–56.

Karagiannis, S., Y. Panagopoulos and P. Vlamis (2010), "Interest rate pass-through in Europe and the US: Monetary policy after the financial crisis", *Journal of Policy Modeling*, 32, 323-338.

Kleimeier, S. and H. Sander (2006), "Expected versus unexpected monetary policy impulses and interest rate pass-through in euro-zone retail banking markets", *Journal of Banking and Finance*, 30, 1839-1870.

Krishnamurthy, A. and A. Vissing-Jorgensen (2011), "The effects of quantitative easing on interest rates: channels and implications for policy, *NBER Working Paper Series*, w17555.

Landier, A., D. Sraer and D. Thesmar (2013), "Banks' Exposure to Interest Rate Risk and The Transmission of Monetary Policy", *NBER Working Paper*, n°18857.

Lenza, M., H. Pill and L. Reichlin (2010), "Monetary policy in exceptional times", *Economic Policy*, 25(62), 295-339.

Michaud, F-L. and C. Upper (2008), "What drives interbank rates ? Evidence from the Libor panel", *BIS Quarterly Review*, March.

Panagopoulos, Y., I. Reziti and A. Spiliotis (2010), "Monetary and banking policy transmission through interest rates: an empirical application to the USA, Canada, the UK and the Eurozone", *International Review of Applied Economics*, 24(2), 119-136.

Sorensen, C. and T. Werner (2006), "Bank interest rate pass-through in the Euro area: a cross-country comparison", *European Central Bank Working Paper Series*, 580.

Stroebel, J. and J. Taylor (2009), "Estimated impact of the Fed's mortgage-backed securities purchase program", *NBER Working Paper Series*, w15626.

Szczerbowicz, U. (2015). "The ECB unconventional monetary policies: have they lowered market borrowing costs for banks and governments?", *International Journal of Central Banking*, forthcoming.

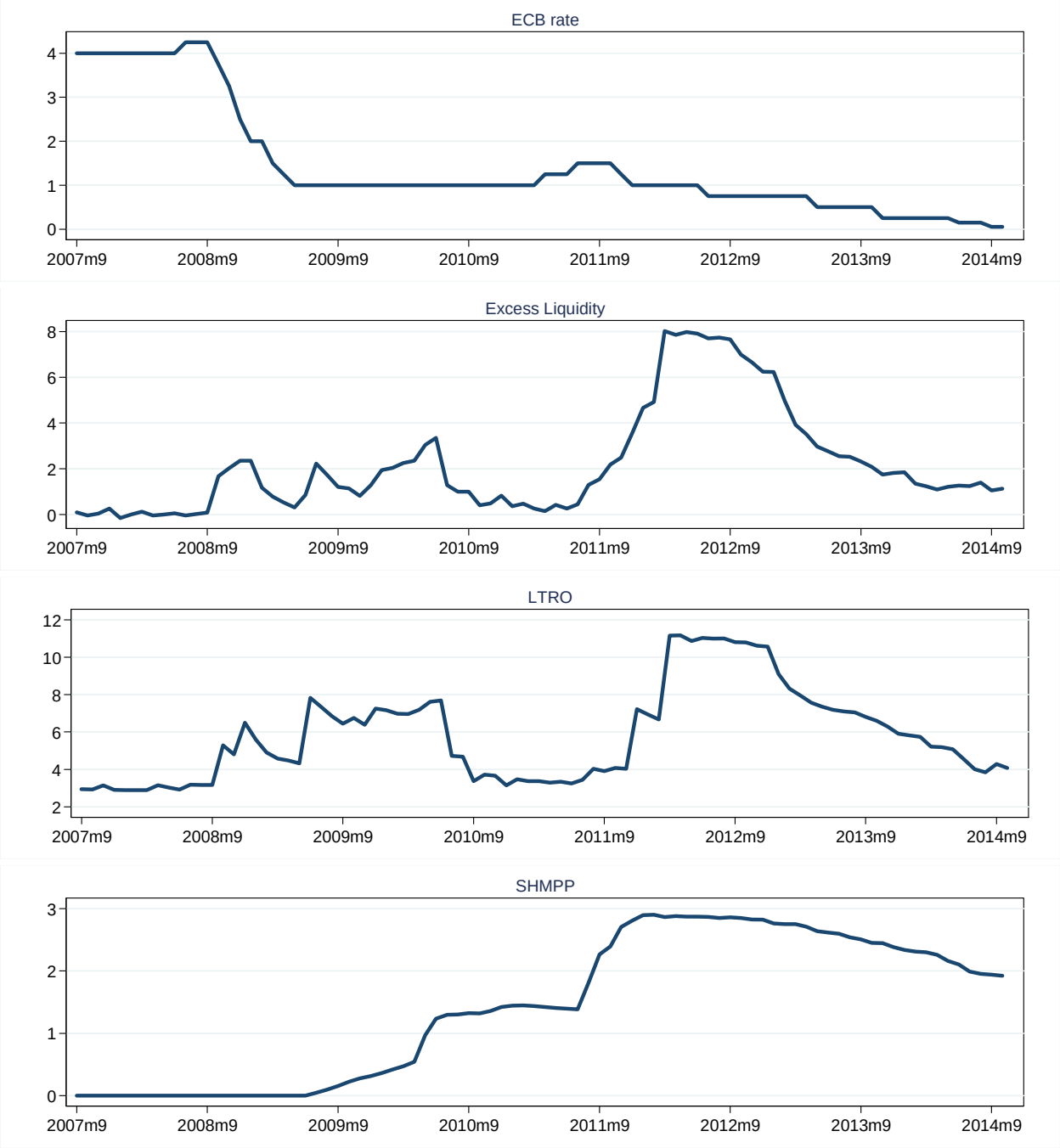
Thornton, D. (2011), "The Effectiveness of Unconventional Monetary Policy: The Term Auction Facility", *Federal Reserve Bank of St. Louis Review*, 93(6), 439-453.

Uhlig, H. (1998). "The robustness of identified VAR conclusions about money. A comment". *Carnegie-Rochester Series in Public Economics* 49, 245–263.

Uhlig, H. (2005). "What are the effects of monetary policy on output? Results from an agnostic identification procedure". *Journal of Monetary Economics,* 52, 2, 381–419.

Wu, J.C. and F.D. Xia (forthcoming), "Measuring the macroeconomic impact of monetary policy at the zero lower bound", *Journal of Money, Credit, and Banking*.

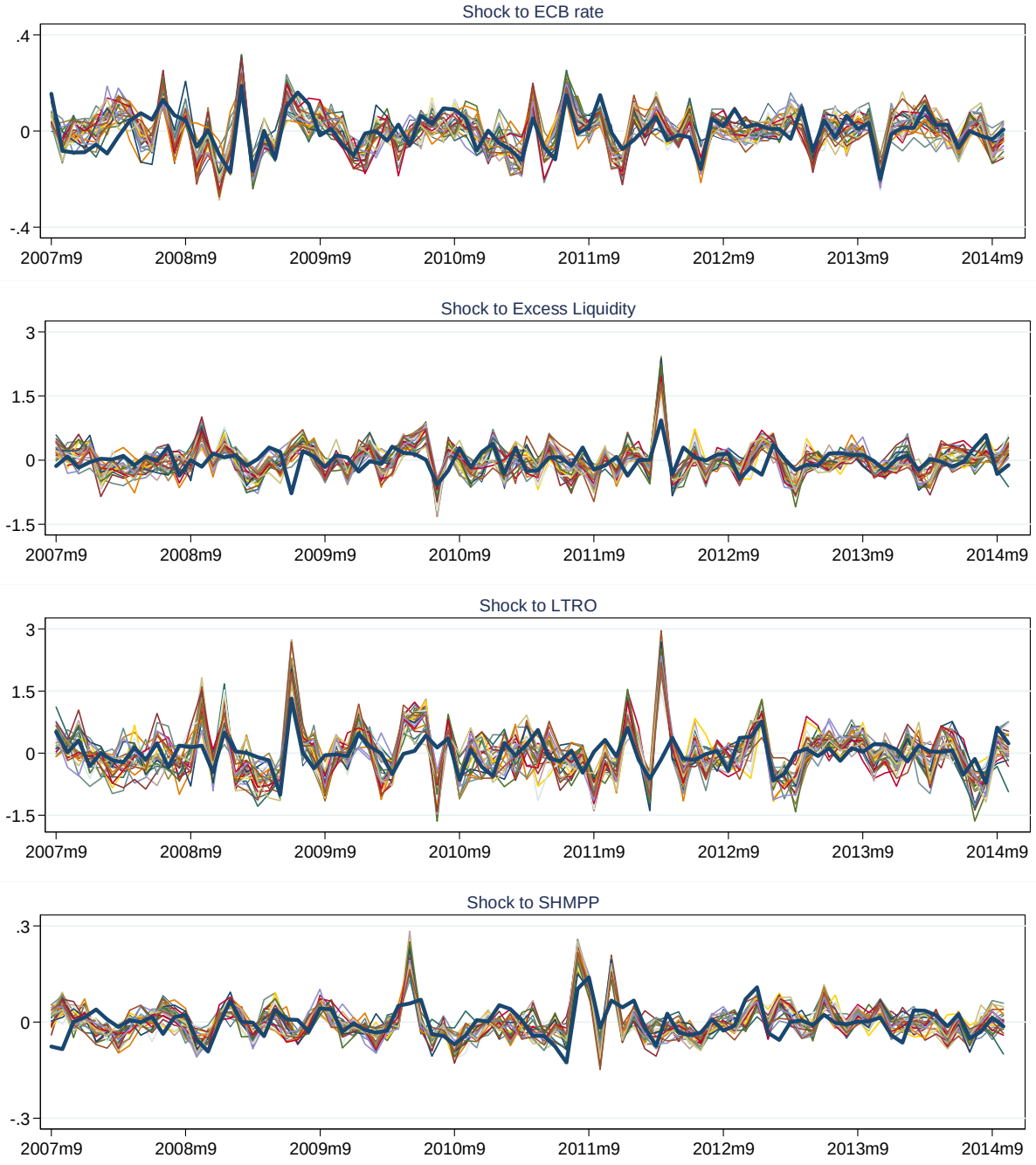
Figure 1: ECB policy instrument time series



Note: The ECB rate is expressed in % while the three unconventional tools are expressed in percentage of EA GDP.

