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UNCONVENTIONAL MONETARY POLICY AND HETEROGENEITY OF MONETARY TRANSMISSION

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UNCONVENTIONAL MONETARY POLICY AND HETEROGENEITY OF MONETARY TRANSMISSION

Abstract

The severity of the global financial crisis, erupting in 2008, forced central banks in most of the developed economies into intense and reactionary cutting of main interest rates. With key interest rates at historically unprecedented low levels, monetary authorities adopted a variety of unconventional measures in attempt to provide additional stimulus to the economy beyond standard interest policies. This dissertation offers a timely exposition of the tools developed to quantify the monetary stance once the interest rates become uninformative, and it analyzes the effectiveness of unconventional monetary policies in the Euro area.

The dissertation is divided into four parts. The first part provides a detailed topic overview and contextual placement for the dissertation. The second part analyzes the impact of the announcements of unconventional monetary policies on the Euro-area bond markets. In particular, to isolate the role of the ECB, the Euro-area yield changes are examined inside a one-day window surrounding the announcement of selected non-standard measures. Furthermore, for the purpose of determining the channels through which the monetary policy operates, the Arbitrage-free Nelson Siegel model adjusted for lower bound is employed in order to decompose yield changes into the part corresponding to monetary policy expectations and the part related to the change in term premium. Focusing on seven particular announcement dates, the analysis shows that the non-standard measures introduced before 2014 did not manage to produce a wider reduction of the Euro-area yields. The reasons are twofold. First, the non-standard measures have been highly targeted to specific market segments and countries, which caused a considerable degree of heterogeneity in response across the Euro area. Second, the detailed yield decomposition reveals that financial markets did not recognize a permanent shift toward the expansionary policy, but they expected a correction to follow in the near future instead.

The third part examines the usefulness of the recently proposed shadow short rates (SSR) as an alternative policy stance measure for the Euro area. Moreover, the SSR can be used to study the country-specific financing conditions and liquidity stance. The shadow short rate is incorporated in a standard vector autoregressive (VAR) 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. The results of the analysis show that the monetary policy shocks identified from the SSR produce similar macro responses as shocks identified by a 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 stochastic component of the SSR series shows that the unconventional
policy measures were effective in stabilising the sovereign crisis in 2011, however, their relatively limited quantity provided only a weak stimulus to the economy.

The fourth part elaborates on the analysis conducted in the second part. It revisits the analysis of monetary policy transmission by employing a Factor Augmented VAR (FAVAR) framework. The structural analysis shows that FAVAR successfully overcomes the anomalies related to the baseline monetary VAR model, in particular the puzzling price responses. In addition, with an attempt to find most suitable alternative monetary stance measure from the perspective of the Euro area, it compares the performance of three recently proposed alternative measures and their ability to meaningfully summarize the Euro area monetary policy in the combined period of the global financial crisis and the zero lower bound. The alternative measures considered are the Economic Measure of Stimulus, introduced by Krippner (2014), and two respective shadow short rate measures obtained from the respective benchmark term structure models, proposed by Wu and Xia (2016) and Krippner (2011-2015). The analysis shows that the Euro-area monetary policy shock is consistently identified through Economic Measure of Stimulus, which is also the measure exhibiting the highest robustness and consistency with the actual monetary policy events. The Economic Measure of Stimulus is then used to perform a counter-factual analysis to examine the effectiveness of the ECB's unconventional monetary policies. The results suggest that the realization of the Euro area industrial production index could have potentially been lower by up to 0.8%, had the non-standard measures not been introduced by the ECB.

This dissertation contributes to the field of science both from the aspect of analysing the effects of the non-standard measures in the Euro area as well as from the perspective of empirical modelling of monetary policy. First, the dissertation offers a clear outline of the channels through which the monetary policy decisions are translated to the general financing conditions in unconventional times. This is particularly important as the functionality of policies beyond interest rates will essentially be determined by their ability to steer monetary policy expectations. Furthermore, to the extent of the literature considered, it is the first to examine the usefulness of the shadow rate measures and the economic stimulus measure for assessing the Euro area monetary stance. Moreover, it also considers the usefulness of shadow rates from the perspective of individual countries that no longer practice their own monetary policy and by that offers an insight into the heterogeneity of monetary transmission in the crisis period. Finally, the dissertation offers a timely assessment of effectiveness of the non-standard programs in reviving the economic activity in the Euro area.

