Shadow Short Rate and Monetary Policy in the Euro Area[☆]

Milan Damjanović[1]

Bank of Slovenia

Igor Masten[1]

University of Ljubljana, Faculty of Economics, and Bank of Slovenia

Abstract

Empirical modeling of the monetary policy effects using conventional linear econometric models is put to a great test when interest rates approach the zero-lower bound. A possible remedy recently proposed in the literature is to introduce a shadow short rate (SSR) obtained from the yield curve model as an alternative monetary policy measure. This paper examines the usefulness of shadow rates as a policy stance measure for the Euro area. Moreover, the SSR can be used to study the country-specific monetary policy stance. We incorporate the short shadow rate in a standard vector autoregressive analysis to study the effects of monetary policy shocks both at the level of the Euro area and for two periphery EA countries, Italy and Spain, that endured significant financial stress during the crisis. Our analysis shows that monetary policy shocks identified form the SSR produce similar macro responses as shocks identified from the standard policy rate. The Euro area shocks can directly translate to a corresponding change in the country-specific financing conditions in the periphery, whereas the reverse effect is limited. The historical decomposition of the stochastic component of the SSR series show that the unconventional policy measures were effective in stabilising the sovereign crisis in 2011, however, did not provide sufficient stimulus to offset major negative impacts of the crisis on the real economy.

JEL-Codes: E51, E32, E43, E44, E52, E58

Keywords: Zero lower bound, Shadow short rate, Term structure, European Central Bank, VAR analysis, Historical decomposition

[☆]We would like to thank Leo Krippner for providing the shadow short rate estimates, and the participants of the NoEG meeting 2015 for providing valuable comments.

Email addresses: milan.damjanovic@bsi.si (Milan Damjanović), igor.masten@ef.uni-lj.si (Igor Masten)

[1]The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Bank of Slovenia.

1. Introduction

Since the onset of the global financial crisis, countries around the world have put great effort into reviving the ailing economic activity. Considering the monetary policy perspective, central banks initially resorted to their standard policy measure of reducing main refinancing rates. However, the intensity of the financial crisis and enormous liquidity needs soon exhausted the primary monetary policy option of further reducing interest rates. The period since the beginning of 2009, therefore, resembled the state of near-zero short rates accompanied by various alternative monetary measures in several developed economies.

With policy rates in the zero lower bound (ZLB) range for a prolonged period of time, the practitioners have been put into a very awkward position of not being able to observe the actual stance of monetary policy. This has posed a great challenge to researches dealing with empirical monetary policy to find alternative quantitative measures that would successfully embed the non-standard policy actions and summarize the monetary policy stance for a particular economy also at the ZLB. One possible approach would be to turn attention from the short rates to interest rates of longer maturities that have remained sufficiently above zero and have therefore exhibited enough manoeuvre space for further downward movement. However, movements in the 10-year yield, for example, do not offer a clear interpretation as they may carry other information aside from the stance of monetary policy itself, like changes in the natural rate of interest, inflation expectations, and risk and liquidity premia. The other available variable considered in the literature is the quantity of money. The problem with the latter is its ambiguous relation to macroeconomic variables and non-comparability of transmission channels in the crisis period compared to pre-crisis times. The distorted transmission channels could also clearly be observed in the recent period, where all the standard and non-standard measures have mostly been reflected in increased reserve balance positions and hardly helped to increase the actual level of money in circulation (Krippner, 2015).

Another possibility offered by the literature is the so called Shadow Short Rate (SSR hereafter) obtained by modelling the term structure of the yield curve. Extracting information from the yield curve, in particular the level and the slope, could offer a summary of how monetary policy is perceived by the markets and what are the expectations of the future policy actions and the interest rates. However, since the yield curve modelling could broadly be described as summarizing the information from market interest rates at different maturities, it also requires a zero lower bound adjustment in the crisis period. The zero lower bound term structure modelling has most notably been provided by works of Krippner (2013, 2015) and Wu and Xia (2014).

The advantage of using the SSR in modelling monetary policy is twofold. Firstly, the SSR is not constrained by the zero lower bound and thus allows to combine the data from the ZLB period with the data from the non-ZLB period in a fixed-parameter model. Secondly, it allows us to study the heterogeneity of monetary policy stance across countries of a monetary union provided there is yield curve data at a country level.

This paper conducts the analysis along these two lines. We provide an analysis of macroeconomic effects of monetary policy in the Euro area using the SSR of Krippner (2015). We employ a simple, but tractable empirical framework, in which monetary policy shocks are identified in a VAR model using recursive ordering of variables. Such framework has been extensively used in the literature, which allows a direct comparison with monetary policy shocks identified using conventional a measure of policy rate. Moreover, the analysis is conducted for the Euro area and for two periphery countries, Italy and Spain. The SSR measure evolved significantly different across the core and periphery countries in the crisis period. Provided that the SSR reflects the monetary policy stance, this allows us to study the effectiveness of the ECB policy on the most distressed member countries during the crisis. In addition, such analysis is not limited to the

crisis period. It is true that the differences in the SSR are most pronounced in the crisis period, but differences may arise also in normal times. Modelling monetary policy with the SSR thus potentially allows for studying cross-country heterogeneity in monetary policy transmission of the ECB policy.

Our results show that identified monetary policy shocks with the SSR exhibit similar dynamic effects on prices and output to monetary policy shocks obtained from conventional monetary policy instruments as for example the federal funds rate in the US, or EONIA in the Eurozone. An interest rate hike induces delayed and persistent negative effects on both prices and output. This holds for both the Euro area as a whole and individual countries under investigation. By incorporating the EMU-wide SSR measure into country-specific VAR models, we observe a very straightforward transmission of the common Euro-area policy shock to a country-level monetary stance, but only delayed expected contractionary impact on the real economy.

To the best of our knowledge this paper offers the first analysis of the macroeconomic effects of monetary policy shocks obtained from a SSR measure for the Euro area and some of its member countries. Wu and Xia (2013) provide similar results for the US using their estimate of the SSR in the factor-augmented VAR framework of Bernanke et al. (2005). For the Euro area a similar analysis has not been conducted. Lemke and Vladu (2014) consider the estimation of the SSR for the Euro area using the framework of Wu and Xia (2013). Borstel et al. (2015) use the SSR to evaluate the effects of ECB policy measures on bank lending rates and mark-ups in the Eurozone. Using the same Krippner's (2015) SSR measure, our analysis in contrast studies the effects of monetary policy on output and prices.

