Unconventional monetary policy and inflation expectations in the Euro area

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Abstract

With the ECB's policy rate having reached the zero lower bound, traditional monetary policy tools became ineffective and the ECB was forced to adopt a set of unconventional monetary policy (UMP) measures. This paper examines the effects of the ECB's UMP on inflation expectations in the Euro area as inflation expectations play a key role for achieving the inflation target of below, but close to 2%. Quantifying the impact of UMP is not straightforward, as standard empirical tools such as VAR cannot be applied. Hence, we use the Qual VAR approach pioneered by Dueker (2005) to overcome this problem. We indeed find that UMP leads to a rise in inflation expectations in the short run but that this effect appears to evaporate in the medium term. Our results put some doubt on the common claim that UMP has consistently contributed to a re-anchoring and a stabilisation of inflation expectations at the zero lower bound. Nevertheless, they indicate a rise in medium-term real GDP growth triggered by UMP.

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1 Introduction

The complexity of the conduct and transmission of monetary policy has tremendously increased since the beginning of the Great Recession in 2008. While central banks around the globe had primarily used their short-term policy rates as main tools before the crisis, the conduct of monetary policy changed when policy rates were quickly cut to zero without generating sufficient economic stimulus. With their main policy tool stuck at the zero-lower bound (ZLB), the European Central Bank (ECB), as well as several leading central banks, used new unconventional instruments in their attempt to provide further economic stimulus like Forward Guidance as well as large-scale asset purchase programmes with Quantitative Easing (QE) being the most notable one.

While the Federal Reserve was able to raise the federal funds rate substantially above zero until recently, the ECB is still "going strong". Even more than ten years after the crisis, the European Central Bank is still pushing interest rates further into negative territory with no end in sight: after the ECB discontinued its QE programme at the end of 2018, the ECB president Mario Draghi announced its continuation in September 2019 in addition to a further reduction of the rate on the deposit facility to -0.5%. According to the ECB, the monetary expansion is implemented to support the economic development and to decrease worries about an economic slowdown in the Euro area and, by this, to support the convergence of the inflation rate to near two percent in the medium run (ECB (2019a)).

As the risks and negative consequences of UMP (side effects such as the alleged "zombification of the economic sector" Acharya et al. (2019)) are well-known from the literature

which increase disproportionately over time, one feel legitimised to ask what the ECB has achieved by pushing interest rates into negative territory and more than tripling the size of its balance sheet. Due to the significance of the topic, several papers have addressed this question from different angles. Most papers attempt to assess the effects of these so-called unconventional monetary policies (UMPs) merely focusing on their impact on interest rates on capital markets (Bhattarai and Neely (2016)). While this approach is in line with the canonical transmission channel of monetary policy, the aim of the UMPs is also to improve conditions in the real economy and, thus, to raise inflation expectations. Those studies assume that lower long-term interest rates are beneficial to significantly improve real economic conditions even in the current economic environment and, thus, to steer inflation back to a level close to 2 percent (Ambler and Rumler (2019)). However, the overall impact on interest rates for loans and the impact on inflation expectations is far from conclusive. Other empirical studies have thus also attempted to measure the impact on the real economy, i.e. variables such as GDP and gross investment and income (Mouabbi and Sahuc (2019)).

According to Keynesian theory, a large adverse shock can not only push an economy into recession, but also generate a new equilibrium which is characterized by high unemployment and low output as the self-healing powers of the market are limited (Krugman (1998)). In line with this reasoning, monetary policy (besides fiscal policy) is necessary to push the economy back to the "old" equilibrium. De Grauwe and Ji (2013) have argued in the same vein, justifying the ECB's UMP and especially the purchase of sovereign bonds from the periphery of the Euro area. The ECB has argued several times that its measures were mainly directed to ensure to achieve its inflation objective, but by preventing further

economic decline and recessionary developments in the Euro area (ECB (2015)).

For the purpose of achieving central banks' inflation targets, inflation expectations play a crucial role for the transmission of monetary policy (Ciccarelli et al. (2017) and Potter and Smets (2019)). The capability of a central bank to affect inflation expectations is a direct measure of its credibility (Demertzis et al. (2012) and Potter and Smets (2019), Lee and Kim (2018)). The recent period of UMP after interest rates have reached the zero lower bound has made signaling and reputation effects the most important tool for monetary policymakers. Well-anchored inflation expectations are a key factor for achieving economic stability since inflation expectations are also important for decisions of investors, firms and negotiations of labor contracts (Coibion et al. (2018)). Therefore, in order to analyse the effectiveness of UMP, we take a closer look at the transmission from UMP announcement and implementation to inflation expectations in the Euro area and investigate whether the ECB was able to affect inflation expectations by undertaking a set of UMP measures.

However, measuring the effects of UMP is not at all straightforward. With the policy rate having reached the zero lower bound, traditional approaches for the identification of monetary policy effects such as standard VAR tools became inappropriate, for instance, since, for instance, VARs cannot be estimated including an endogenous variable that is constant and zero (e.g the short-term interest rate at the zero lower bound). Hence, a challenging decision about which variable to include as a proxy for UMP is challenging (Rossi (2019)).

In event studies such as Altavilla et al. (2015) which mostly focus on the short-term impact of UMP on the financial markets, this problem is often avoided by modelling the

UMP measure as a binary variable. Although binary variables can be used for event study regressions, an implementation in a standard VAR model is not easily possible without further econometric deliberations (Meinusch and Tillmann (2016)). To solve this highly relevant issue, we use the Qual VAR methodology of Dueker (2005) in order to estimate the ECB's UMP impact on inflation expectations and, to check for consistency of our empirical results, also on real economic activity and the shadow rate. By constructing a latent variable which is based on binary information from the ECB's announcements and implementations of UMP, we are able to create an endogenous variable that represents the ECB's propensity to UMP. Since the Qual VAR methodology allows us to use the estimated latent variable endogenously (and to model policy announcements endogenously) in a VAR framework, we are able to combine the advantages of a VAR system with those inherent in event studies and simultaneously solve the problem of a missing single policy instrument that reflects UMP (El-Shagi and von Schweinitz (2016)). We analyse the period between 2009:01 and 2018:01 as the ECB started its first UMP measures in the year 2009. We find that an unanticipated shock to our UMP measure (the propensity to UMP of the ECB) raises inflation expectations in the Euro area. Accordingly, real GDP growth is reacting positively in the medium term while the shadow rate is decreasing as a response to a shock in the latent UMP variable.