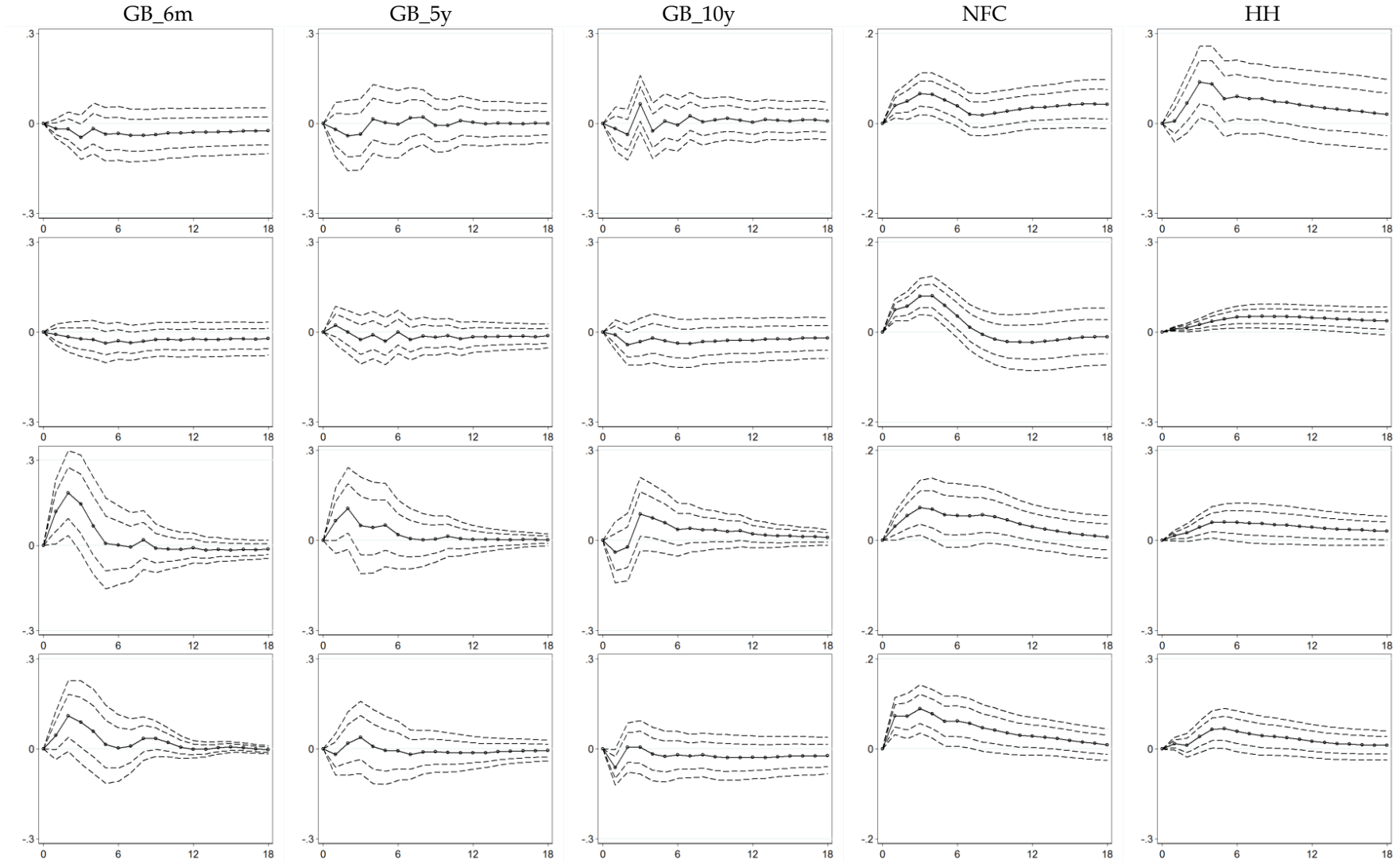
.

Figure 2: Euro Area aggregate policy shocks and **country- and market-specific shocks**



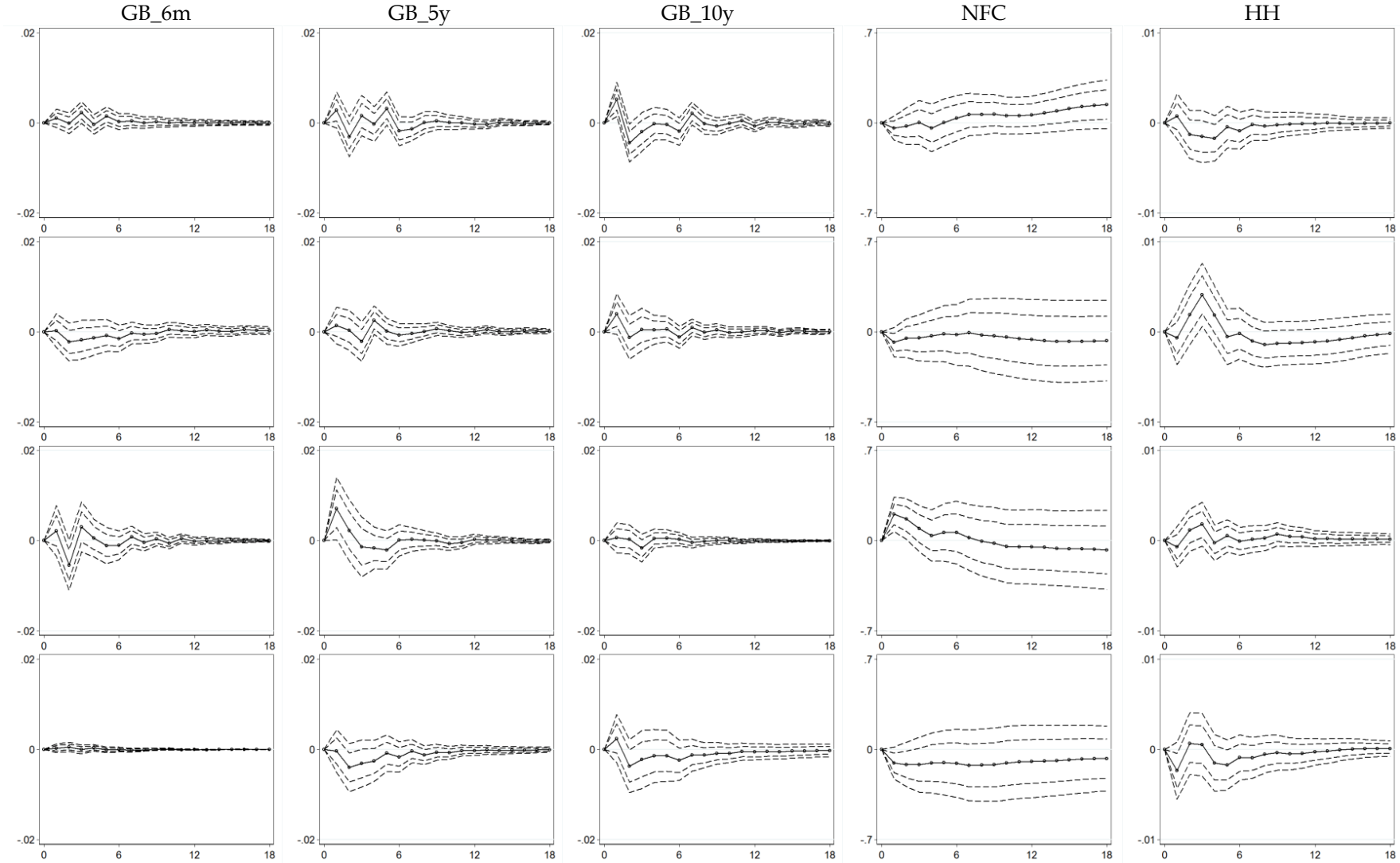
Note: Thick lines plot the Euro Area aggregate policy shocks estimated in section 4 while thin lines plot the country- and market-specific shocks estimated with equation (4) but including ECB and unconventional variables in the vector of endogenous variables $\bar{Z}_t$ in section 5.1. Since the analysis is performed for 4 countries and 5 markets, there are 20 series of country- and market-specific shocks plotted.

Figure 3: Response of interest rates to a positive ECB interest rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