The structure of the paper proceeds as follows. Section 2 summarizes the findings of the recent research and results obtained from the other empirical country cases, Section 3 offers a brief overview of the ZLB - Term Structure mechanism and presents the shadow short rate data for the Euro Area, Section 4 offers a standard VAR analysis of macroeconomic effects of monetary policy shocks, identified from the SSR. Section 5 extends the basic VAR analysis to distinguish between the effects of EMU wide SSR and country-specific SSR, where the latter is considered a noisy measure of the monetary stance as it incorporates also a sovereign risk premia. Section 6 concludes.

2. Term Structure Modeling and Shadow Rates in the Analysis of Monetary Policy

The first analysis of monetary policy and its effect on macroeconomy with the use of shadow short rates as a proxy for the monetary policy instrument at the ZLB is provided by Wu and Xia (2013). They use an analytical approximation of the forward rate and apply it to discrete time data. To calculate the effects of US monetary policy actions since 2009 they include the estimated shadow rates into the factor-augmented VAR framework proposed by Bernanke et al. (2005). The estimated impulse responses show consistency in the pre-ZLB period and the period since 2009. In the evaluation of unconventional monetary policy measures Wu and Xia (2013) conclude that the stimulus measures undertaken by the Federal Reserve managed to decrease unemployment by 0.23 % compared to the unemployment rate that would prevail in absence of unconventional policy actions.

Analogous to the Wu and Xia (2013) shadow rates, Krippner (2012, 2013) proposes the approximation of instantaneous forward rates in continuous time. Francis et al. (2014) compare the performance of both alternative measures of SSR. They confirm the results of Wu and Xia (2013) as far as the responses of key macroeconomic variables to a monetary policy shock are concerned, however, they also point out that a linear VAR incorporating the Wu and Xia (2013) shadow rates exhibits a structural break and parameter instability at the onset of the crisis. Conversely, Krippner's shadow rate estimates favor the assumption of a constant parameter

model and results seem to be robust to a choice of the sample period (post WWII sample vs post-Great Moderation sample). According to the results of Francis et al. (2014), Krippner's shadow rate offers a better proxy for the policy instrument, when compared to the Wu and Xia (2013) shadow rates or a naive VAR that simply uses the Federal Funds Rate data also in the ZLB period.

Instead of extracting information from the yield curve by term structure modelling Lombardi and Zhu (2014) calibrate the US monetary policy rate at the zero lower bound by means of dynamic factor modelling, which effectively yields a weighted sum of various monetary policy measures before and during the zero lower bound. The weights are determined by dynamic factor modelling of historical correlation between Federal Funds Rate and monetary policy variables. As in the case of Krippner (2013) and Wu and Xia (2013) shadow short rates, the policy rate obtained by Lombardi and Zhu (2014) tracks closely the movement of FFR before the crisis. Using a standard VAR analysis, they show that compared to their shadow policy rate, using the actual FFR during the ZLB would lead researchers to wrongly assume that too little stimulus had been induced since the beginning of the global financial crisis.

Claus, Claus, and Krippner (2014) verify the usefulness of Krippner (2013) shadow short rates by quantifying the effect of monetary policy shock on asset markets. They apply a latent factor model to daily data on interest rates and asset prices. They found that the shadow short rate represents a good proxy for a monetary policy instrument. The unconventional measures employed by the Federal Reserves are estimated to have a higher impact on interest rates, prices of gold, corporate bonds and the dollar exchange rate, while there was a weaker effect noted for the equity prices compared to the conventional period.

Most of the research mentioned above uses pre-estimated shadow short rates and explores their relation to either macro or asset market variables in a separate model. The term structure modelling, however, can be used in conjunction with macro-finance data. Jackson (2014) incorporates data on unemployment and inflation to the ZLB - Affine term structure model, in addition to unobserved latent state variable summarizing unconventional policies by interpreting it as a monetary policy shock. It turns out, that the macro-augmented term structure modelling produces a more negative short rate with extended projection of the duration of the zero-lower bound period.

While most of the literature is predominantly concentrated on the US and to a lesser extent to the Japanese data, literature on verifying the usefulness of shadow short rate estimates for modelling monetary policy in the Euro area has been rather scarce. Borstel et al. (2015) use the SSR measure for the Euro area to assess the effects of the unconventional monetary policies on the banking system and interest rate pass-through effects during the sovereign crisis. Lemke and Vladu (2014) use shadow term structure modelling to analyze the shifts in the Euro area yield curve during in relation to perceived shifts of the level of the interest rate lower bound. In contrast, our paper focuses on macroeconomic responses rather then on the effects on financial markets.

3. Estimated Shadow Rates

The yield curve represents a relation among yields at different maturities and their evolution over time. The shape of the yield curve, therefore, offers a good indication of expected economic activity, inflation, and monetary policy. With interests near the ZLB, however, there exists a material probability of yield curve evolving to negative values, which could lead to empirically and theoretically inconsistent information. Namely, the negative realizations of some interest rates would not be supported by the observed historical data and would in conceptual terms offer arbitrage opportunity of materializing non-risky profit by holding a physical currency borrowed

at negative rates. In such environment the term structure models have to be adjusted to account for the ZLB. As proposed by Black (1995), this can be done by decomposing the short rate process into a shadow rate that is free to evolve to arbitrary negative values and to a call option offering a payoff to holding a physical currency. The corresponding ZLB adjusted yield curve at time t and as a function of time to maturity τ, denoted as $\underline{R}(t,\tau)$ can then be defined as:

$$\underline{R}(t,\tau) = R(t,\tau) + Z(t,\tau) \tag{1}$$

Where $R(t,\tau)$ represent a shadow yield curve that does not account for possibility of holding physical currency at the ZLB, and $Z(t,\tau)$ representing a call option. The SSR rate is the interest rate of the shortest maturities that is extracted from the shadow yield curve but with parameters estimated in the ZLB-adjusted framework. The specification of the yield curve adjusted for the ZLB and a tractable framework for estimating was proposed by Krippner (2015). The Krippner SSR rates used in this paper were estimated in the Krippner shadow/ZLB term structure framework incorporating two latent factors.[2] Krippner (2015) shows that in comparison to the three-factor model, the two-factor model offers a poorer fit to the yield data, but provides more robust and consistent SSR estimates. Two latent factors relate to the level, intuitively interpreted as the neutral interest rate, and the slope of the yield curve.