The remainder of this paper is organized as follows. Section 2 reviews the literature related to our research question. Section 3 conveys the methodology and theoretical aspects of the model specification. In section 4, the data and the empirical model are described. Section 5 comes up with the results, their interpretation and some robustness checks. Section 6 finally concludes.

2 Related literature

For the transmission of monetary policy shocks inflation expectations play a crucial role. If inflation expectations are well-anchored, central banks can affect inflation through inflation expectations (Scharnagl and Stapf (2015)). The capability of a central bank to affect inflation expectations is therefore a direct measure of central bank credibility. To reach their inflation target, central banks not only affect aggregate demand through the traditional interest rate channel but also affect agents' expectations about future inflation (Bernanke et al. (1999), Woodford and Gürkaynak et al. (2007)). After having reached the zero lower bound, conventional monetary policy tools such as the traditional interest rate channel became uneffective. Signaling (for instance, via Forward Guidance) and reputation effects therefore have become the most important tool for central bankers to affect inflation (Coibion et al. (2018)). Analysing the Japanese experience, Krugman (1998) argues that monetary policy is only ineffective in a liquidity trap because the central bank is faced by a credibility problem. If central banks could credibly show that they accept higher long-run money supply and higher future inflation they could achieve sufficiently low real interest rates and, by this, escape the liquidity trap. Accordingly, the increase in the ECB's balance sheet size through purchasing assets may affect confidence and thus inflation expectations by the signalling channel (Borio and Disyatat (2010) and van den End and Pattipeilohy (2017)).

The focus of previous empirical research, mainly event studies, on UMP has been preponderantly on the short-term financial market impacts of announced or actually implemented UMP using high-frequency data (Bhattarai and Neely (2016), Beck et al. (2019), Belke

et al. (2017) and Hofmann and Zhu (2013)). Overall, these studies find that such policies were effective in reducing financial market risk spreads or yields. However, less papers have looked at the effects of unconventional monetary policy by using VAR models with traditional identification strategies (Beck et al. (2019), Belke et al. (2017)).[1]

Only a few papers within both strands of the literature try to assess the impact of UMP on inflation expectations (see, among others, Ciccarelli et al. (2017), van den End and Pattipeilohy (2017)). Among them, the majority of studies is in contrast to our study not focusing upon the Euro area. In addition, findings of a positive impact of UMPs on expected inflation are rare (see, as an early reference, Williams (2011)). Already the earliest and least unconventional liquidity support programmes, elastically supplying liquidity to markets during the global financial crisis, such as the ECB's fixed-rate full allotment (FRFA), were quite popular among central bankers.

On June 6, 2011, the former ECB President Trichet contemplated that, "[T]he decisions we took during the crisis were effective. They have ... helped to preserve a very solid anchoring of inflation expectations" (Trichet (2011); see also Bhattarai and Neely (2016)). One of the most notable failures of UMP has been its inability to raise Japanese inflation. The latter remained stubbornly low since the mid-90s. Hiroshi Nakaso, former Deputy Governor of the Bank of Japan (BOJ), commented upon both the BOJ's successes and still virulent problems in employing UMP, "QQE has brought about a steady improvement in Japan's economy, but the price stability target of 2 percent is yet to be achieved. The

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[1]For instance, Ciccarelli et al. (2017) show based on an SVAR framework that the expansion of the Fed's balance sheet contributed decisively to prevent and gradually reverse the de-anchoring of inflation expectations during the Great Recession.
Mallick et al. (2017) look at the effectiveness of UMP using a TVP-VAR model and asset purchase shocks, showing that both before and after the 2008 financial crisis a QE-based monetary policy stimulus tends to reduce the term premium. But, post-crisis, the fall in the term premium does not appear to boost economic activity, unlike in the pre-crisis period.

main reason for this is that inflation expectations remain weak" (Nakaso (2017)).

Beck et al. (2019) find that QE policies as a variant of UMPs have led to a sustained rise in the CPI and in inflation expectations in the Euro area. However, van den End and Pattipeilohy (2017) come up with the result that UMPs, defined as shocks to balance sheet size or composition, do not have substantial effects on long-term inflation expectations in the Euro area, the US and the UK. Farmer (2012) argues graphically by using the 1-year inflation swaps that the Fed's QE1 stopped deflationary expectations in their tracks, which was good for real activity. Ito (2014) assesses in a single equation model whether changes in the central bank's balance sheet affect inflation expectations in Japan. He does not arrive at conclusive evidence in that respect. Employing an event study approach, Moessner (2015) analyses whether market-based measures of inflation expectations are affected by balance sheet policy announcements. According to his findings, the announcement of Asset Purchase Programmes and long-term refinancing operations merely caused a slight increase in long-term inflation expectations. Combining microeconometric data with macroeconomic shocks and applying the empirical model to the United Kingdom, Boneva et al. (2016) come up with the result that firms' price and wage inflation expectations increase by 0.22 percentage points as a reaction to 50 billion pound of QE, in turn implying that inflation expectations are part of the transmission mechanism of QE (Aruoba (2014)).

We do not claim to present an exhaustive list and description of all studies available in the field of studies on impacts of UMP. We only tried to sketch the main strands of the relevant literature and the main pattern of results in order to exactly identify the research

gap to be filled by this paper[2]. For detailed surveys of studies on the impacts of UMP see Belke et al. (2017), Bhattarai and Neely (2016), Beck et al. (2019) and Potter and Smets (2019).