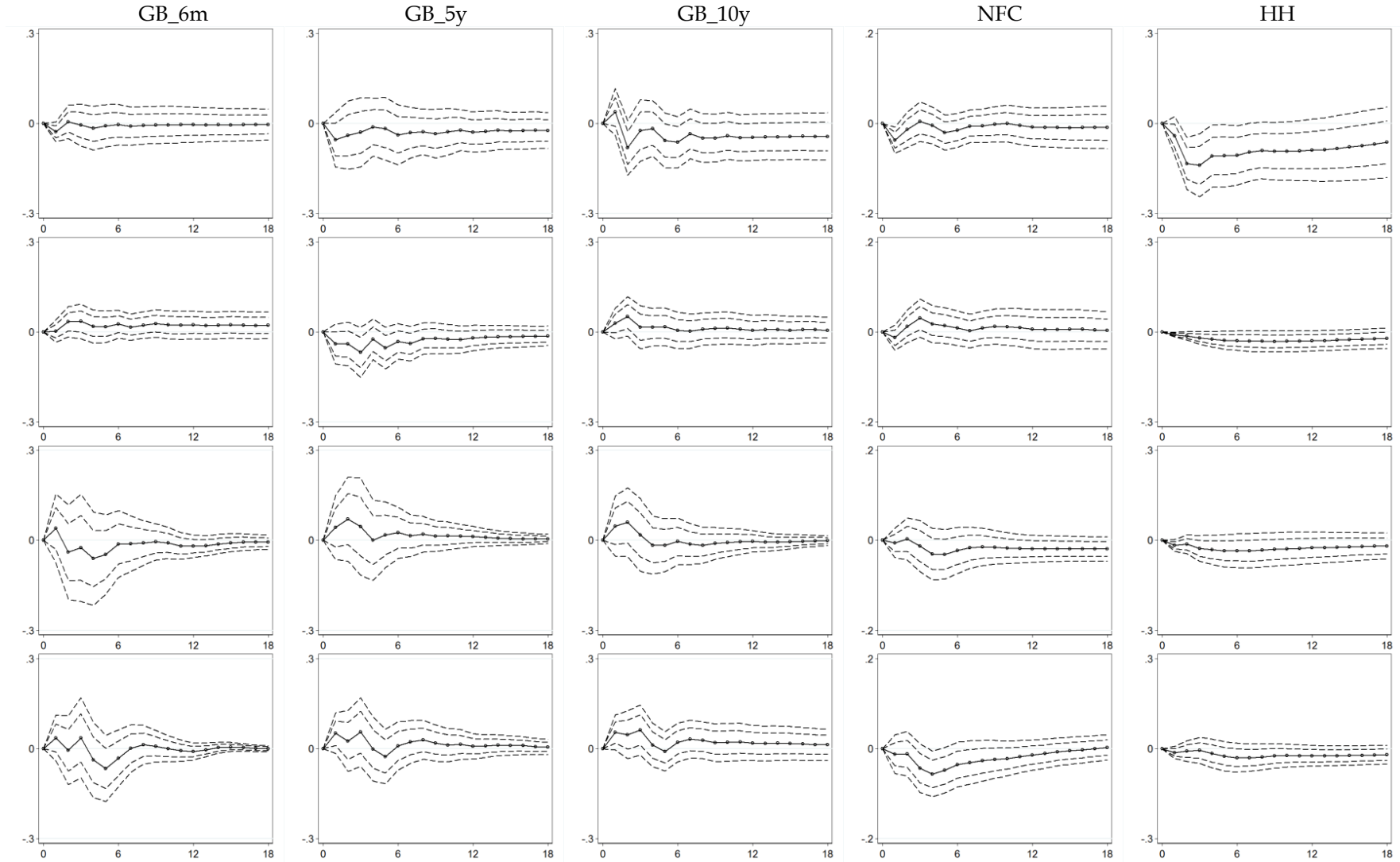
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 4: Response of volumes to a positive ECB interest rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



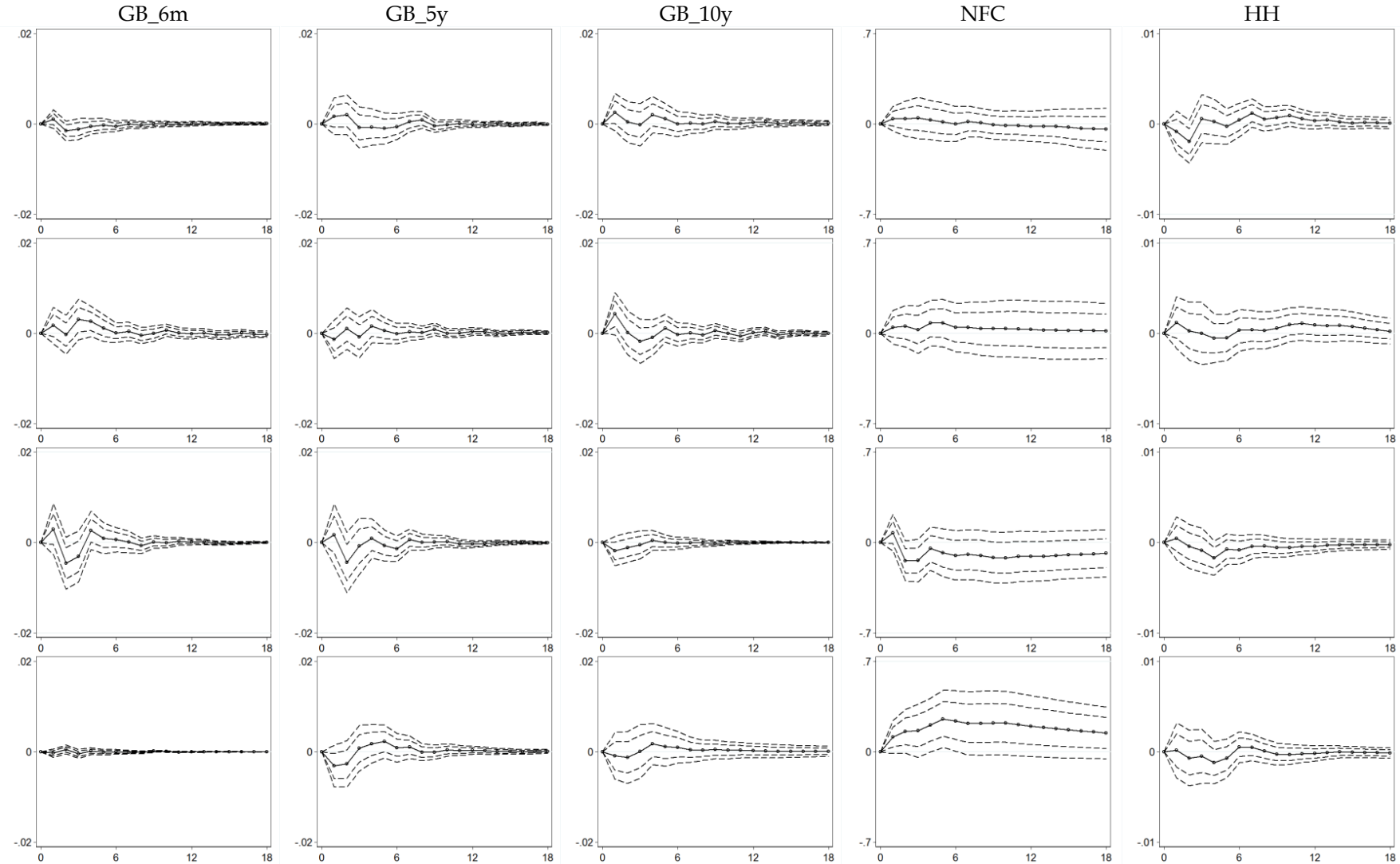
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 5: Response of interest rates to a positive Excess Liquidity shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



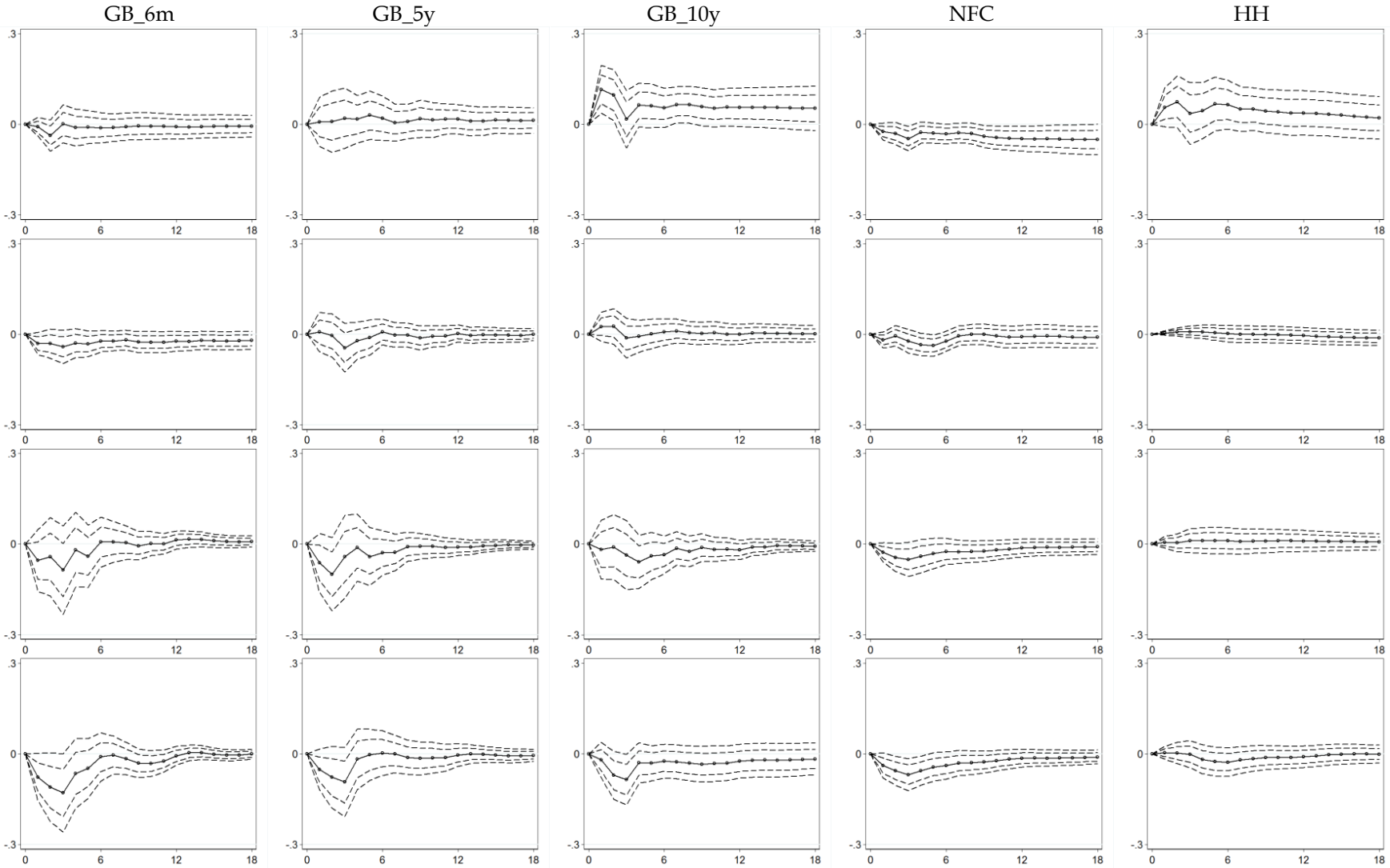
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 6: Response of volumes to a positive Excess Liquidity shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