This paper examines the validity of the SSR series for the Euro area as a whole and two specific cases representing countries that had been significantly stressed by the global financial crisis: Italy and Spain.[3] For comparison, the SSR is estimated also for two core Euro area countries, Germany and France.

In case of the overall Euro area the interest rate of shortest maturity, extracted from the corresponding shadow yield curve should intuitively represent an analogue to the ECB's Marginal Lending Rate (rate at which Eurosystem banks borrow over night from their respective national central banks). Namely, the Euro area shadow short rate is calculated based on the Euro Overnight Index Average Swap (EONIA Swap) data for period from May 2008 till December 2013 and supplemented by data on German government bond yields for period from January 1995 till April 2008. The overnight indexed swaps (OIS) can be considered as contracts under which one party pays the other the marginal lending rate, compounded over particular horizon, in exchange for a fixed interest at the end of the same horizon. This means that the fixed rates for the EONIA swap contracts should in principal be very closely related to the agents' expectations about the development of the Euro marginal lending rate over the horizon determined by these contracts. Unfortunately, the reliable Bloomberg data for EONIA swaps exist only for the period since May 2008, which is the reason why the series prior to that is supplemented by the German government bond data that is assumed to most closely resemble the Euro area yield curve since the beginning of the sample.

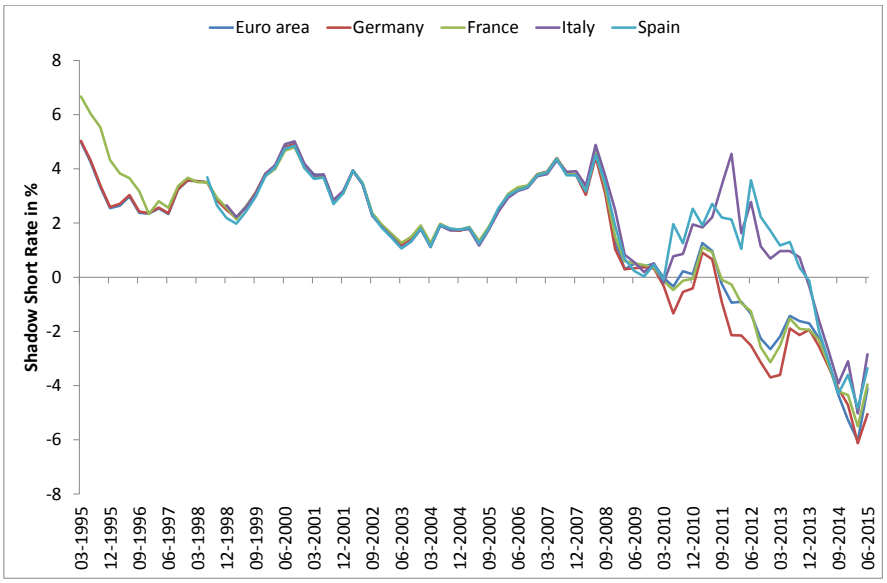
The country-specific shadow rates are estimated based on Bloomberg government bond yields data. The data for Germany and France spans the period from January 1995 till December 2013, data for Italy range from October 1998 to December 2013, and data for Spain range from October 1998 to June 2013. In order to incorporate short- as well as long-horizon expectations about the policy rate, all countries' yield curves include a wide maturity span: 3 months, 6 months, 1, 2, 3, 5, 7, 10, 15, 20, and 30 years. However, when compared to the OIS data, the government bond yields data may be considered as a somewhat noisy measure of expectations about the future interest rates as it may also include other information, in particular credit and liquidity risk. This becomes especially evident in the period of unconventional monetary policies some

[2] We are grateful to Leo Krippner for providing us the estimates.

[3] Other periphery countries are not included in the analysis due to data limitations.

of which were implemented through government bond purchase programs and were therefore directly targeting sovereign bond markets.

Figure 1: Shadow short rate estimates for individual countries and the Euro area



The respective country-specific shadow short rates (SSRs) are depicted in Figure 1. During the ZLB period, the dynamics of German and French SSR evolves to slightly lower values compared to the Euro area SSR estimates. Since the Euro-area SSR is OIS based estimate of its policy expectations, the spreads between Euro SSR and German and French SSR estimates therefore represent pure safety premium. The positive spreads of Italian and Spanish SSR estimates conversely reflect the corresponding higher default risk. The spikes in Italian and Spanish SSR estimates are summarizing the credit issues of those two countries at the peak of the crisis in 2011. The highest spreads between the countries in the sample exceeds 900 basis points at the peak of the crisis and following the lowering of the ECB rate in November 2011 and July 2012. The average spread in the period from 2010 to 2013 between Italian and German SSR rates amounted to more than 350 basis points. In other words, the estimated policy rates clearly summarize the capital outflows from the most distressed countries into the core Euro countries indicating the flight to quality effect. The Italian and Spanish SSR declined in the second half of 2011, with a more notable convergence to the core of the area in the beginning of 2012, coinciding with introduction of several additional non-standard programs and expressed determinations to save the common currency union. The latter could potentially reflect the timing when the ECB measures actually came into effect in the most distressed countries. In Section 5 we analyse whether this convergence in SSR rates can in fact be associated with improved perceived sustainability of the Italian and Spanish debt due to the non-standard measures targeted at reviving most distressed sovereign markets.

The fact that the overall Euro area SSR estimate coincides heavily with the SSR series for

Germany and France is not surprising as these countries represent the very core of the Euro area. In addition, the EA SSR is until 2008 estimated on German data. For these reasons we see the EA SSR as a candidate variable for measuring area-wide monetary policy stance that is representative also for the core Euro area countries. The fact that the SSRs for Italy and Spain deviate quite significantly in the crisis period does not allow for a similar interpretation for the Euro area periphery. For this reason we investigate the transmission between the EA SSR and periphery SSR further in Section 5.

4. SSR as a policy rate

It is important to highlight the fact that the SSR estimates are obtained from financial data. This means that the Euro area SSR is not under the direct control of the ECB, but is governed by the movements in the market yield curve data. The SSR series should, therefore, offer an indication of how have different ECB's measures, including unconventional, influenced market expectations about the monetary policy, rather than being considered to embed all the policy actions directly (Krippner, 2015). In this respect this section analyzes whether the SSR can be used to identify monetary policy shocks. In line with the analysis of Bernanke and Gertler (1996) or Sims (1992) we do this by including the SSR into a VAR system that contains also a measure of output and prices. In particular, our VAR consist of the following variables: the log of real GDP, the log of implicit GDP price deflator, and the SSR. [4] We denote such a VAR as the Shadow VAR. The details of the statistical specification of estimated VARs are deferred to Appendix A, here we present the main results.