One of the main remaining problems is to identify an adequate measure of unvonventional monetary policy when assessing the impact of UMP on inflation expectations (Rossi (2019)). In the presence of UMP, the traditional approach to the identification and estimation of monetary policy is clearly confronted with unseen econometric challenges. For instance, the VAR cannot be estimated with the short-term interest rate, which is constant and equal to zero at the zero lower bound (ZLB), as an endogenous variable. What is more, our sample period is rather short. But we would like to employ „both pre- and post-ZLB data" (Rossi (2019)). That the data are thus most likely belonging to different regimes has to be taken into account in our VAR estimation exercise. Finally, it is not at all clear ex ante which variables have to be included in a VAR to proxy UMP. Hence, seen on the whole, how to identify and estimate monetary policy shocks in times of UMP is at least a challenging issue in econometric practice. Expressed differently, quantifying the effect UMP exerts on inflation expectations, is not at all straightforward, since standard tools such as VAR models cannot be applied easily without further significant modifications (Meinusch and Tillmann (2016)). We thus proceed with an alternative approach, i.e. the Qual VAR, to estimate the effect of UMP on inflation expectations (Dueker (2005), Meinusch and Tillmann (2016)) which has – according to the best of our knowledge - not yet been applied to Euro area data. The Qual VAR model integrates information from the announcements and implementations of UMP into an otherwise standard monetary

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[2]Ciccarelli et al. (2017) call the effects of UMP on the anchoring of long-term inflation expectations "a key dimension of UMP that has been largely overlooked". We take up their argument and devote our paper to exactly this issue, with a focus upon the Euro area. See also Bauer and Weber (2016).

policy VAR (El-Shagi and von Schweinitz (2016)).

With an eye on the fact that slow recoveries and long periods of ultra-low interest rates are turning to become the general norm (Gürkaynak and Davig (2015), Kocherlakota (2019) and Roubini (2016)), we will most probably face unconventional monetary policy measures regularly in the future as well.

The key to the efficacy of UMP is 'expectations' – what the private sector believes the future holds, and the confidence it has in a central bank's capability to achieve its targets. In other words, the bank's credibility matters: "When markets have trust in central banks' ability to deliver price stability, the central bank needs to do less to deliver it. And conversely, without credibility more aggressive action is needed to achieve the same objective" (Demertzis and Viegi (2016)). This is all the more valid in times of high uncertainty (Drazen and Masson (1994)). Hence, the research question tackled in this paper is related to monetary policy issues in practice (Rossi (2019)). Moreover, our piece of research is currently of particular relevance for the Euro area, since the past and more recent slides of medium- to long-term inflation expectations triggered the ECB to announce an „active balance sheet policy" to push the inflation rate closer to its policy target of „below, but close to 2%" (Constâncio (2014), van den End and Pattipeilohy (2017)).

For instance, the expansion of the ECB's Asset Purchase Programme which was announced in the year 2015 was made conditional on the future path of expected inflation - in the same way as the current one on 12 September 2019 (ECB (2019b)). On the latter date, the ECB has announced that net purchases will be restarted under the Governing Council's Asset Purchase Programme (APP) at a monthly pace of 20 billion Euro as from 1 November 2019 on. The Governing Council expects them to run "for as long as neces-

sary to reinforce the accommodative impact of its policy rates, and to end shortly before it starts raising the key ECB interest rates" (ECB (2019b)). The protocol of the ECB's press conference on that date is revealing that UMP has been activated with an eye on re-anchoring inflation expectations in the Euro area: " .... the appropriateness of the APP, by the way one reason to also act now concerns inflation expectations that we've seen not only the ones that are now at low levels but we see that inflation expectations are not de-anchoring but are re-anchoring at levels between zero and 1.5% which is not our aim. That's why the Governing Council, in full consistency with its mandate, did decide to act now and the package is quite powerful both in the short run but also in the long run in designing action over the coming months" (ECB (2019a)).

Seen on the whole, the Qual VAR model employed by us has several advantages over other approaches to estimate UMP effects on inflation expectations. In particular, the model treats UMP as an endogenous response to the state of the business cycle and takes the anticipation of policy measures into account. Nevertheless, a Qual VAR can be considered to be a still rather easy tool for policy analysis, since it shares most of its properties with standard VAR models (El-Shagi and von Schweinitz, 2016, Meinusch and Tillmann (2016)).

3 Methodology and model specification

The Qual VAR allows us not only to capture the effects of UMP but also to explicitly include announcement effects by endogenously modelling a latent variable that is based on monetary policy announcements. For the estimation of a Qual VAR we construct a binary variable that captures the effects of the UMP in the Euro area. Let y^* be a latent

variable that captures the UMP measures in the Euro area. As in a dynamic probit model (Eichengreen et al., 1985) which is the starting point of Dueker (2005) Qual VAR specification, we ssume that the latent variable y^* is following an autoregressive process of order ρ depending on a constant δ, its own lagged values and on a set of explanatory variables X_{t-p}. As shown in Eq. (1), φ and β are coefficient vectors and ϵ_t is a standard normal distributed error term and $t = 1, ..., T$:

$$y_t^* = \delta + \sum_{l=1}^{\rho} \varphi_l y_{t-l}^* + \sum_{l=1}^{\rho} \beta_l X_{t-l} + \epsilon_t, \ \epsilon \sim N(0,1). \tag{1}$$

The latent variable y^* is assumed to lie behind a binary dependent variable y_t which takes the value of one in case an UMP event took place in that quarter t and zero otherwise. Hence, the latent variable that determines our UMP measures takes the form:

$$y_t \begin{cases} 0 \ if \ y_t^* \leq 0 \\ 1 \ if \ y_t^* > 0. \end{cases} \tag{2}$$

The autoregressive character of the latent variable y^* makes it possible to include the dynamic probit equation in a standard VAR framework. Hence, Dueker (2005) used the single-equation dynamic probit model of Eichengreen et al. (1985) and extended it to a VAR system.

A Qual VAR model with k endogenous variables and p lags can be written as

$$\Phi(L)Y_t = \mu + \epsilon_t \tag{3}$$

with

$$Y_t = \begin{pmatrix} X_t \\ y_t^* \end{pmatrix} \qquad (4)$$

where the observed macroeconomic data constitute the X_t vector and the UMP measures the latent variable y_t^*. $\Phi(L)$ is a set of $k \times k$ matrices, from $L = 0, ..., p$ with the identity matrix at $L = 0$. μ consists of a set of intercepts and ϵ are normally distributed error terms.

Dueker (2005) and Dueker and Assenmacher-Wesche (2010) show that the Markov Chain Monte Carlo (MCMC) technique, in particular via Gibbs sampling, constitutes an attractive estimation procedure for the Qual VAR. Via Gibbs sampling the joint estimation of the VAR coefficients Φ, the covariance matrix of the VAR residuals Σ and the latent variable y^* is possible.