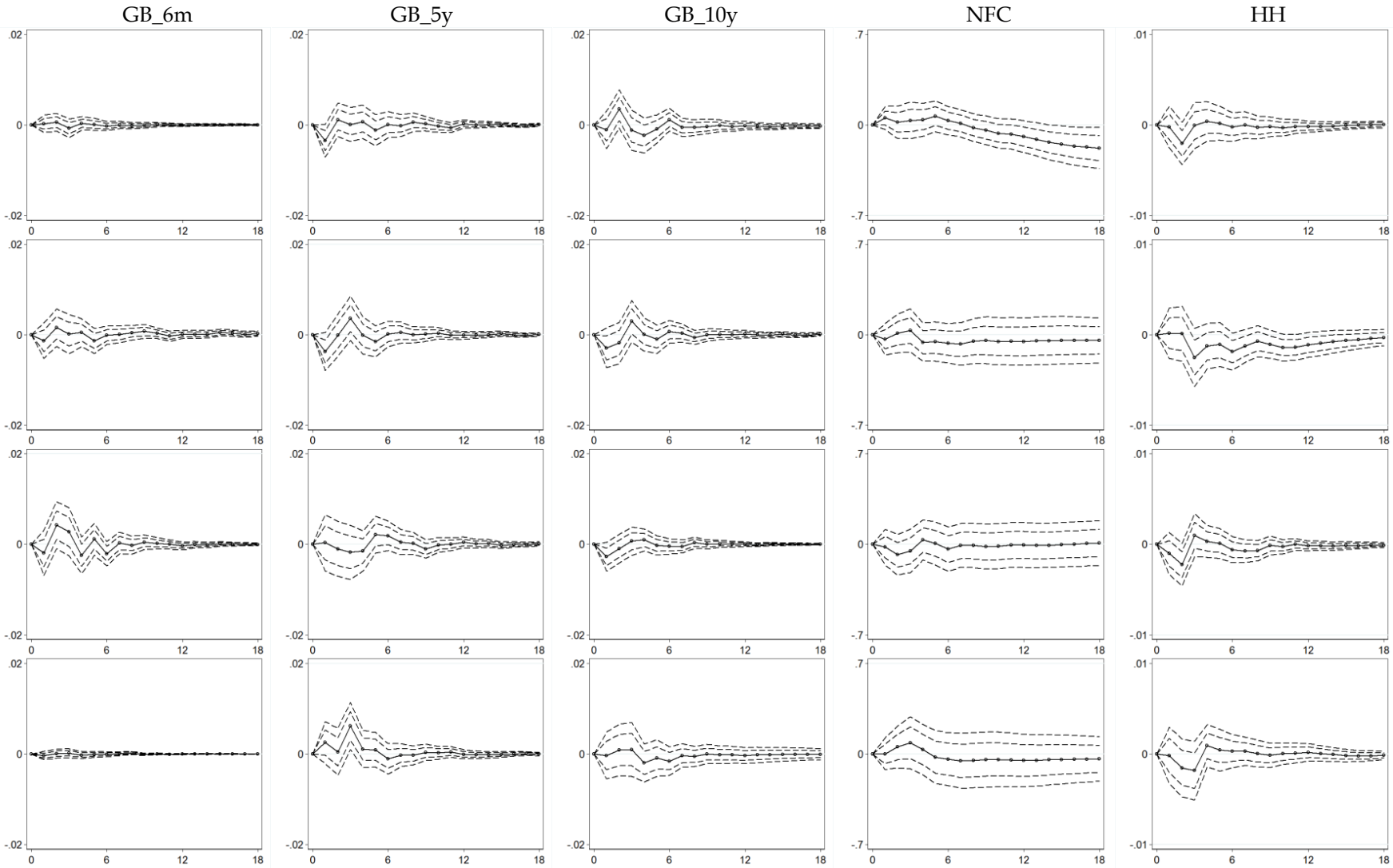
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 7: Response of interest rates to a positive LTRO shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



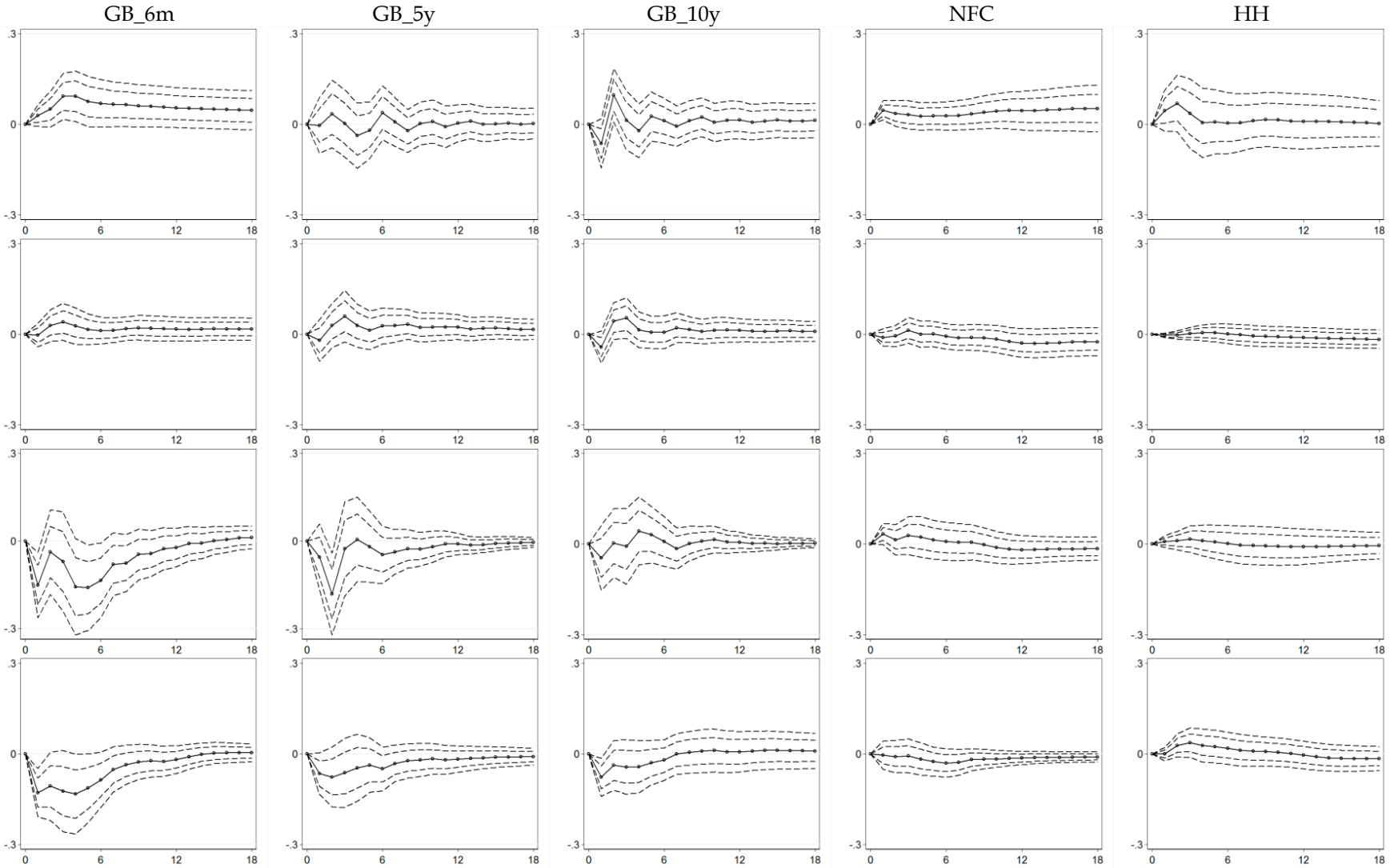
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 8: Response of volumes to a positive LTRO shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



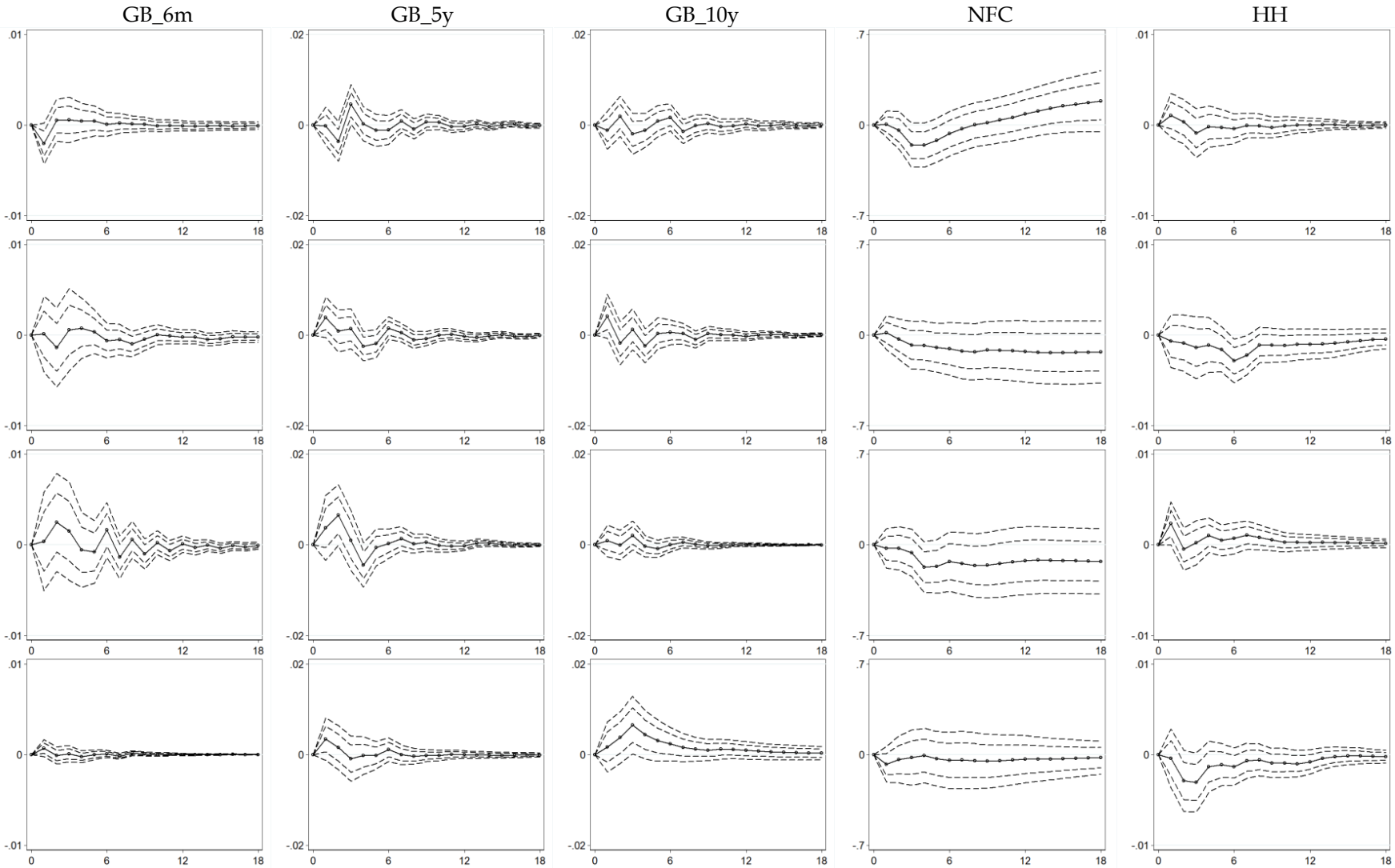
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 9: Response of interest rates to a positive SHMPP shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