Monetary policy shocks are identified by ordering the SSR last in the VAR and using the Cholesky decomposition of the variance-covariance matrix of reduced-form residuals. It is expected that an unanticipated tightening of monetary policy would lead to (delayed) declines in output and the general price level.

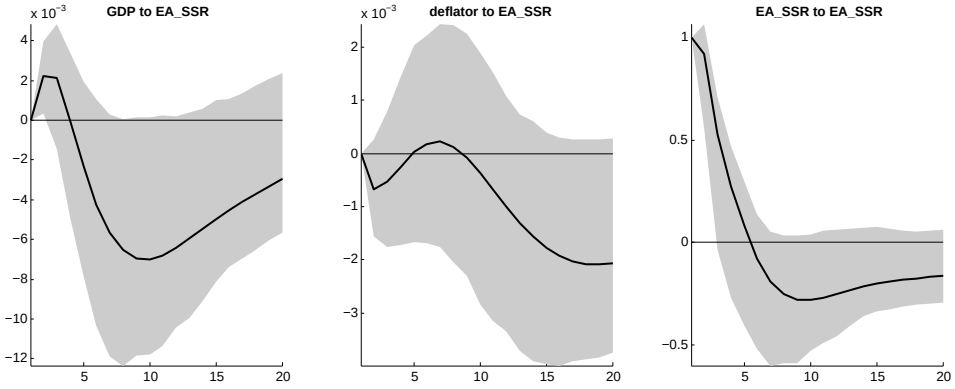
Figure 2 shows the core Euro area impulse response functions for the VAR(3) model, estimated over the 1996Q1-2015Q2 period. An unanticipated shock to the SSR rate produces responses of the real GDP and the price level that are broadly in line with economic theory. After an initial positive, but insignificant, response, output declines steadily, reaching the peak negative effect after 9 quarters. The response of the price level is negative throughout and thus does not exhibit a price puzzle. It achieves the peak negative effect after roughly 16 quarters. Both responses are thus in line with conventional economic wisdom, but compared to some of the findings in the literature, i.e. Smets and Wouters (2002) for the Euro area, the peak expected responses are more delayed and exhibit a higher degree of persistence.

Given that we dispose with the estimates of the SSR also at country level we can perform an analogous analysis for individual Euro area countries. In this respect, Spain and Italy are of particular interest. Namely, as Figure 1 reveals the SSR for these two countries deviated significantly from the EA SSR at the onset of the European debt crisis in 2010, while those of Germany and France closely co-move. Clearly, one cannot interpret the SSRs of Italy and Spain as the pure indicators of the ECB's monetary policy as they are affected also by sovereign risk factors. Nevertheless, we can assume that they summarize the financial conditions in individual countries and we can use them in a similar analysis to trace the effects of exogenous shocks to country-specific SSR measures on the macroeconomy.

Detailed impulse response analysis results for Italy and Spain are presented in Figure B.6 in Appendix B. Here we reproduce the main responses and compare them to the Euro area results

[4] The data are seasonally adjusted. The Euro area data refers to EA12 aggregate.

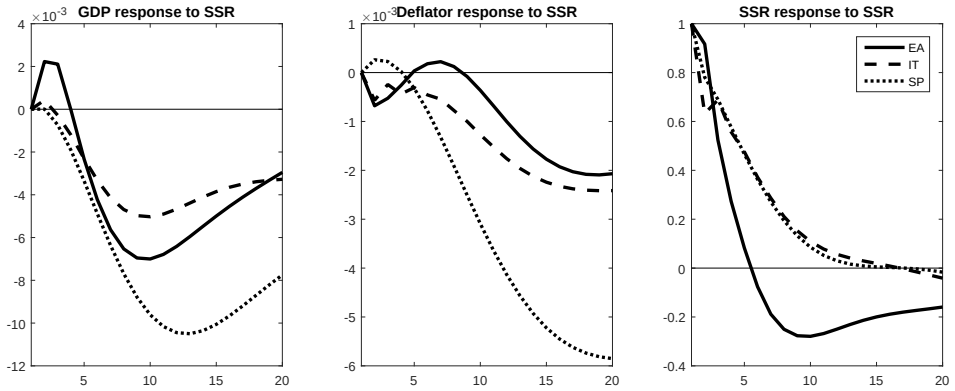
Figure 2: Impulse responses of output and prices to a monetary policy shock in the Euro area



Shaded areas represent 95% confidence intervals.

in Figure 3. The responses are to an exogenous shock to the SSR of equal size (100 basis points) and we can observe from the Figure that the adjustments of the SSRs after the initial shock exhibit a great degree of similarity in the sense that the interest rate hike lasts about 6 quarters in all three cases.

Figure 3: Standardized impulse responses to SSR shock



The dynamics of output responses (expressed as percent deviation from model equilibrium) in Italy and Spain are in line with the EA responses in terms of shape, a similar finding applies to the responses of the Spanish price level. For Italy, however, the effect is weaker, in the medium term about a half of that observed for Spain and the EA as a whole. The responses of prices are negative (without the price puzzle) and initially considerably faster than in the EA. In Spain the negative effect on prices is also considerably stronger [5].

[5]Note that a magnitude of impulse responses must be interpreted with additional caution as the it has been

All in all, the SSR-driven VAR, qualitatively speaking, produces very similar impulse responses to the conventional VAR analysis, but has the advantage of using the data from the ZLB period. Considering the core EA perspective, the macro responses to SSR induced shock evolves similarly as in the US case for the Krippner (2015) type of SSR shown by Francis et. al (2014). Namely, we can observe an anticipated contractionary effect on output after 2 quarters and immediate decline in prices in line with the stylized results set by the monetary policy literature. Moreover, shocks to country-specific SSRs produce similar macroeconomic effects we observe from monetary policy shocks for the Euro area as a whole. The SSR estimates can thus be considered as a good proxy for country-level monetary policy stance across the EA countries.

5. Transmission of (unconventional) monetary policy measures across the Euro zone

In the previous section we established that the Shadow Short Rates can represent a good empirical proxy for the standard monetary policy rate as the identified monetary policy shocks produced similar macroeconomic responses to those reported in literature using standard policy rates. However, our analysis revealed another benefit of using the SSR: the analysis of country-specific policy stances and country-specific macroeconomic responses. In this section we explore cross-country heterogeneity further.