The iterative algorithm of the MCMC estimation of this model generates a sequence of draws from the following conditional distributions:

VAR coefficients $\sim$ Normal

$$f(\Phi^{(i+1)} | \{y_t^{*(i)}\}_{t=1,...,T}, \{X_t\}_{t=1,...,T}, \Sigma^{(i)}); \qquad (5)$$

Covariance matrix $\sim$ inverted Wishart

$$f(\Sigma^{(i+1)} | \{y_t^{*(i)}\}_{t=1,...,T}, \{X_t\}_{t=1,...,T}, \Phi^{(i)}); \qquad (6)$$

Latent variable $\sim$ truncated Normal

$$f(y_t^{*(i+1)}|\Phi^{i+1}, \left\{ y_j^{*(i+1)} \right\}_{j<t}, \left\{ y_k^{*(i)} \right\}_{k>t}, \{X_t\}_{t=1,...,T}, \Sigma^{(i+1)}). \tag{7}$$

To obtain the mean and the variance of the states, e.g the latent variable, conditional on its past and future values and on the other macroeconomic variables, we apply Kalman Smoothing. The Kalman Smoother uses initial values obtained from the binary data for the latent variable and from OLS estimates for the coefficients given the binary data. In a next step, for each period the latent variable, which is based on the first two moments, is drawn from the truncated Normal. In each iteration, the VAR model is estimated by use of the sampled time series of the latent variable and the OLS estimates for Φ and Σ denoted by $\hat{\Phi}$ and $\hat{\Sigma}$.

Taking the above information into account and assuming Jeffrey's prior, a draw is conducted for Σ from the inverted Wishart distribution with $T - k$ degrees of freedom with T being the number of observations, k the number of explanatory variables and $(T\Sigma)^{-1}$ describing the covariance from OLS:

$$\Sigma \sim \mathcal{IW}\left\{ (T\hat{\Sigma})^{-1}, T - k \right\}. \tag{8}$$

By adding the mean from the OLS estimates to a draw following a multivariate Normal distribution with a covariance matrix that is specified by the Kronecker product of the draw for Σ and $(y'y)^{-1}$, we obtain a draw for Φ, given Σ:

$$\Phi \sim \mathcal{N}\left\{ \hat{\Phi}, \Sigma \otimes (y'y)^{-1} \right\}. \tag{9}$$

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For a sufficiently high number of iterations, the draws from the respective conditional distribution represent the true joint posterior distribution. We follow Dueker (2005) and run the Gibbs sampling for a total of 10,000 iterations. The first 5000 iterations are discarded to allow the sample to converge to the posterior distribution. In case a draw of the VAR coefficient was not stationary, it was rejected and resampled. From the derived sample, we calculate the mean of the latent variable, the VAR coefficients and the variance (for more details, see Dueker (2005), Dueker and Assenmacher-Wesche (2010) and Meinusch and Tillmann (2016)).

4 Data and and empirical model

4.1 Data

For estimation purposes we used quarterly data between 2009:01 and 2018:01 for the Euro area. We started the sample roughly one quarter before the ECB's first announcement to purchase liquidty-providing Longer-term Refinancing Operations (LTRO) with the maturity of one year. Regarding our sample period decision, we follow Meinusch and Tillmann (2016) and Gambacorta et al. (2014) who show that starting the sample earlier than the first intervention improves the efficiency of the estimation. The Qual VAR is constructed by four endogenous variables: the real GDP growth taken from FRED, the shadow rate by Wu and Xia (2016), the ECB's Survey of Professional Forecasters (SPF) 12 months ahead and the latent propensity to UMP of the ECB. The latter is based on a binary index of important ECB UMP measures (see table 1), it equals one if there was an important UMP event in a specific quarter and zero otherwise. Therefore we do not only include

ECB's quantitative easing but several other policies implemented by the ECB in the last ten years. Our index is mainly based on dates taken from Ambler and Rumler (2019) and Beck et al. (2019). Besides the official announcements of all major UMP packages and their extensions, we include important speeches of ECB presidents regarding further policy steps.

To reflect inflation expectations in our model we use the survey of professional forecasters instead of a market-based measure of inflation expectations. Although market-based inflation expectations measures have the advantage that they are mostly very timely, available at a high frequency and based on financial transactions of a large share of market participants, financial market prices also include other factors such as risk and liquidity premia. Since these factors may distort the signals about inflation expectations they have to be separated from them. Due to severe data limitations, we rely on survey-based inflation expectations data which have also the advantage to provide a broader array of expectations based on a holistic macroeconomic view compared to market-based measures which are based in financial market participants (Grothe and Meyler (2018)).

We estimate the model in first differences to fulfill the stationarity assumption which Dueker (2005) pointed out to be crucial for the concept of a latent binary variable. As lag selection criteria such as AIC or BIC are only defined for non-binary data, we follow Meinusch and Tillmann (2016) and choose two lags according to our data. As a robustness check, however, we will include also results with different lag lengths.

Besides the latent variable that captures the ECB's propensity to UMP, the included variables in the model capture the Euro area business cycle (real GDP growth rate), a

measure of the ECB's monetary policy strance (shadow rate)[3] and the expectations about future inflation (SPF).

4.2 Empirical model

As Dueker (2005) shows, the Qual VAR methodology is consistent with standard VAR tools. We therefore apply impulse response functions to analyse the effects of a shock on the latent UMP variable using a Cholesky identification scheme with the ordering

$$y_t^* = (\Delta GDP, \Delta SPF, y_t^*, \Delta shadowrate). \tag{10}$$

According to this ordering, we assume that UMP displayed by our latent variable y^* affects the shadow rate within one quarter but not the inflation expectations (SPF) or the real GDP growth rate. Simultaneously, we allow monetary policy to react to business cycle movements and respond to changes in the inflation expectations.

As the goal of UMP was the easing of financing conditions in the Euro area and provide the economy with liquidity to recover from the global financial crisis, we expect the real GDP growth rate to react positively to a shock on UMP. If UMP was effective, we expect inflation expectations to increase after an UMP shock and the shadow rate to fall.