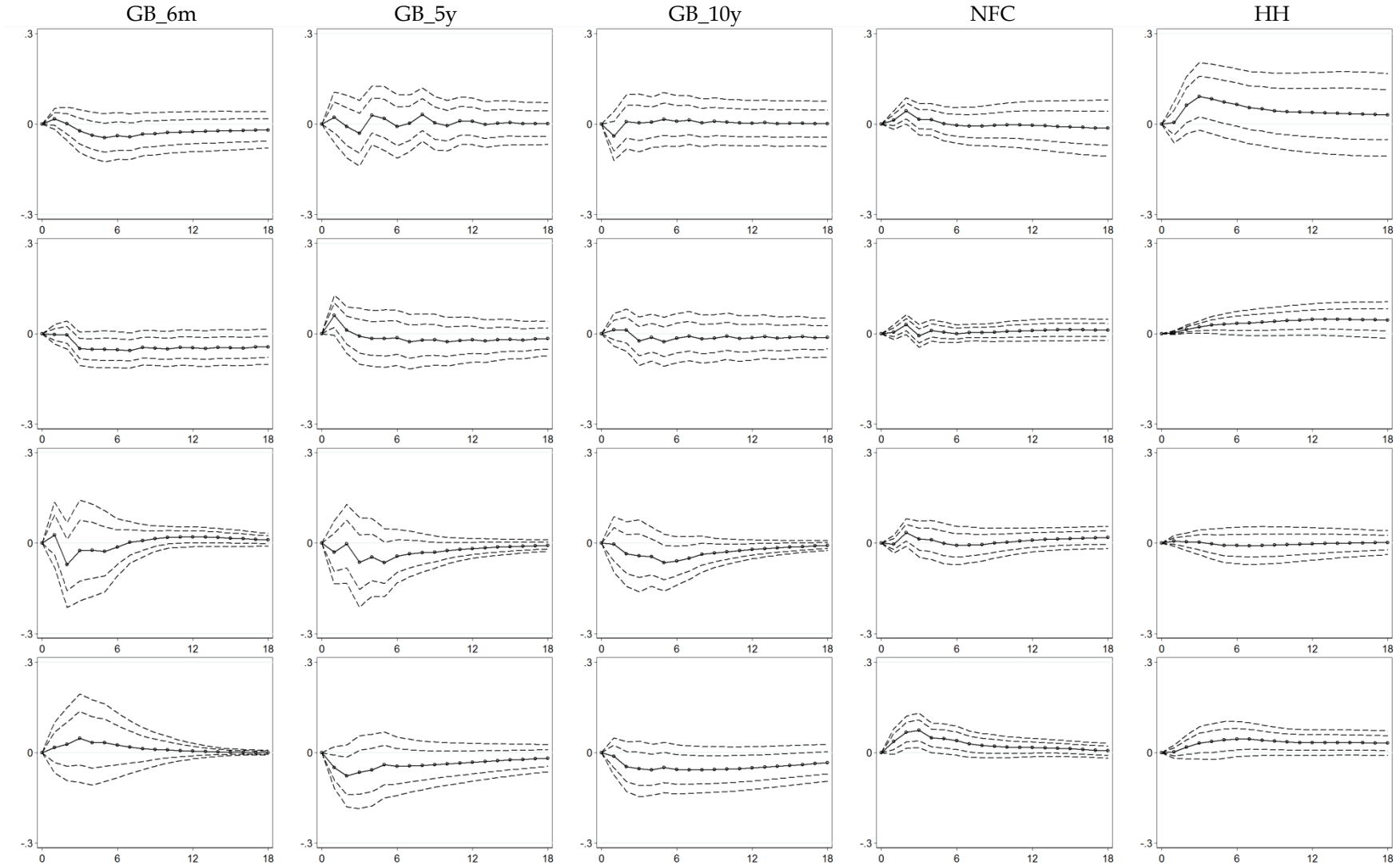
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 10: Response of volumes to a positive SHMPP shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



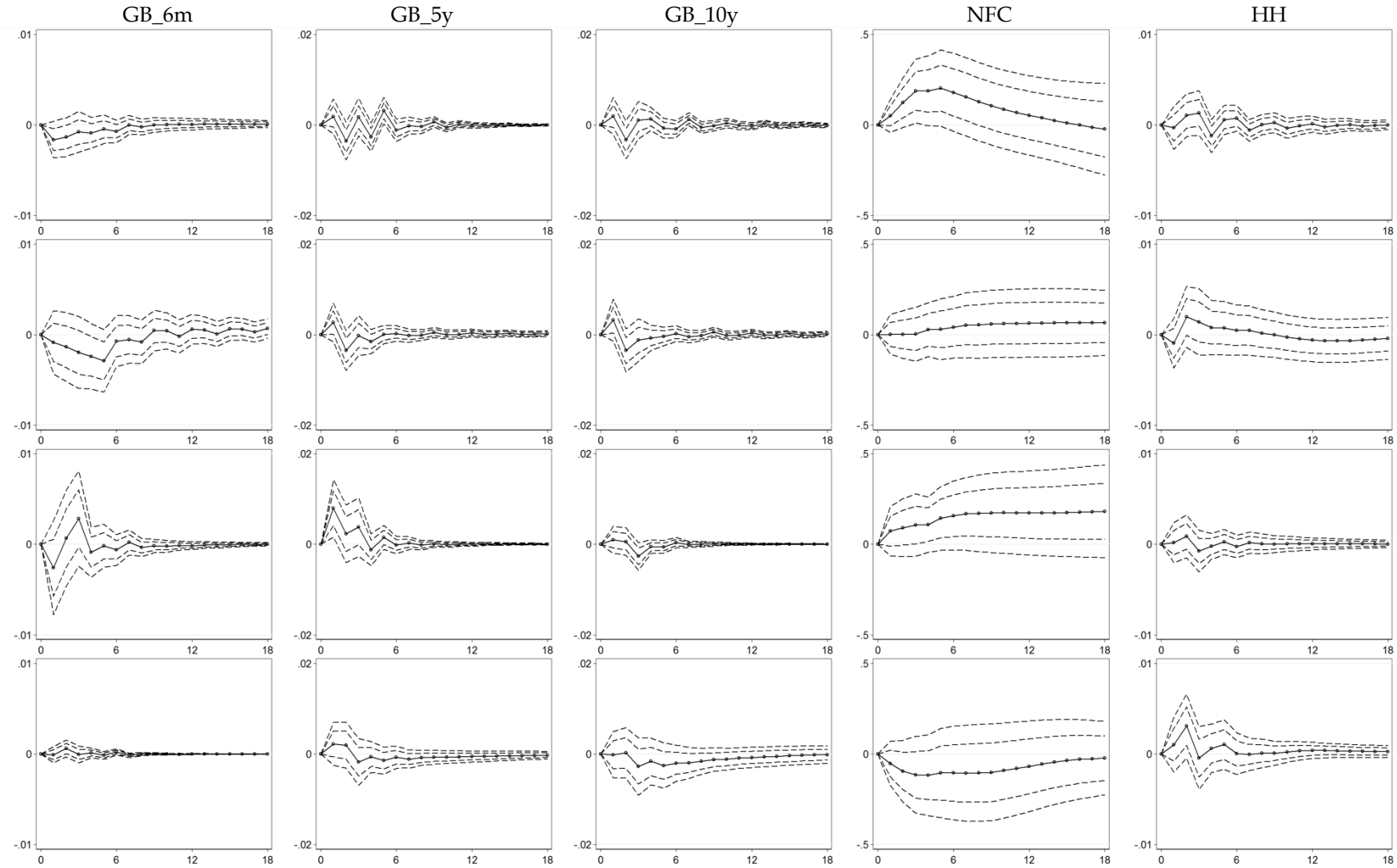
The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 11: Response of interest rates to a positive shadow rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Figure 12: Response of volumes to a positive shadow rate shock in Germany (1st row), France (2nd), Italy (3rd) & Spain (4th)



The impulse response corresponds to the percentage point change in interest rates, in response to a one-S.D. innovation in the ECB interest rate, together with 1 and 2 S.E. confidence band intervals.