Keywords: unconventional monetary policy, zero lower bound, ECB, term structure modelling, shadow rate, structural VAR, FAVAR
NEKONVENCIONALNA MONETARNA POLITIKA IN
HETEROGENOST MONETARNE TRANSMISIJE

Povzetek

Resnost globalne finančne krize, ki je nastopila v letu 2008, je mnoge centralne banke v razvitrških ekonomijah prisiliša v intenzivno in reakcijsko nižanje obrestnih mer. Ob zgodovinsko nizkih n Kohovih ključnih obrestnih mer so bili sprejeti številni nekonzencionalni ukrepi z namenom zagotavljanja dodatnih sposobnosti gospodarstvu. V tem kontekstu disertacija nudi časovno relevantno analizo učinkov nekonzencionalnih politik Evropske centralne banke in razvoj metodoloških konceptov za ovrednotanje monetarnih politik v času, ko obrestne mere včelj ne zagotavljajo tovrstne informacije.

Disertacija je razdeljena na štiri dele. V prvem delu je podana podrobnna predstavitev problema in kontekstulana umestitev disertacije v trenutno ekonomsko stanje. V drugem delu je predstavljena analiza odzivov dolžinskih trgov na napovedane programe ne-standardne monetarne politike. Natančneje, z namenom osamitvave vloge ECB v obdobju finančne krize in ničelnih obrestnih mer od ostalih dejavnikov analiza preučuje spremembe donosov evrskih finančnih trgov, ki so se zgodili znotraj enega dneva ob uradnih napovedih obrestnih mer. Še več, da bi jasno določili kanale preko katerih se monetarna politika implicira na finančne trge, so spremembe v donosih razdeljene na spremembe v pričakovanjih glede bodočih monetarne politike in na spremembe v terminski premiji donosov, za kar je bil uporabljen Arbitrage-free Nelson Siegel terminski model z vgrajeno spodnjo mejo za obrestne mere. Analiza sedanjih uradnih napoveditev ne-standardnih ukrepov kaže, da ti niso proizvili znatnega znižanja evrskih donosov pred letom 2014. Za to obstajata dve razlagi. Prvič, nestandardni ukrepi so bili močno osredotočeni na specifične tržne segmente in državo, kar je privedlo do močne heterogenosti v odzivu. Drugič, modelska razdelitev sprememb donosov kaže, da trgi v ukrepih niso prepoznali trajnejšega premika k ekspanzivni monetarni politiki.

Tretji del preučuje primernost uporabe v literaturi nedavno predstavljene koncepta senčnih obrestnih mer kot alternativne mere monetarne politike v Evro območju. Še več, senčne obrestne mere je prav tako moč obnavljati z vidika posameznih držav, njihovih pogojev zadolževanja in likvidnostnega stanja. V analizi so senčne obrestne mere vključene v standardno monetarno vektorsko avtoregresijo (VAR) z namenom preučevanja učinkov monetarne politike, tako z vidika celotnega Evro območja kot tudi z vidika dveh perifernih držav, Italije in Španije, ki sodita med države, ki so doživele najmočnejši finančni šok. Rezultati kažejo, da je s pomočjo senčnih obrestnih mer moč identificirati monetarne šoke z zelo podobnim vplivom na makroekonomske spremenljivke kot v primeru konvencionalnih mer monetarne politike. Poleg tega je iz analize razvidno, da se šok skupne monetarne politike močno in skoraj v celoti odraža v pogojih financiranja posameznih držav članic, medtem ko šok v posameznih državah nima večjih destabilizaci-
jskih vplivov na celotno Evro območje. Nadalje, historična dekompozicija stohastične komponente senčnih obrestnih mer kaže, da so bili nekonvencionalni ukrepi učinkoviti z vidika stabilizacije dolžniške krize v 2011, a so bili njihovi učinki z vidika realne ekonomije neznatni.


Prispevek disertacije k ekonomski znanosti je moč opredeliti tako z vidika analize učinkovitosti nekonvencionalnih politik v Evro območju kot tudi z vidika modeliranja monetarne politike. Prvič, disertacija nudi jasno opredelitev kanalov, skozi katere se monetarna politika odraža na finančnih trgih v času krize. To je še z lasti pomembno z vidika funkcionalnosti nestandardnih ukrepov, ki je pogojena z njihovim vplivom na pričakovana o bodoči monetarni politiki. Drugič, disertacija kot prva preučuje uporabnost senčnih obrestnih mer in mere monetarne ekspanzije z vidika ovrednotenja monetarne politike v času ne-informativnih ključnih obrestnih mer. Še več, z vidika obravnave senčnih obrestnih mer v kontekstu posameznih držav, disertacija nudi vpogled v heterogenost monetarne transmisije v času krize. Kot zadnje, disertacija nudi ažurno oceno učinkov nekonvencionalnih ukrepov monetarne politike na gospodarstvo Evro območja.