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[3]If the ECB's policy rate is above its zero lower bound the ECB's policy rate is equal to the shadow rate.

5 Empirical results

5.1 Benchmark results from the Qual VAR

The aim of the analysis is to study the effectiveness of UMP in the Euro area. Having reached the zero lower bound and in the presence of UMP, the identification and estimation of monetary policy effects with traditional approaches such as VARs has become more challenging. Especially the variable that represents UMP is not straightforward. For example using the ECB's balance sheet size or the shadow rate as a proxy for monetary policy, as often done in the literature (see, for instance, Belke and Klose (2013)), means also ignoring possible announcement effects as often uncovered in event studies (see Altavilla et al. (2015)).

The Qual VAR approach by Dueker (2005) allows us to include possible announcement effects, through a dynamic probit model, and to analyse the effects of UMP and its implications.

The latent variable, which is derived in the first part of the Qual VAR method, describes the propensity of the ECB to UMP and can also be interpreted as the change in the ECB's unobservable policy stance.
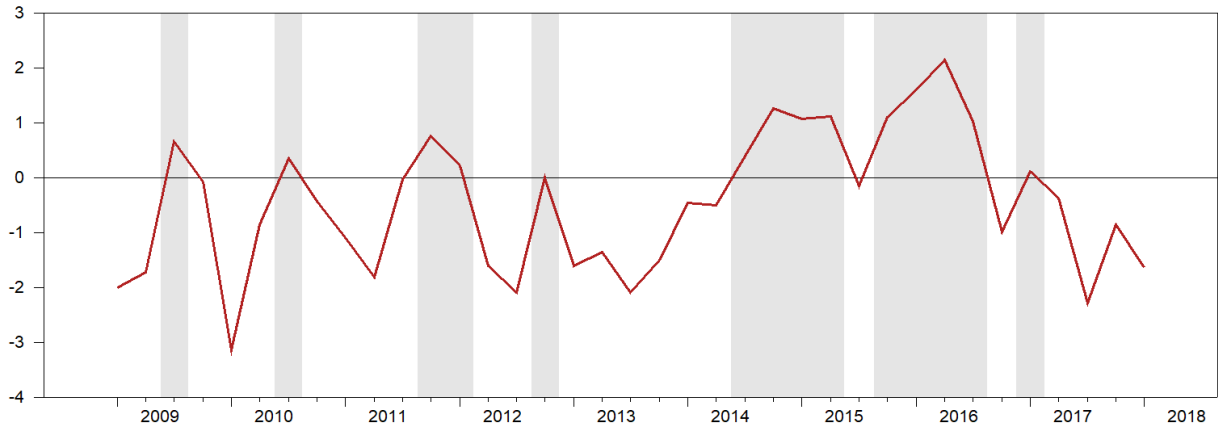
Figure 1: Unconventional Monetary Policy announcements (shaded) and latent propensity to UMP (solid line)

Figure 1 shows the estimation of the latent propensity to UMP in the Euro area. Given that the series is per definition either taking the values 1 if a UMP measure took place or 0 otherwise, the series is positive at each of the announcement dates. The announcement dates are shown in Figure 1 as shaded areas.

In line with Meinusch and Tillmann (2016), the sharp increases in the latent variable before a UMP measure occurred signal growing pressure to conduct a UMP measure. Besides that, there is a difference in the intensity of the peaks at each announcement date. The maximum is reached in 2016 when the ECB announced the expansion of QE3 to 80 billion Euro and the introduction of the Public Sector Purchase Programme (PSPP).
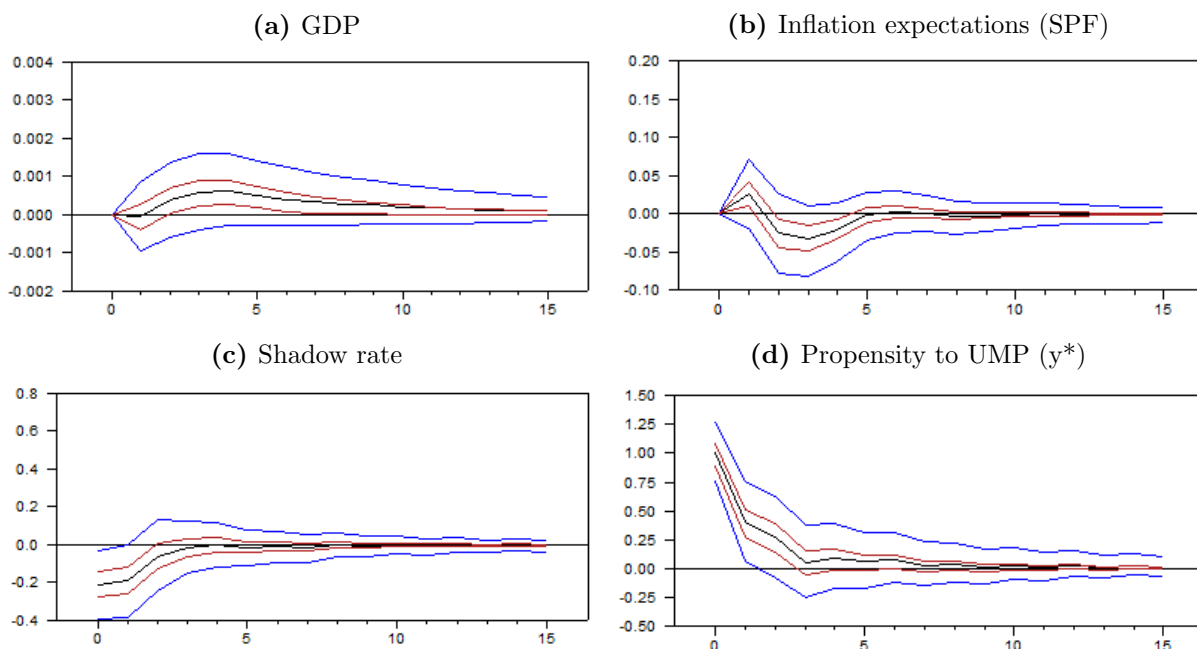
(a) GDP

(b) Inflation expectations (SPF)

(c) Shadow rate

(d) Propensity to UMP (y*)

Figure 2: IRFs: Responses to a shock on the latent propensity to EBC's UMP with 68% credible band (red line) and 90% credible band (blue line).