Table 2 - Estimates of the direct effect of policy variables on rates and volumes

Effect on interest rates

ECB rate - b_{49}			EL - b_{48}			LTRO - b_{47}			SHMPP - b_{46}		
model	param	se	model	param	se	model	param	se	model	param	se
g_gb_6m	-0.72	[0.41]	g_gb_6m	-0.18	[0.24]	g_gb_6m	-0.14	[0.16]	g_gb_6m	1.49**	[0.74]
g_gb_5y	-0.76	[1.09]	g_gb_5y	-0.60	[0.63]	g_gb_5y	-0.19	[0.43]	g_gb_5y	0.05	[1.95]
g_gb_10y	-0.20	[0.96]	g_gb_10y	-0.47	[0.54]	g_gb_10y	0.42	[0.39]	g_gb_10y	-0.66	[1.71]
g_nfc	0.74	[0.38]	g_nfc	0.01	[0.21]	g_nfc	-0.21	[0.14]	g_nfc	2.05***	[0.64]
g_hh	0.89	[0.82]	g_hh	-1.41***	[0.49]	g_hh	-0.52	[0.32]	g_hh	0.65	[1.43]
f_gb_6m	-0.41	[0.49]	f_gb_6m	0.24	[0.27]	f_gb_6m	-0.08	[0.19]	f_gb_6m	0.91	[0.82]
f_gb_5y	-0.49	[0.83]	f_gb_5y	-0.74	[0.49]	f_gb_5y	-0.74**	[0.35]	f_gb_5y	1.27	[1.47]
f_gb_10y	-0.39	[0.62]	f_gb_10y	0.10	[0.39]	f_gb_10y	0.13	[0.27]	f_gb_10y	0.54	[1.17]
f_nfc	1.13***	[0.34]	f_nfc	0.21	[0.21]	f_nfc	0.04	[0.14]	f_nfc	1.04	[0.56]
f_hh	0.16	[0.09]	f_hh	-0.07	[0.05]	f_hh	-0.04	[0.04]	f_hh	0.08	[0.16]
i_gb_6m	1.33	[1.38]	i_gb_6m	0.02	[0.80]	i_gb_6m	-0.52	[0.52]	i_gb_6m	-3.66	[2.31]
i_gb_5y	0.93	[1.34]	i_gb_5y	0.99	[0.82]	i_gb_5y	0.15	[0.52]	i_gb_5y	-1.79	[2.41]
i_gb_10y	1.01	[1.25]	i_gb_10y	0.73	[0.73]	i_gb_10y	0.25	[0.50]	i_gb_10y	0.18	[2.18]
i_nfc	0.44	[0.46]	i_nfc	0.01	[0.25]	i_nfc	-0.18	[0.16]	i_nfc	0.58	[0.73]
i_hh	0.34	[0.24]	i_hh	-0.16	[0.14]	i_hh	-0.05	[0.09]	i_hh	0.26	[0.47]
s_gb_6m	1.96**	[0.98]	s_gb_6m	0.77	[0.57]	s_gb_6m	-0.45	[0.39]	s_gb_6m	-1.46	[1.75]
s_gb_5y	1.07	[0.83]	s_gb_5y	0.92	[0.54]	s_gb_5y	-0.09	[0.36]	s_gb_5y	-1.06	[1.46]
s_gb_10y	0.26	[0.69]	s_gb_10y	0.72	[0.44]	s_gb_10y	-0.12	[0.29]	s_gb_10y	-0.91	[1.31]
s_nfc	2.19***	[0.64]	s_nfc	0.12	[0.31]	s_nfc	-0.37	[0.20]	s_nfc	0.67	[0.91]
s_hh	0.33	[0.29]	s_hh	-0.02	[0.16]	s_hh	-0.01	[0.10]	s_hh	0.66	[0.46]

Effect on volumes

ECB rate - b_{59}			EL - b_{58}			LTRO - b_{57}			SHMPP - b_{56}		
model	param	se	model	param	se	model	param	se	model	param	se
g_gb_6m	0.04	[0.03]	g_gb_6m	0.00	[0.01]	g_gb_6m	0.00	[0.01]	g_gb_6m	-0.03	[0.05]
g_gb_5y	0.06	[0.05]	g_gb_5y	0.04	[0.03]	g_gb_5y	0.01	[0.02]	g_gb_5y	0.06	[0.09]
g_gb_10y	0.00	[0.05]	g_gb_10y	0.04	[0.03]	g_gb_10y	0.03	[0.02]	g_gb_10y	-0.03	[0.09]
g_nfc	0.58	[1.30]	g_nfc	0.22	[0.72]	g_nfc	0.34	[0.48]	g_nfc	-2.10	[2.16]
g_hh	-0.03	[0.03]	g_hh	-0.02	[0.02]	g_hh	-0.02	[0.01]	g_hh	-0.02	[0.05]
f_gb_6m	-0.02	[0.05]	f_gb_6m	0.02	[0.03]	f_gb_6m	0.02	[0.02]	f_gb_6m	-0.03	[0.09]
f_gb_5y	-0.01	[0.05]	f_gb_5y	-0.02	[0.03]	f_gb_5y	-0.03	[0.02]	f_gb_5y	0.24**	[0.09]
f_gb_10y	0.03	[0.06]	f_gb_10y	0.06	[0.03]	f_gb_10y	0.02	[0.02]	f_gb_10y	0.23**	[0.10]
f_nfc	-1.33	[1.67]	f_nfc	0.17	[0.99]	f_nfc	0.67	[0.67]	f_nfc	0.21	[2.71]
f_hh	0.07**	[0.04]	f_hh	0.00	[0.02]	f_hh	-0.01	[0.02]	f_hh	-0.01	[0.06]
i_gb_6m	-0.05	[0.07]	i_gb_6m	-0.02	[0.04]	i_gb_6m	0.02	[0.03]	i_gb_6m	0.01	[0.12]
i_gb_5y	0.03	[0.08]	i_gb_5y	-0.01	[0.05]	i_gb_5y	0.00	[0.03]	i_gb_5y	0.15	[0.15]
i_gb_10y	-0.01	[0.04]	i_gb_10y	-0.02	[0.02]	i_gb_10y	-0.02	[0.02]	i_gb_10y	0.06	[0.07]
i_nfc	3.35	[1.96]	i_nfc	-0.73	[1.06]	i_nfc	-1.02	[0.68]	i_nfc	0.14	[3.08]
i_hh	0.02	[0.03]	i_hh	-0.02	[0.02]	i_hh	-0.01	[0.01]	i_hh	0.09	[0.06]
s_gb_6m	0.01	[0.01]	s_gb_6m	0.00	[0.01]	s_gb_6m	0.00	[0.00]	s_gb_6m	0.02	[0.02]
s_gb_5y	-0.09	[0.06]	s_gb_5y	-0.06	[0.04]	s_gb_5y	0.01	[0.02]	s_gb_5y	-0.03	[0.10]
s_gb_10y	-0.06	[0.06]	s_gb_10y	-0.02	[0.04]	s_gb_10y	0.00	[0.03]	s_gb_10y	0.12	[0.12]
s_nfc	-0.53	[1.96]	s_nfc	0.78	[0.94]	s_nfc	0.89	[0.61]	s_nfc	-0.16	[2.79]
s_hh	0.02	[0.04]	s_hh	-0.01	[0.02]	s_hh	-0.02	[0.02]	s_hh	-0.08	[0.07]

Notes: Estimated from equation (3). ** $p < 0.05$, *** $p < 0.01$.