From Figure 1, where monetary stances are compared among countries in our sample, we can observe that initial reductions of the ECB's main refinancing rate in 2009 and 2010 did not produce a policy easing for the most distressed countries, in our case represented as Italy and Spain. As we already stated, the reason for that could be sought in high risk premia that caused much of the liquidity and capital to drain in to better performing countries. In 2011, however, the Italian and Spanish Shadow Short Rates started to converge rapidly to those of the core area countries. This convergence coincides heavily with the introduction of several non-standard monetary programs in 2011, specified directly at reviving sovereign markets, and more determined position that the ECB undertook in preserving the common currency union as exemplified by the "whatever it takes" speech of ECB chairman Mario Draghi in July 2012. In this section we therefore want to examine whether the monetary easing in the most distressed countries can in fact be ascribed to the effectiveness of the ECB's unconventional policies or is the reduction in Italian and Spanish SSRs a natural course of development and consequence of exogenously reduced uncertainty.

We analyze this issue by augmenting the VAR systems for Italy and Spain with the Euro-area SSR, which we order before the country-specific SSR. This implies that within a quarter the EA SSR is exogenous to the country-specific SSR. The Euro-area SSR captures the Euro-wide monetary policy stance, while the country-specific SSR captures the corresponding country-specific financial conditions that may differ from those of the Euro-area as a whole.[6] Structural

shown that the size of estimated shadow rates tends to be model dependent, see for example Christensen and Rudebusch (2015a). This implies that divergence of shadow rates from other traditional policy rates (as for example those derived from a Taylor rule) should not be interpreted as over-expensionary or over-restrictive policy. The literature, however, does show that relative movement and qualitative dynamics stays similar regardless of the model specification. In that sense our cross-country comparison of shadow rate dynamics and the test whether a reduction in SSR has accommodative effects on macroeconomic variables remain valid

[6]In principal, a similar analysis could be conducted also for core Euro area countries. Note, however, that this would be possible only to the extent the EA SSR and country-specific SSR exhibited were stochastically independent. As evident from Figure 1 the EA SSR and Germany's or France's SSR co-move very closely and thus cannot be treated as fully independent. In fact, we verified that estimated VARs for Germany and France incorporating both the EA SSR and the country-specific resulted in a singular covariance matrix of VAR innovations. In such a case, independent shocks to the EA SSR (common monetary policy shocks) and country-

shocks are again identified by the Cholesky decomposition of the variance-covariance matrix of the estimated reduced form VAR innovations.[7]

The results of impulse response analysis are for easier comparison both for Italy and Spain presented in Figure 4). Results for Italy and Spain individually, with confidence intervals for impulse responses are deferred to Appendix B (see Figures B.7 and B.8). The left panel of Figure 4 contains the responses to an identified common monetary policy shock (induced by the ECB), while in the right panel there are responses to a country-specific financial conditions (exogenous shock to a country SSR orthogonal to the ECB monetary policy shock).

The effects of common monetary policy shocks on GDP and the price level are broadly in line with theory and comparable to those for the Euro area as a whole (see Figure 2). The significantly negative effect on output comes with a delay of about one year and is stronger and more persistent for Italy. The negative effect of common monetary policy shock on prices is faster and stronger for Spain (for Italy the effect is statistically significant only for about a year after the shock, see Figure B.7). We can also observe that the common monetary policy shock induces a very strong co-movement between the EA SSR and country-specific SSR. The transmission common monetary policy is immediately and to a large extent rather directly observed in peripheral countries' financial conditions. Namely, to a 100 basis points increase in the EA SSR the Italian and Spanish SSRs increase by more than 60 basis point on impact.

Exogenous shocks to country-specific SSRs result to be quite persistent and exhibit a great degree of similarity between Italy and Spain (see bottom right of Figure 4). In addition, they also cause contractionary effects. It is interesting to note that the negative effect on output comes without a delay observed for the common monetary policy shocks and are stronger and more persistent for Spain. This indicates that the divergence of SSR between the core and periphery of the Euro area we observed after the eruption of the European sovereign crisis in the period 2010-2012 contributed significantly to the negative output performance in the periphery. The effect of country-specific shocks on prices are similar to those of the common monetary policy shocks, the only notable difference is perhaps a one-year delay observed for Spain.

While we noted that the transmission of common monetary policy shocks to national financing conditions is rather strong and direct, the converse is not true. The feedback effect of shocks originating in the periphery to the core of the Euro area is weak and, as can be observed from Figures B.7 and B.8, statistically insignificant. This is an indication that the sovereign crisis in the Euro periphery might have had only a limited destabilizing effect on the Euro core.

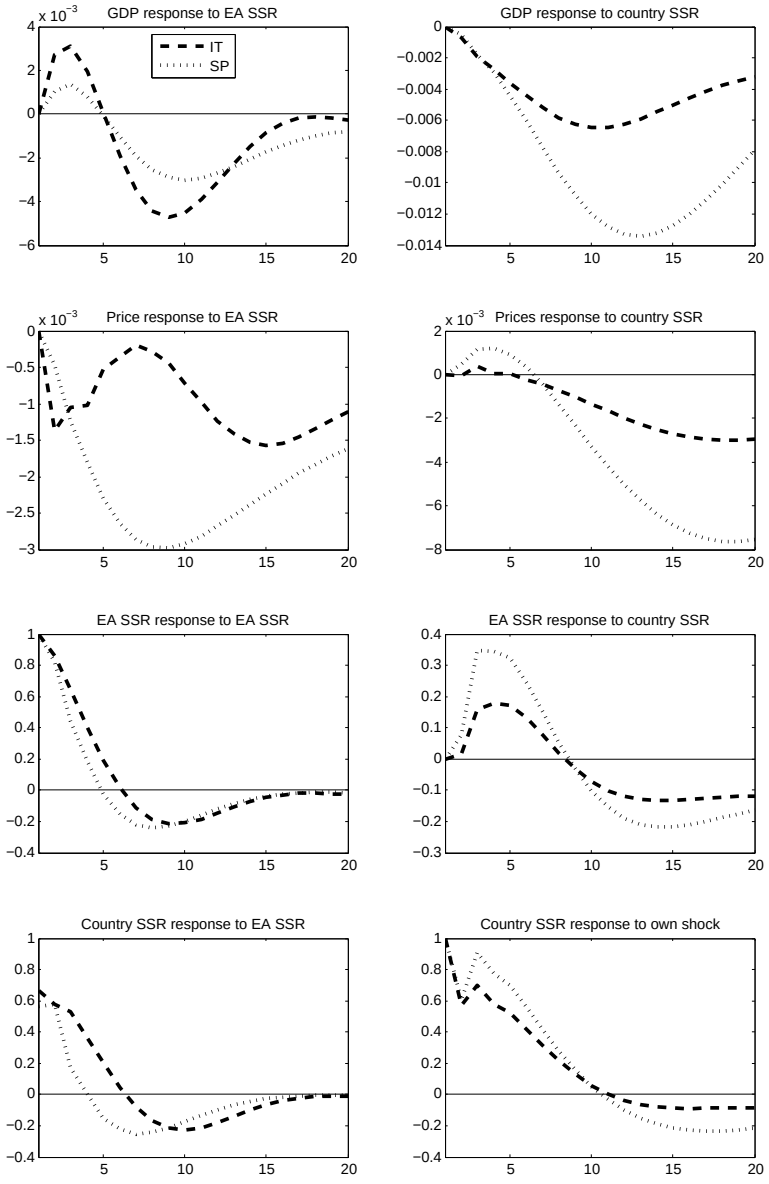
More on the effects of common monetary policy in the crisis period and the effects of unconventional monetary policy measures at the zero lower bound can be inferred from the historical decomposition of variables. In particular, we focus on stochastic components of real GDP and country-specific SSR. The results of historical decomposition are presented in Figure 5, which at the bottom for comparison reports also the corresponding historical decomposition of the Euro area GDP and the Euro area SSR.[8]