As explained earlier in section 3, the Qual VAR methodology allows us to use standard VAR tools such as impulse response functions through applying Cholesky Identification (see Equation 10). Figure 2 shows the dynamic median responses of all four endogenous variables to an one standard deviation shock on the latent variable y^*. The shock to the latent variable y^* can be interpreted as an unexpected increase in the propensity of the ECB to undertake UMP measures. As Meinusch and Tillmann (2016) highlight, applying a shock of one standard deviation most likely underestimates the policy impact on the exact announcement dates. It results from the fact that the standard deviation of the latent propensity is much larger on a specific announcement or implemenation date than the full sample standard deviation. The impulse responses in figure 2 show the response to the shock on the latent variable (black line) with the 68% (red line) and 90% (blue line) credible intervals to reflect the uncertainty about the coefficient matrix of the VAR. For the interpretation of our results, we follow the Bayesian literature by using the 68%

credible intervals.

We find that an increase in the propensity to UMP of the ECB raises the growth rate of real GDP in the medium term. The positive response of real GDP to the shock in the latent variables occurs after about two quarters. We find that by increasing the propensity to UMP, inflation expectations increase immediately in the next period but decline significantly three to four periods after the shock. We can therefore conclude that the announcement or implementation of UMP is affecting inflation expetcations positively in the short run but that by agents revising their expectations in the medium term the effect becomes negative. Our results show that the ECB's UMP measures were indeed able to raise inflation expectations but that this only holds for the periods directly after the announcements or implementations. With agents revising their expectations and thus the effect turning negative in the medium term, we can conclude that the ECB's UMP measures were not able to push inflation expectations permanently up on a higher level. Well-anchored inflation expectations are a key aspect of the ECB's monetary policy but our results cannot support that the conducted UMP measures helped to re-anchor inflation expectations in the Euro area.

The shadow rate which illustrates the ECB's policy rate when reaching the zero lower bound responds instantly and negatively to an unanticipated increase in the propensity to UMP.

In order to ensure the robustness of our empirical model, we compared our benchmark estimation with specifications using different lag lengths and estimating the model using the full available sample (see Figure 4). Furthermore, we used the shadow short rate of Krippner (2013) instead of the one of Wu and Xia (2016) (see Figure 5) as these two time

series differ in their underlying model and thus in their calculation for the short-term interest rate below the zero lower bound. The results show that the dynamics captured by our benchmark model are robust and they do not change significantly under different specifications.

6 Conclusions

In this paper we have empirically assessed the impact of UMP on inflation expectations in the Euro area. For this purpose we have estimated a Qual VAR, since it overcomes most of the weakennesses of the traditional approach to the identification and estimation of monetary policy in the presence of UMP and the zero lower bound. We have used quarterly data and the period from 2009:01 to 2018:01 as the ECB started its first UMPs in 2009.

We find that unanticipated shocks to the propensity to UMP of the ECB raise inflation expectations in the Euro area in the short run but not in the medium term. The positive effect on inflation expectations becomes significantly negative after about two quarters for three periods. Furthermore it shows - consistent with the former result - a positive and significant effect on the real economy in the medium term as well as an instant significantly negative response to the shadow rate. Our results are currently of particular relevance for the Euro area, as the recent slide of long-term inflation expectations motivated the ECB to announce an active balance sheet policy to steer the inflation rate closer to its policy target of below, but close to 2%.

With an eye on the fact that slow recoveries and long periods of ultra-low interest rates are turning to become the general norm, we will most probably face UMP measures regularly

in the future as well. In this case, the key to the success of central banks in safeguarding price stability will be inflation expectations, i.e. the credibility of central banks. This is all more valid in times of high uncertainty.

In our paper, we have thus tried to estimate the success or failure of UMP in terms of its effect on inflation expectations. This is a critically important issue since monetary policy has become the main tool of discretionary stabilisation policy also in the Euro area. It can be implemented faster and more flexibly than discretionary fiscal policy (Bhattarai and Neely (2016)). Our study is one of the few which are able to identify positive effects of UMP in the framwork of a VAR on inflation expectations, at least in the short run. Nevertheless, our results clearly indicate that the positive effect of UMP on inflation expectations tends to evaporate in the medium term. In general, this puts some doubt on the common claim that the ECB was able to re-anchor inflation expectations through the announcement and implementation of UMP measures. However, there may be limitations to the method used by us. For instance, our Qual VAR model is unable to decompose different transmission channels (Meinusch and Tillmann (2016)). Moreover, we did not explicitly include announcements of exiting from UMP or "tapering" unconventional measures. Both issues represent interesting and relevant avenues how to augment our study. We leave this task to further research.