Table 3 - Estimates of the cross-effects of policy variables

Effect of unconventional policy variables on the ECB rate								
EL - b_{98}			SHMPP - b_{97}			LTRO - b_{96}		
model	param	se	model	param	se	model	param	se
g_gb_6m	-0.15	[0.12]	g_gb_6m	-0.17**	[0.08]	g_gb_6m	0.42	[0.36]
g_gb_5y	-0.15	[0.12]	g_gb_5y	-0.18**	[0.08]	g_gb_5y	0.31	[0.37]
g_gb_10y	-0.22**	[0.11]	g_gb_10y	-0.14	[0.08]	g_gb_10y	0.03	[0.35]
g_nfc	-0.14	[0.12]	g_nfc	-0.11	[0.08]	g_nfc	0.20	[0.38]
g_hh	-0.17	[0.14]	g_hh	-0.13	[0.09]	g_hh	0.03	[0.40]
f_gb_6m	-0.06	[0.12]	f_gb_6m	-0.09	[0.08]	f_gb_6m	0.30	[0.35]
f_gb_5y	-0.21	[0.12]	f_gb_5y	-0.18**	[0.08]	f_gb_5y	-0.02	[0.35]
f_gb_10y	-0.21	[0.13]	f_gb_10y	-0.16	[0.09]	f_gb_10y	0.01	[0.38]
f_nfc	0.00	[0.12]	f_nfc	-0.09	[0.08]	f_nfc	0.04	[0.33]
f_hh	-0.26**	[0.13]	f_hh	-0.23**	[0.09]	f_hh	0.35	[0.38]
i_gb_6m	-0.16	[0.12]	i_gb_6m	-0.10	[0.08]	i_gb_6m	0.16	[0.35]
i_gb_5y	-0.13	[0.13]	i_gb_5y	-0.11	[0.08]	i_gb_5y	0.13	[0.38]
i_gb_10y	-0.14	[0.12]	i_gb_10y	-0.13	[0.08]	i_gb_10y	0.22	[0.35]
i_nfc	-0.14	[0.13]	i_nfc	-0.08	[0.08]	i_nfc	-0.27	[0.37]
i_hh	-0.17	[0.13]	i_hh	-0.15	[0.09]	i_hh	-0.20	[0.43]
s_gb_6m	-0.17	[0.13]	s_gb_6m	-0.17*	[0.09]	s_gb_6m	0.12	[0.39]
s_gb_5y	-0.14	[0.14]	s_gb_5y	-0.13	[0.09]	s_gb_5y	-0.05	[0.38]
s_gb_10y	-0.16	[0.13]	s_gb_10y	-0.12	[0.09]	s_gb_10y	-0.10	[0.40]
s_nfc	-0.19	[0.12]	s_nfc	-0.21***	[0.08]	s_nfc	-0.01	[0.36]
s_hh	-0.16	[0.13]	s_hh	-0.14	[0.08]	s_hh	0.33	[0.36]
Effect of the ECB rate on unconventional policy variables								
EL - b_{89}			SHMPP - b_{79}			LTRO - b_{69}		
	param	se		param	se		param	se
g_gb_6m	-0.82	[0.62]	g_gb_6m	0.06	[0.80]	g_gb_6m	0.17	[0.11]
g_gb_5y	-0.81	[0.63]	g_gb_5y	0.59	[0.75]	g_gb_5y	0.15	[0.11]
g_gb_10y	-0.93	[0.66]	g_gb_10y	0.37	[0.87]	g_gb_10y	0.20	[0.12]
g_nfc	0.15	[0.64]	g_nfc	-1.21	[0.87]	g_nfc	0.13	[0.12]
g_hh	-0.88	[0.67]	g_hh	0.54	[0.92]	g_hh	0.17	[0.12]
f_gb_6m	-0.53	[0.68]	f_gb_6m	-0.13	[0.89]	f_gb_6m	0.15	[0.12]
f_gb_5y	-0.36	[0.64]	f_gb_5y	-0.14	[0.83]	f_gb_5y	0.13	[0.10]
f_gb_10y	-0.55	[0.62]	f_gb_10y	0.10	[0.82]	f_gb_10y	0.15	[0.10]
f_nfc	-0.21	[0.71]	f_nfc	-0.41	[0.95]	f_nfc	0.15	[0.13]
f_hh	0.05	[0.69]	f_hh	-0.15	[0.89]	f_hh	0.03	[0.12]
i_gb_6m	-0.47	[0.64]	i_gb_6m	-0.16	[0.86]	i_gb_6m	0.10	[0.11]
i_gb_5y	-0.69	[0.62]	i_gb_5y	0.64	[0.84]	i_gb_5y	0.08	[0.11]
i_gb_10y	-0.40	[0.60]	i_gb_10y	0.20	[0.85]	i_gb_10y	0.12	[0.11]
i_nfc	-0.20	[0.71]	i_nfc	-0.45	[1.01]	i_nfc	0.13	[0.13]
i_hh	-0.68	[0.66]	i_hh	0.36	[0.90]	i_hh	0.14	[0.11]
s_gb_6m	-0.26	[0.67]	s_gb_6m	-0.02	[0.93]	s_gb_6m	0.13	[0.12]
s_gb_5y	-0.36	[0.64]	s_gb_5y	0.06	[0.89]	s_gb_5y	0.11	[0.11]
s_gb_10y	-0.42	[0.61]	s_gb_10y	0.05	[0.87]	s_gb_10y	0.13	[0.11]
s_nfc	-0.86	[0.76]	s_nfc	0.17	[1.08]	s_nfc	0.25	[0.14]
s_hh	-0.40	[0.68]	s_hh	-0.34	[0.97]	s_hh	0.23	[0.12]

Notes: Estimated from equation (3). ** $p < 0.05$, *** $p < 0.01$.

Table 4 - Estimates of the effect of a shadow rate

on interest rates			on volumes		
model	param	se	model	param	se
g_gb_6m	-0.03	[0.17]	g_gb_6m	-0.01	[0.01]
g_gb_5y	-0.07	[0.37]	g_gb_5y	0.00	[0.02]
g_gb_10y	0.06	[0.36]	g_gb_10y	0.00	[0.02]
g_nfc	0.12	[0.16]	g_nfc	0.78	[0.46]
g_hh	0.47	[0.32]	g_hh	0.01	[0.01]
f_gb_6m	-0.13	[0.17]	f_gb_6m	-0.01	[0.02]
f_gb_5y	-0.02	[0.30]	f_gb_5y	0.00	[0.02]
f_gb_10y	-0.05	[0.24]	f_gb_10y	-0.01	[0.02]
f_nfc	0.07	[0.15]	f_nfc	-0.36	[0.67]
f_hh	0.07**	[0.03]	f_hh	0.01	[0.01]
i_gb_6m	0.05	[0.49]	i_gb_6m	0.00	[0.02]
i_gb_5y	-0.37	[0.48]	i_gb_5y	0.06**	[0.03]
i_gb_10y	-0.34	[0.42]	i_gb_10y	-0.01	[0.01]
i_nfc	0.11	[0.15]	i_nfc	0.92	[0.68]
i_hh	-0.01	[0.09]	i_hh	0.00	[0.01]
s_gb_6m	0.21	[0.37]	s_gb_6m	0.00	[0.00]
s_gb_5y	-0.28	[0.30]	s_gb_5y	0.00	[0.02]
s_gb_10y	-0.26	[0.27]	s_gb_10y	-0.01	[0.02]
s_nfc	0.53**	[0.22]	s_nfc	-0.60	[0.64]
s_hh	0.09	[0.13]	s_hh	0.01	[0.02]

Notes: Estimated from equation (3) in which the 4 policy variables are replaced by a shadow rate. ** $p < 0.05$, *** $p < 0.01$.

APPENDIX

Table A - Descriptive Statistics

	Obs	Mean	Std. Dev.	Min	Max		Obs	Mean	Std. Dev.	Min	Max
g_gb_6m_r	89	1.03	1.45	-0.09	4.38	g_gb_6m_v	89	0.04	0.02	0.00	0.07
g_gb_5y_r	89	1.80	1.27	0.02	4.69	g_gb_5y_v	89	0.03	0.02	0.00	0.09
g_gb_10y_r	88	2.54	1.11	0.90	4.66	g_gb_10y_v	89	0.04	0.02	0.00	0.08
g_nfc_r	89	3.23	1.22	1.79	5.77	g_nfc_v	89	2.23	3.99	-3.40	11.60
g_hh_h_r	89	4.70	1.12	2.84	6.47	g_hh_h_v	88	0.14	0.01	0.11	0.18
f_gb_6m_r	89	1.13	1.49	-0.01	4.46	f_gb_6m_v	89	0.04	0.03	0.00	0.11
f_gb_5y_r	89	2.19	1.20	0.37	4.91	f_gb_5y_v	89	0.04	0.02	0.00	0.08
f_gb_10y_r	89	3.09	0.92	1.21	4.85	f_gb_10y_v	89	0.04	0.02	0.00	0.09
f_nfc_r	89	3.14	1.13	2.05	5.80	f_nfc_v	89	4.27	5.53	-2.80	16.00
f_hh_h_r	89	3.91	0.67	2.75	5.32	f_hh_h_v	88	0.11	0.03	0.05	0.23
i_gb_6m_r	89	1.79	1.41	0.14	6.50	i_gb_6m_v	89	0.10	0.03	0.00	0.19
i_gb_5y_r	89	3.47	1.22	0.29	6.47	i_gb_5y_v	89	0.04	0.03	0.00	0.27
i_gb_10y_r	89	4.42	0.95	1.66	7.56	i_gb_10y_v	89	0.04	0.01	0.00	0.09
i_nfc_r	89	3.57	1.04	1.93	5.84	i_nfc_v	89	2.21	6.07	-6.30	14.30
i_hh_h_r	89	3.91	1.04	2.51	5.95	i_hh_h_v	88	0.04	0.02	0.01	0.09
s_gb_6m_r	89	1.80	1.35	0.08	4.45	s_gb_6m_v	89	0.01	0.00	0.00	0.03
s_gb_5y_r	89	3.61	1.08	0.96	6.18	s_gb_5y_v	89	0.05	0.03	0.00	0.16
s_gb_10y_r	89	4.52	0.95	2.08	6.74	s_gb_10y_v	89	0.06	0.04	0.00	0.15
s_nfc_r	89	3.78	0.98	2.46	5.91	s_nfc_v	89	-0.63	10.74	-14.30	27.60
s_hh_h_r	89	3.61	1.09	2.36	6.07	s_hh_h_v	88	0.05	0.03	0.01	0.16
f_cpi	89	1.64	1.05	-0.80	4.00	f_ip	89	-1.72	6.24	-20.80	7.26
s_cpi	89	1.99	1.64	-1.30	5.30	s_ip	89	-4.09	6.62	-21.71	4.85
i_cpi	89	2.00	1.23	-0.20	4.20	i_ip	89	-3.11	7.97	-25.70	10.41
g_cpi	89	1.70	0.96	-0.70	3.50	g_ip	89	0.90	8.57	-23.65	14.89
rate	95	1.65	1.38	0.05	4.25	op	95	9.15	28.56	-48.89	63.89
el	95	1.99	2.29	-0.15	8.02	unemp	95	9.87	1.64	7.20	12.03
ltro	95	5.42	2.67	1.39	11.17	ciss	95	0.30	0.20	0.03	0.78
shmpp	95	1.28	1.16	0.00	2.90	stoxx	95	0.03	20.28	-45.12	44.96
shadow	95	1.18	1.64	-0.61	4.33	bonds	95	3.69	0.75	1.69	4.81
cpi	95	1.83	1.07	-0.60	4.00	credit	95	3.33	4.38	-2.21	12.12
ip	95	-0.48	6.96	-21.57	9.18	eurodol	95	1.43	9.07	-16.22	17.84