specific SSR cannot be identified. From the point of view of our modeling framework the policy stance of the EA core is most directly determined by the ECB and reflected in the EA SSR.

[7]We checked for robustness of our results by considering sign-restrictions as an alternative identification approach. The impulse response analysis remains qualitatively largely unaltered, which confirms the sensibility of our benchmark identification approach. Results are available upon request.

[8]The results for the Euro area historical decomposition are from the Euro area VAR we used to produce the impulse response analysis in Figure 2.

Figure 4: Standardized impulse responses to Euro area and country-specific shadow rate shocks



From the bottom left of Figure 5 it follows that the common monetary policy stance significantly relaxed in 2010 and between the second half of 2011 and third quarter of 2012. In the latter period, this translated to easier financing at the Euro area periphery. Both for Italy and

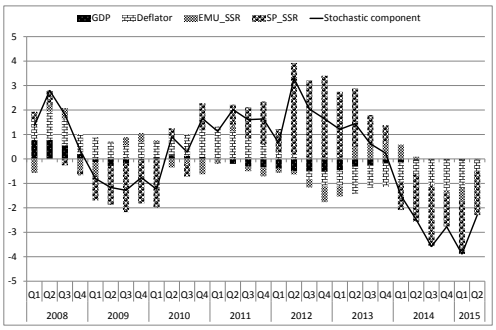
Spain there is a clear and significant dampening effect of common monetary policy (EMU_{SSR} shocks) on country-specific SSRs coming to effect in the second half of 2011 and persisting over 7 quarters. This is an indication that the ECB unconventional measures were indeed helpful in countering the sovereign crisis and reviving the government bond markets. In contrast to the effect on financial markets, however, the ECB policy measures seemed not to have produced a stimulating effect on the real economy, especially in the Euro area core. In contrast, a stimulative effects can be observed for Italy, coming into effect in 2013, while for the case of Spain, unconventional monetary programms seem to have no effect on Spanish GDP.

These results are in line with the results of impulse response analysis, from which we either observed significant delays in the effect of common monetary policy shocks on output (Euro area) or, as it was case for Spain, we observed insignificant effect on output. From the historical decomposition we can also see there was insufficient monetary stimulus provided 2009 and in the first three quarters of 2011 and given the time delays in the effect on output, the monetary policy stance seemed to be to restrictive for the output dynamics for the major part of the Great recession in Europe. Moreover, this has been more so for the countries at the periphery that found themselves under significant pressure of international financial markets.

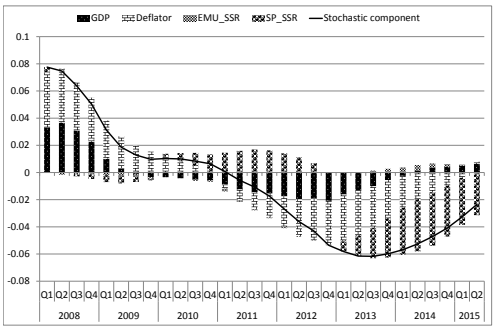
Additional rationale for the above results could be found in the nature of the Eurozone and the difference in the ECB's mandate compared to the other major central banks. Given the banking orientation of Euro economies, the majority of the non-standard measures devised by the ECB were directed towards providing sufficient liquidity to banking sector in form of long-term refinancing operations (LTROs). Compared to the FED whose measures have actively been employed in public as well as in the private sector, an important share of the Euro LTROs was utilized by Spanish and Italian banks who directly transmitted this excess liquidity into local sovereign markets where they were able to generate far greater yields than in the private sector. While revived sovereign markets have restored the confidence in the Euro area it has also strengthened the euro that appreciated considerably towards all major currencies. In addition to hindered liquidity transmission to private sector, the Euro-area SMEs were therefore put into a worse competitive position also from the perspective of the exports activity (Benassy-Quere et al., 2014). On the other hand, cheaper imports had a further downward effect on already deflationary environment, essentially preventing the real interest to fall and to affect the economy in expansionary manner. This means that while easing effect could be observed in the Euro area financial and sovereign markets, the ECB policy has in fact remained relatively restrictive from the perspective of the real economy.