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Appendix

Table 1: Unconventional monetary policy announcements

| Date	Event
07.05.2009	LTRO1 First LTRO: three 1-year tenders, full allotment
04.06.2009	CBPP1 First CBPP: purchase of 60 bn. EUR as of July 2009
10.05.2010	SMP1 First phase of SMP: purchase of IE, PT and GR bonds
08.08.2011	SMP2 Second phase of SMP: purchase of IT and ES bonds
06.10.2011	CBPP2 Second CBPP: purchase of 40 bn. EUR as of Nov 2011
08.12.2011	LTRO2 Second LTRO: two 3-year tenders, full allotment
02.08.2012	OMT1 Conditional on EFSF/ESM programme
06.09.2012	OMT2 Details of OMT: full sterilization, terminates SMP
26.05.2014	Speech of the ECB's President in Sintra
05.06.2014	TLTRO1 Series of 4-year tenders, up to 7% of private sector loans
24.08.2014	Speech by the President of the ECB, in Jackson Hole, "We stand ready to adjust our policy stance further."
04.09.2014	ABSPP Intended for at least 2 years, starting in Q4 2014
	CBPP3 Third CBPP: purchases starting in Oct 2014
02.10.2014	Release of operational details of both the asset-backed securities pur-chase programme and the new covered bond purchase programme.
06.11.2014	GovC meeting, "Together with the series of targeted [...]
04.12.2014	GovC meeting, "Taken together, our measures will have a sizeable im-pact on our balance sheet [...]
22.01.2015	APP1 ABSPP+CBPP+PSPP: 60 bn. EUR/m up to Sept 2016
05.03.2015	GovC meeting, "Following up on our decisions of 22 January 2015, we will, on 9 March 2015, start purchasing euro-denominated public sector securities in the secondary market."
03.09.2015	GovC meeting, increase the issue share limit from the initial limit of 25% to 33%