Ključne besede: nekonvencionalna monetarna politika, ničelna meja obrestnih mer, ECB, terminski strukturni model, senčna obrestna mera, strukturni VAR, FAVAR
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Introduction

This dissertation has been highly motivated by, at the time of writing, a prevailing low interest rate environment and monetary policy conduct that has in many ways been unprecedented historically. In response to the global financial crisis, erupting in 2008, the key policy rates have, short into the crisis, been brought to near zero levels in most of the developed economies around the world. Therefore, to properly accommodate for the severe adversity caused by the financial meltdown, the primary policy instrument of the central banks had to be complemented by various unconventional monetary policies. These policies have predominantly been connected to extended liquidity provisions and measures affecting asset prices and money market rates by expanding central bank balance sheets. In addition, many central banks engaged in the active use of the forward guidance, that is, employing a communication strategy to steer market expectations about future monetary policy. Proving that the European Central Bank has been no exception in this are at least nine programs, introduced between the years 2008 and 2015, that can be classified as non-standard and were specifically devised to tackle different aspects obstructing the monetary transmission in the Euro area. The scope of the non-standard programs introduced may best be resembled in the amount of ECB’s total assets that were at the end of 2015 more than double compared to the end-year stock position in 2007. With the development of the crisis in Europe we can also observe a clear shift towards a more assertive communication strategy employed by the governing bodies of the ECB, landmarked with the renowned speech of president Mario Draghi at the peak of the sovereign crisis in 2012, stating: "(...)the ECB is ready to do whatever it takes to preserve the Euro. And believe me, it will be enough!".

A near zero interest rate environment has, to a large extent, been considered a novelty that arose with the latest crisis in the most parts of the developed world with the exception of Japan. In that respect, the unconventional monetary policies remain a relatively unexplored field from both, the methodological and conceptual point of view. With regard to the methodological aspect, a question that naturally imposes is how to properly quantify the stimulus, induced by non-standard programs, and how to measure the monetary stance, once the key interest rates become uninformative. With respect to the conceptual aspect the existing stylized relations to macroeconomic variables and channels of monetary transmission need to be revisited. Although alternative measures of the monetary stance have been considered in past in the context of applied monetary policy research, none of them exhibited satisfying empirical and theoretical consistency to robustly quantify the contraction or stimulus induced to the system. For example, the practitioners often resorted to longer-term interest rates which could potentially offer an indication of the monetary policy expectations. However, long-term interest rates also indicate the excessive return demanded by investors for bearing additional risk connected
to the unknown future state of the economy, which introduces a noise in the information associated with the state of monetary policy. In similar fashion the quantity of money could be considered as a compelling alternative, but has empirically exhibited inconsistent relations to macroeconomic variables, often not reconciled with the monetary theory.

In contrast, information extracted from the yield curve models seems to offer the most parsimonious indication of future economic activity and monetary and inflation expectations, the concepts that in essence govern monetary policy decisions. Yield curve models are essentially factor models, that is, they re-express interest rates as a function of residual maturity and components driving the common dynamics of yield curve data. The estimated yield curve model parameters are used to simultaneously determine the relation of interest rates of different maturities at a given point in time, where the shape of the estimated yield curve indicates the market expectations related to the future monetary policy. Therefore, as long as monetary measures effectively influence market expectations, they will be captured by the yield curve models, regardless of whether policy actions are conducted via conventional interest rate channels, large asset purchases, extended long term refinancing, or a combination of all (Krippner, 2015b). While the application of yield curve models was very straightforward and popular among practitioners before the financial crisis, the extremely low interest rate environment revealed an important flaw of these models. Namely, the model implies a future path of interest rates as random dynamics following the Gaussian distribution around the observed current estimated state, which potentially leads to negative predictions of future rates. In this fashion, arbitrage opportunities are allowed, which makes yield curve models theoretically infeasible as well as empirically inconsistent since the negative rates have not been observed historically.

In that respect, the yield curve models have to properly account for the zero lower bound (ZLB) in order to still be able to provide reliable information on the current monetary policy stance.