Figure 5: Historical decomposition

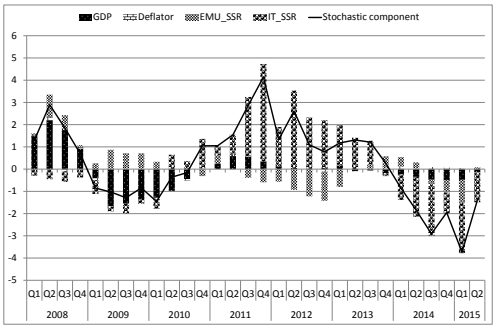
(a) HD SSR - Spain



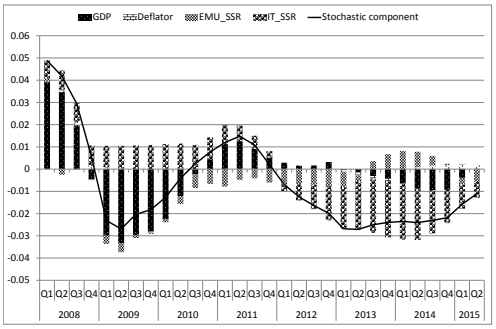
(b) HD GDP - Spain



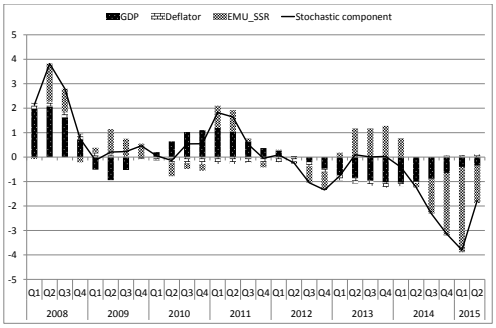
(c) HD SSR - Italy



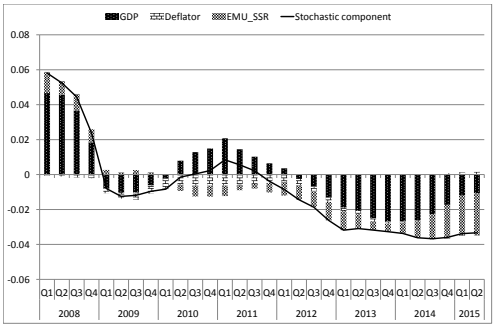
(d) HD GDP - Italy



(e) HD SSR - Euro area



(f) HD GDP - Euro area



6. Conclusion

Measuring monetary policy stance and the analysis of monetary policy transmission in a zero-lower-bound environment represent a great challenge for applied macroeconomic research. A measure that is gaining ever more popularity in the empirical literature is the shadow short rate extracted from the yield curve using a term structure model adjusted for the ZLB. The shadow short rate mimics the movement of standard policy measures when interest rates are positive, but is able to evolve to negative values when the policy rate is caught at the zero lower bound. This paper examines the informational content of Krippner's (2013) shadow short rate estimated for the Euro area and two periphery member countries, Italy and Spain, that were adversely affected by the European sovereign crisis of 2010.

We employed the SSR estimate as a policy measure in a standard VAR analysis commonly used in the empirical monetary policy literature. For all cases, the macro impulse responses qualitatively mimic the stylized results expected by the conventional monetary wisdom, implying that the SSR rates could be considered as an alternative policy stance measure when interest are bounded by the zero lower bound. By examining the effectiveness of the Euro-area common policy on the cases of Italy and Spain we showed that common monetary policy shocks almost directly translate to financing conditions of both the core and periphery Euro-area countries. From this perspective, the non-standard measures resulted effective in restoring the stability of sovereign bond markets in 2011, however, the stimulative effects on real economic activity, operating with significant time lags, could be identified only towards the end of our estimation sample in 2013 for the case of Italy, while it had negative or no effect for the core Euro area and Spain, respectively. This implies that till the end of 2013 the ECB measures provided only limited stimulus to the real economy, especially so from the perspective of the Euro-area core.

References

[1] Aastveit, K. A., Carriero, A., Clark, T., & Massimiliano, M. (2014). *Have Standard VARs Remained Stable since the Crisis?*. Available at `http://www.norges-bank.no/en/Published/Papers/Working-Papers/2014/13/`.

[2] Bank for International Settlements (2015). *Ultra-low or negative interest rates: what they mean for financial.*. Available at `www.bis.org/speeches/sp150424.pdf`.

[3] Benassy-Quere, A., Gourinchas, P. O., Martin, P., & Plantin, G. (2014). The euro in the 'currency war'. *CEPR: Policy Insight, No. 70.*

[4] Bernanke, B. S., Boivin, J., & Eliasz, P. (2005). Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR). *Quarterly Journal of Economics, Vol. 120.*

[5] Bernanke, B., Getler, M., & Glichrist, S. (1996). THE FINANCIAL ACCELERATOR AND THE FLIGHT TO QUALITY. *The Review of Economics and Statistics, Vol. LXXXVIII(1)*

[6] Black, F. (1995). Interest Rates as Options. *Journal of Finance, pp. 1371-1376 Vol. 50 (5)*

[7] Borstel, E., Eickmeir, S., & Krippner, L. (2015). *The interest rate pass-through in the euro area during the sovereign debt crisis.* Available at `https://www.bundesbank.de/Redaktion/EN/Downloads/Publications/Discussion_Paper_1/2015/2015_06_05_dkp_10.pdf?__blob=publicationFile`.

[8] Claus, E., Claus, I., & Krippner, L. (2014). *Asset markets and monetary policy shocks at the zero lower bound.*. Available at `http://www.rbnz.govt.nz/research_and_publications/discussion_papers/2014/dp14_03.pdf`

[9] Francis, N. R., Jackson, L. E., & Owyang, M. T. (2014). *How Has Empirical Monetary Policy Analysis Changed After the Financial Crisis.*. Available at `http://research.stlouisfed.org/wp/2014/2014-019.pdf`.

[10] Holzhausen, A., & Sikova, S. (2014). *The impact of the low interesst rate policy on private households in the eurozone.* Available at `https://www.allianz.com/en/economic_research/publications/working_papers/europe/lowinterest14.html/`.

[11] Jackson, L. E. (2014). *Monetary Policy, Macro Factors, and the Term Structure at the Zero Lower Bound.*. Available at `http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2474128`

[12] Krippner, L. (2012). Modifying Gaussian term structure models when interest rates are near the zero lower bound. *Reserve Bank of New Zealand Discussion Paper Series.*

[13] Krippner, L. (2013). A tractable framework for zero lower bound Gaussian term structure models. *Bank of New Zealand Discussion Paper Series.*

[14] Krippner, L. (2014). Measuring the stance of monetary policy in conventional and unconventional environments. *CAMA Working Papers.*

[15] Krippner, L. (2015). *Zero Lower Bound Term Structure Modeling.* New York: PALGRAVE MACMILLAN.

[16] Lemke, W. and A. L. Vladu (2014). *A Shadow-Rate Term Structure Model for the Euro Area*. Available at https://www.ecb.europa.eu/events/pdf/conferences/140908/lemke_vladu.pdf?68b4093d2247e1d0ff5159d1b7b0347b.