03.12.2015	APP2 Extension of APP to March 2017, reinvestment policy
21.01.2016	GovC meeting, "It will therefore be necessary to review and possibly re-consider our monetary policy stance at our next meeting [...]
10.03.2016	APP3 Expansion to 80 bn. EUR/m and corporate bonds (CSPP)
	TLTRO2 Series of 4-year tenders, up to 30% of private sector loans
21.04.2016	GovC meeting, "in June, we will conduct the first operation of our new series of TLTRO II [...]
02.06.2016	GovC meeting, "As a next step, on 8 June we will start making pur-chases under our corporate sector purchase programme (CSPP) [...]
20.10.2016	GovC meeting, "To that end, we will continue to act, if warranted, by using all the instruments available within our mandate [...]
08.12.2016	GovC meeting, "From April 2017, our net asset purchases are intended to continue at a monthly pace of 60 billion euro until the end of Decem-ber 2017 [...]
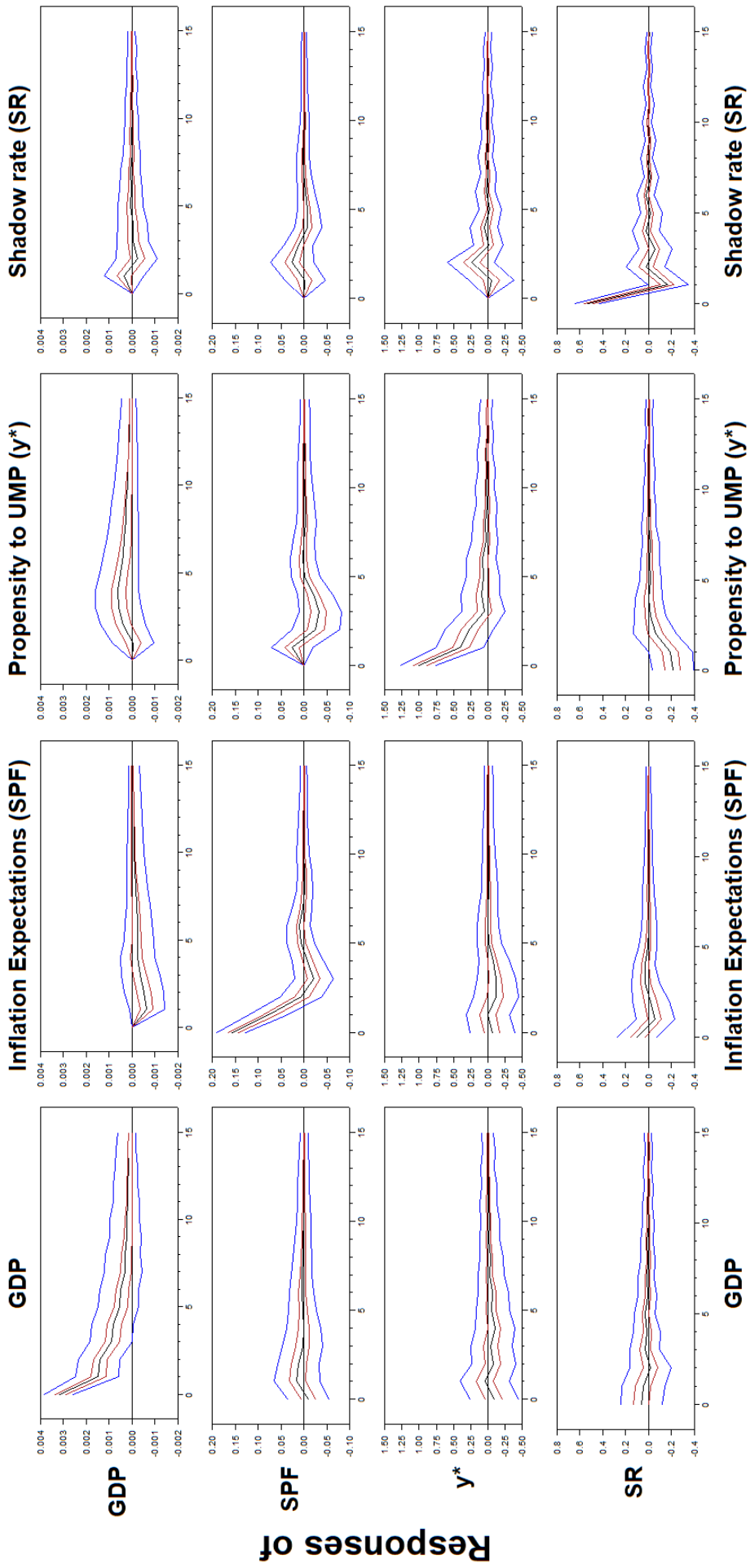
Figure 3: IRFs: Responses to a shock on the latent propensity to EBC's UMP with 68% credible band (red line) and 90% credible band (blue line). Sample from 2009:Q1 to 2018:Q1
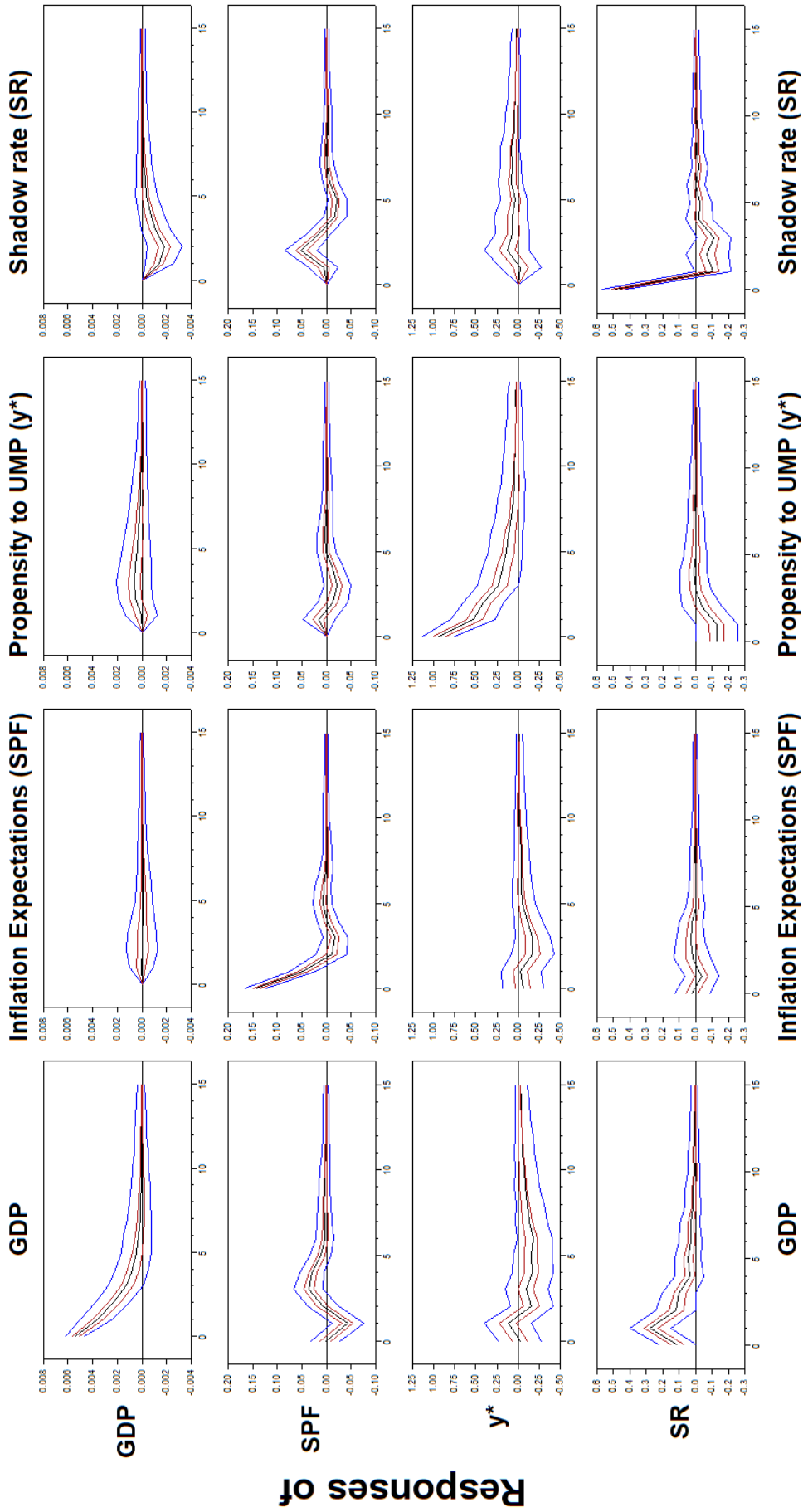
Figure 4: IRFs: Responses to a shock on the latent propensity to EBC's UMP with 68% credible band (red line) and 90% credible band (blue line). Sample from 2004:Q4 to 2018:Q1
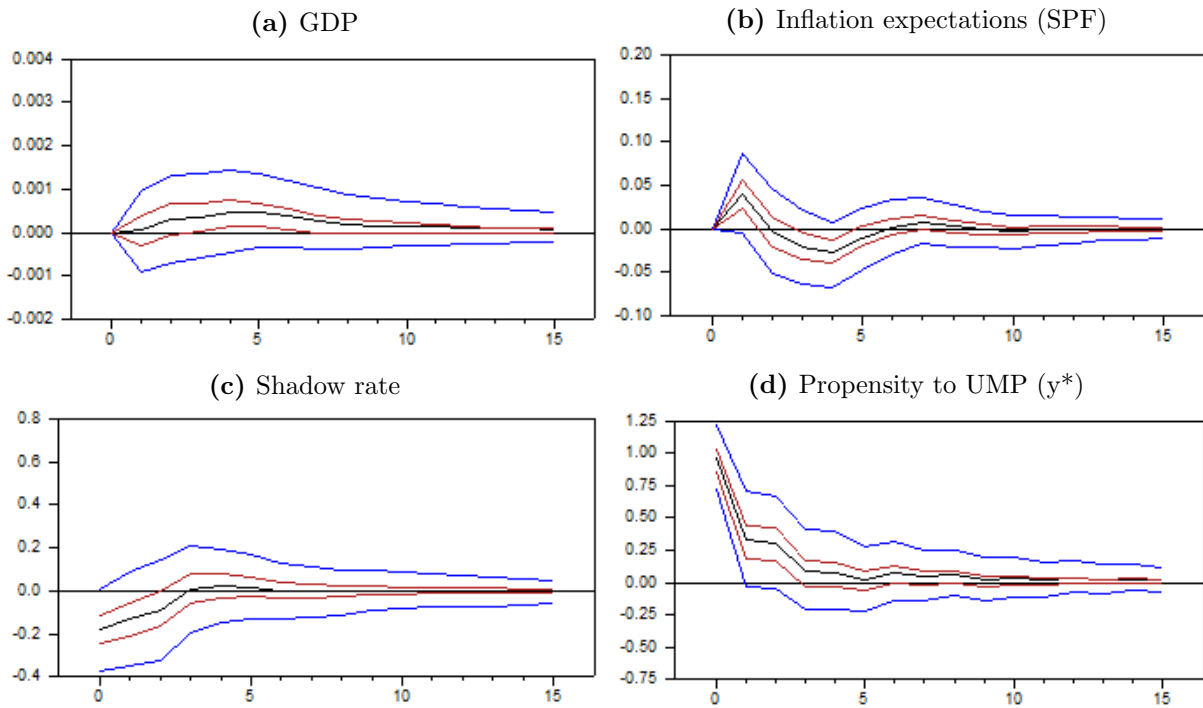
Figure 5: IRFs: Responses to a shock on the latent propensity to EBC's UMP with 68% credible band (red line) and 90% credible band (blue line) with the Krippner (2013) shadow rate.

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