Table B - Identification of shocks

	(1) ECB rate	(2) EL	(3) LTRO	(4) SHMPP
CPI	0.129*	-0.03	0.383	0.07
	[0.07]	[0.27]	[0.37]	[0.05]
L.CPI	-0.029	0.339	-0.533	-0.066
	[0.08]	[0.26]	[0.39]	[0.05]
L2.CPI	-0.083	-0.148	0.183	0.022
	[0.06]	[0.22]	[0.31]	[0.04]
L3.CPI	0.039	0.028	-0.169	-0.047
	[0.05]	[0.18]	[0.27]	[0.04]
Ind.Pro.	0.01	-0.005	-0.006	0.007
	[0.01]	[0.04]	[0.05]	[0.01]
L.Ind.Pro.	-0.007	0.054	-0.009	0.006
	[0.01]	[0.04]	[0.06]	[0.01]
L2.Ind.Pro.	-0.023**	-0.005	-0.062	-0.003
	[0.01]	[0.04]	[0.05]	[0.01]
L3.Ind.Pro.	0.01	-0.077**	0.078	-0.007
	[0.01]	[0.03]	[0.05]	[0.01]
Oil prices	-0.003	0.001	-0.012	-0.001
	[0.00]	[0.01]	[0.01]	[0.00]
L.Oil prices	0.003	0.001	0.007	0
	[0.00]	[0.01]	[0.01]	[0.00]
Unemp.	-0.721***	1.163	-0.557	0.045
	[0.26]	[1.07]	[1.60]	[0.19]
L.Unemp.	0.489*	-2.776***	2.405	0.136
	[0.28]	[0.94]	[1.47]	[0.20]
CISS	0.006	0.186	0.449	0.215
	[0.25]	[0.88]	[1.35]	[0.15]
L.CISS	-0.559**	-2.114**	2.206*	0.439**
	[0.26]	[0.90]	[1.28]	[0.17]
STOXX	0.001	0.003	0.007	-0.001
	[0.00]	[0.01]	[0.01]	[0.00]
L.STOXX	-0.001	-0.01	0.014	0.002
	[0.00]	[0.01]	[0.01]	[0.00]
10y gov. rates	0.021	-0.285	0.241	0.073*
	[0.06]	[0.20]	[0.31]	[0.04]
L.10y gov. rates	-0.002	-0.138	0.286	0.024
	[0.07]	[0.22]	[0.33]	[0.04]
Credit	0.063**	-0.240**	0.348**	0.01
	[0.02]	[0.09]	[0.14]	[0.02]
L.Credit	-0.037	-0.004	-0.018	-0.029
	[0.03]	[0.11]	[0.15]	[0.02]
Euro/Dollar	-0.003	-0.038***	0.015	0.003
	[0.00]	[0.01]	[0.02]	[0.00]
L.Euro/Dollar	0.011**	0.006	0.02	0
	[0.00]	[0.02]	[0.02]	[0.00]
ECB rate		0.034	-0.462	0.059
		[0.47]	[0.70]	[0.08]
L.ECB rate	0.718***	-0.126	0.81	0.103
	[0.06]	[0.41]	[0.62]	[0.08]
EL	0.005		1.175***	0.069**
	[0.04]		[0.13]	[0.03]
L.EL	0.025	0.292***	0.009	0.007
	[0.03]	[0.11]	[0.17]	[0.02]
LTRO	-0.031	0.477***		-0.038**
	[0.02]	[0.05]		[0.02]
L.LTRO	0.025	0.059	-0.07	-0.01
	[0.02]	[0.08]	[0.12]	[0.02]
SHMPP	0.244	0.677	-1.052	
	[0.18]	[0.65]	[1.05]	
L.SHMPP	-0.144	0.438	-0.976	0.769***
	[0.17]	[0.60]	[1.10]	[0.08]
Constant	2.490**	15.821***	-19.081***	-2.282***
	[1.03]	[3.08]	[5.63]	[0.69]
Announcement dummies	No	Yes	Yes	Yes
Nb of obs.	92	92	92	92
R^2	0.997	0.989	0.982	0.998

Note: Standard errors in brackets. * p < 0.10, ** p < 0.05, *** p < 0.01. L is the lag operator.

Table C - Cumby-Huizinga test for autocorrelation

ECB rate			EL		
lag	chi2	p-val	lag	chi2	p-val
1	0.01	0.92	1	3.76	0.05
2	0.72	0.40	2	0.66	0.42
3	0.13	0.72	3	0.39	0.53
LTRO			**SHMPP**		
lag	chi2	p-val	lag	chi2	p-val
1	2.70	0.10	1	7.69	0.01
2	1.30	0.25	2	2.36	0.12
3	2.64	0.10	3	2.50	0.11

Note: H0: disturbance is MA process up to order q, HA: serial correlation present at specified lags >q.

Table D - Predictability of policy shocks

	3 lags		6 lags	
Variable	F-stat	p-value	F-stat	p-value
ECB rate	0.44	0.99	0.51	0.98
EL	0.23	1	0.41	0.99
LTRO	0.27	0.99	0.44	0.99
SHMPP	0.56	0.95	0.69	0.89

Note: Vector of explanatory variables: CPI, IndPro, Oil, Unemp, CISS, STOXX, 10yBond rates, Credit, Euro/Dollar.

Table E - Descriptive statistics and correlations

	Mean	Std. Dev.	Min	Max
eps_rate	0.00	0.08	-0.20	0.19
eps_el	0.00	0.24	-0.78	0.93
eps_ltro	0.00	0.35	-1.00	1.32
eps_shmpp	0.00	0.05	-0.13	0.14
	eps_rate	eps_el	eps_ltro	eps_shmpp
eps_rate	1			
eps_el	-0.02	1		
eps_ltro	0.14	-0.69***	1	
eps_shmpp	-0.14	-0.19	0.20	1

Note: The *eps* variables correspond to the shocks estimated in section 4. *** means that the p-value < 0.01.

Data description

Common variables

BCE	ECB interest rate on main refinancing operations	Annual Interest Rate	ECB Statistical Data Warehouse
CPI	Overall inflation in the euro area (changing composition)	Index	ECB Statistical Data Warehouse
IP	Industrial production for the euro area (18 fixed composition)	Year over year percentage change	ECB Statistical Data Warehouse
UNEMP	Euro area (changing composition) standardised unemployment rate	Annual Rate	ECB Statistical Data Warehouse
BONDS	Euro area (changing composition) 10-year government benchmark bond yield	Yield	ECB Statistical Data Warehouse
CREDIT	Stocks of loans and securities, all maturities, all amounts, euro area (changing compositon)	As a percentage of euro area GDP	ECB Statistical Data Warehouse
GDP	Gross domestic product at market prices, euro area (changing composition)	Annual level, monthly frequency	ECB Statistical Data Warehouse
SHADOW	Shadow rate for the euro area	Annual Rate	Wu and Xia (forthcoming)
EL	Excess liquidity, computed as current accounts – reserve requirements + deposit facility – marginal lending facility	As a percentage of euro area GDP	ECB Statistical Data Warehouse
SHMPP	Securities held for monetary purposes (Securities Market Program, 1st 2d and 3d Covered Bond Purchase Programs, Asset-Backed Securities Purchase Program)	As a percentage of euro area GDP	ECB Statistical Data Warehouse
LTRO	Longer-term refinancing operations	As a percentage of euro area GDP	ECB Statistical Data Warehouse
SIZE	Size of ECB's balance sheet (total assets / liabilities)	As a percentage of euro area GDP	ECB Statistical Data Warehouse
EL_i	Dummies for excess liquidity announcements	Dummy	Based on ECB Monthly Bulletins
LTRO_i	Dummies for longer-term refinancing operations announcements	Dummy	Based on ECB Monthly Bulletins
SHMPP_i	Dummies for securities held for monetary policy purposes announcements	Dummy	Based on ECB Monthly Bulletins
EURODOL	Euro-dollar exchange rate	Monthly rate	FRED Saint Louis
CISS	Composite Indicator of Systemic Stress	Index	ECB Statistical Data Warehouse
STOXX	Dow Jones Euro Stoxx 50 Price Index (Historical close, average of observations through period)	Equity/index	ECB Statistical Data Warehouse
OP	Oil price (for commodity, brent crude oil 1 month forward) - free on board per barrel, in euro	Year over year percentage change	ECB Statistical Data Warehouse

Country specific variables

C_GB_6M_R	Weighted average yield of 6-month maturity bonds (from 165 to 210 days)	Annual Interest Rate	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_6M_V	Total allotment of 6-month maturity bonds (from 165 to 210 days) over the month	As a percentage of euro area GDP	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_5Y_R	Weighted average yield of 5-year maturity bonds (from 54 to 72 months)	Annual Interest Rate	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_5Y_V	Total allotment of 5-year maturity bonds (from 54 to 72 months) over the month	As a percentage of euro area GDP	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_10Y_R	Weighted average yield of 10-year maturity bonds (114 to 132 months)	Annual Interest Rate	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_10Y_V	Total allotment of 10-year maturity bonds (from 114 to 132 months) over the month	As a percentage of euro area GDP	Deutsche Finanzagentur, Agence France Trésor, Banca D'Italia, Banco de España
C_GB_DMD	Flows of redemptions, securities in nominal value, all currencies combined	Month to month percentage change	ECB Statistical Data Warehouse
C_NFC_R	Lending rate to domestic non-financial corporations (new business, index of notional stocks), all maturities, all amounts	Annual Interest Rate	ECB Statistical Data Warehouse
C_NFC_V	Loans to domestic non-financial corporations (new business, index of notional stocks), all amounts, all maturities	Year over year percentage change	Bundesbank, Banque de France, Banca D'Italia, Datastream
C_NFC_DMD	Diffusion index of loan demand, enterprise, forward looking three months	Quarterly Index, monthly frequency	BLS Survey
C_HH_H_R	Lending rate to domestic households (new business), for housing loans (all maturities, all	Annual Interest Rate	ECB Statistical Data Warehouse
C_HH_H_V	Loans to domestic households (new business), housing loans (all maturities, all amounts)	As a percentage of euro area GDP	Datastream, Banque de France, Banca d'Italia
C_HH_DMD	Diffusion index of loan demand, loans for house purchase, forward looking three months	Quarterly Index, monthly frequency	BLS Survey
C_CPI	Consumer Price Index	Annual rate of change	ECB Statistical Data Warehouse
C_STOXX	DAX (GDAXI), CAC 40, FTSE MIB and IBEX 35 indices	Year over year percentage change	Euronext
C_IP	Volume index of industrial production	Year over year percentage change	Eurostat

C stands for the country : G for Germany, F for France, I for Italy and S for Spain