[17] Lombardi, M. and F. Zhu (2014). *A shadow policy rate to calibrate US monetary policy at the zero lower bound.*. Available at http://www.bis.org/publ/work452.htm.

[18] Sims, C. A. (1991). *INTERPRETING THE MACROECONOMIC TIME SERIES FACTS: THE EFFECTS OF MONETARY POLICY*. Avaialable at http://sims.princeton.edu/yftp/Madrid/EER4.pdf

[19] Smets, F. and Wouters, R. (2002). AN ESTIMATED STOCHASTIC DYNAMIC GENERAL EQUILIBRIUM MODEL OF THE EURO AREA. *ECB WORKING PAPER SERIES, No. 171.*

[20] Wu, J. C., & Xia, F. D. (2013). *Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound.* Available at http://faculty.chicagobooth.edu/jing.wu/.

Appendix A. VAR results and residual analysis

The VAR order was selected based on the most frequently suggested lag order by the 4 different information criteria starting from a maximum lag length of 10 quarters and corrected the lag length if necessary in case the model exhibited residual autocorrelation. If necessary we added dummy variables to address potential outliers in distributions of residuals. Based on repeated residual analysis, a model offering a better statistical specification was selected for the purpose of impulse response analysis. Final model contained 2 lags for Italy, whereas in lag order 3 and 4 were used for the Euro area and Spain respectively.

Table A.1: Specification tests of estimated VAR models

	cons. & trend	cons., trend & dummy
	Euro area	
LM	6.11	22.1**
Jarque Bera	15.5**	14.5**
	Italy	
LM	17.9*	17.8**
Jarque Bera	9.11	11.0*
	Spain	
LM	20.7**	9.36
Jarque Bera	3.99	6.68

Appendix B. Impulse responses to Euro area and country-specific shadow rate shocks

Figure B.6: Impulse responses of output and prices to a monetary policy shock in Italy and Spain

(a) Italy

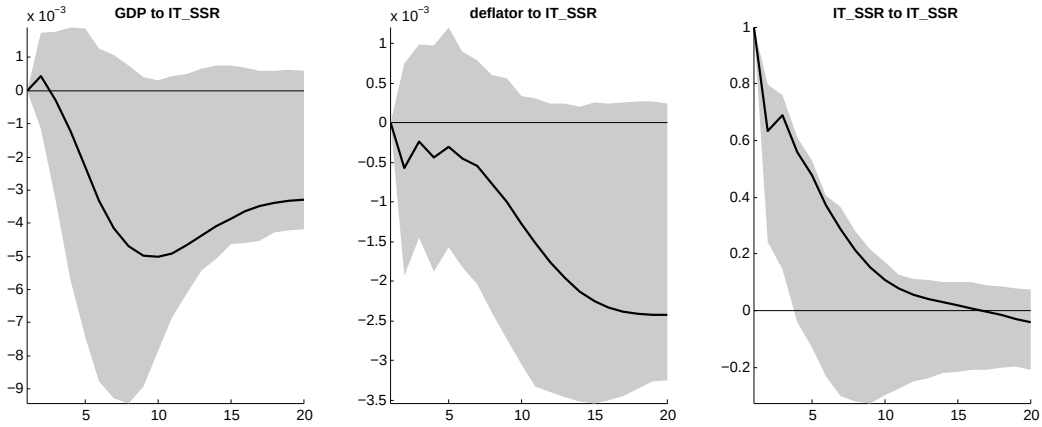
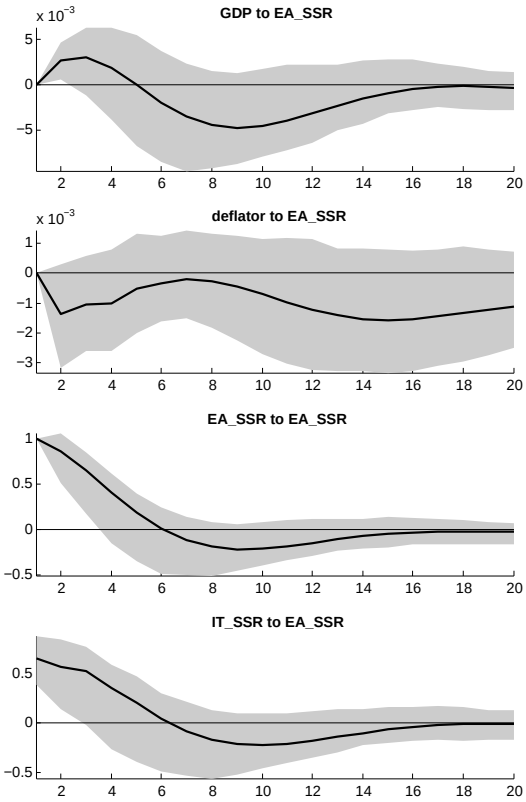


Figure B.7: Impulse responses to Euro area and country-specific shadow rate shocks - Italy

(a) Euro area SSR shock



(b) Italian SSR shock

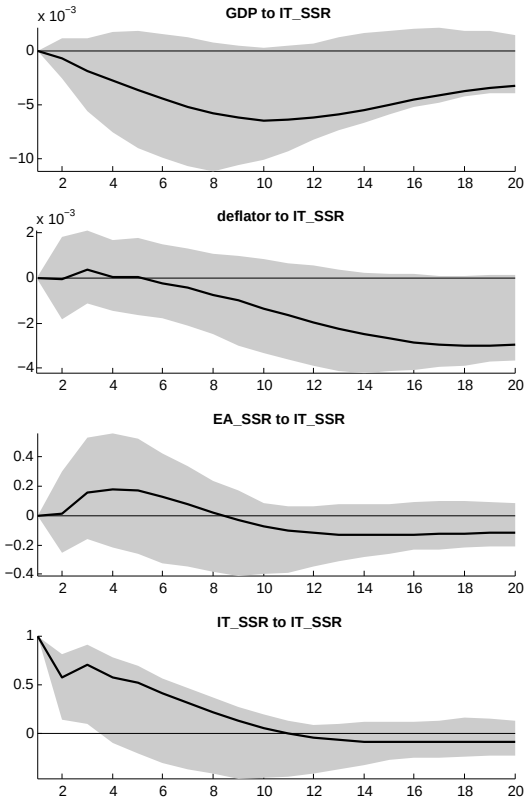


Figure B.8: Impulse responses to Euro area and country-specific shadow rate shocks - Spain

(a) Euro area SSR shock

(b) Spanish SSR shock