In recent years, there has been growing literature on the proper adjustment of yield curve models for the lower bound, where the majority of the research relies on re-expressing interest rates as maximum of the shadow rate (a rate that is free to evolve to arbitrarily negative values) and zero, as proposed by Black (1995). This dissertation puts special focus on somewhat competing concepts, proposed respectively by Wu and Xia (2016) and Krippner (2011-2015) for approximating the Black’s (1995) framework. The works of these authors are singled out as they both advocate the use of interest rates of the shortest maturity, extracted from the shadow part of the estimated ZLB yield curve, as an alternative measure for monitoring monetary stance. The usefulness of the proposed shadow rates was tested on the US data and was extensively used to analyse the effectiveness of the US monetary policy during the ZLB, see for example Wu and Xia (2016) or Francis et al. (2014). In addition to the shadow short rates, Krippner (2014, 2015a) proposes an additional and more robust measure of monetary stance that relates the expected path
of the short rates to the neutral rate, where the latter indicates neither restrictive nor stimulative monetary policy. The aim of this dissertation is to utilize the newly developed concepts in analysing the unconventional monetary policy and its transmission to the Euro area.

Research questions

In line with the overview and motivation outlined above we can divide the research questions into two categories:

Research questions related to the analysis of unconventional monetary policies in the Euro area:

- Q1: What was the role of the ECB in averting the consequences of the global financial crisis and how credible this role was in the eyes of the financial markets?
- Q2: How effective were the non-standard measures introduced by the ECB in improving financing conditions?
- Q3: How effective were the non-standard measures introduced by the ECB in restoring the real economic activity?
- Q4: How did a common monetary policy affect individual member countries in the Euro area?

Research questions related to the empirical modelling of monetary policy in the ZLB environment:

- Q5: How can we properly model monetary policy expectations in the ZLB environment?
- Q6: How to properly quantify the stimulus provided by the non-standard measures?
- Q7: What is the adequate alternative monetary stance measure for the Euro area, once the key Euro interest rates become uninformative?
- Q8: What is the appropriate framework for assessing the effects of monetary policy and its transmission to the Euro area?

Surrounding the questions stated above, the dissertation is divided into four chapters. The chapters are natural continuations of each other from the aspect of empirical modelling as well as the general assessment on the effectiveness of unconventional monetary policies in the Euro area. The next paragraphs briefly describe how the postulated questions are addressed within each research paper.

First chapter provides a detailed topic overview and discusses the issues related to the analysis of monetary policy in the extended crisis and the lower bound period. It explains
how the conventional notion of the monetary policy changed with the crisis and what complications has the change brought from the perspective of effectiveness of monetary transmission and for the practitioners that are trying to understand it. The response of the ECB to the crisis is presented chronologically and compared to the responses of other central banks. In parallel, the general macroeconomic and financial developments are observed with an attempt to provide a first glance on monetary transmission and its effectiveness in the period between 2008 and 2015. In addition, this chapter discusses recommendations, drawn from the recent empirical evidence and theoretical models, that should be followed if maximum effect of the unconventional monetary policy is to be achieved. Namely, the case of Japan, which economy experienced a prolonged period of extremely low interest environment, and structural theory-based modelling have shown that interconnectedness of different unconventional policies will crucially determine their success. That is, the credit and quantitative easing should be accompanied by a transparent forward guidance of a central bank stating the future path of monetary policy, whereas the forward guidance should likewise be supported by the actual tangible programs.

The second paper examines to what extent have these recommendations been considered by the ECB by decomposing the channels through which the monetary policies were propagated to the financial markets in the Euro area. In particular, two channels are considered, the portfolio rebalancing channel and the policy signaling channel. The first reflects the shift in investment strategies employed by market agents due to a change in a relative supply of financial asset in particular market segments as a consequence of monetary policy actions. In contrast, the second affects the financial markets by steering expectations about the future financing conditions with credible commitment to a long-term monetary policy. The role of the ECB in financial markets is isolated from other external factors by studying the yield changes and channels through which they are implied in a one day window surrounding the announcements of the non-standard measures. In addition, potential policy spill-over effects on the Euro area financial markets are examined with respect to the non-standard measures introduced by the FED. In that respect, Chapter 2 directly relates to the research questions Q1 ans Q5, postulated above. The event study conducted in the second paper, however, is essentially a static analysis of the monetary effects relying on the assumption that each particular policy announcement is a complete surprise to financial markets. This assumption may be perceived as somewhat strong as the introduction of particular non-standard measures may have been anticipated, which would imply the potential adjustment of financial markets before the actual announcement.

In relation to that, the third paper adds to the second in two ways. First, it puts the analysis of the effects of the ECB’s unconventional monetary policies into a dynamic perspective by considering the shadow rate as a measure embedding all standard and non-standard monetary measures. Second, the dynamic analysis sheds light not only on
the financial aspect of non-standard measures, but more importantly it also examines the effects on the real economic activity and prices. The shadow short rate used in the analysis is estimated in the benchmark yield curve model specification proposed by Krippner (2011-2015) as the shadow rate obtained within this specification shows relative superiority for the US data in terms of robustness and alignment with the policy actions compared to the competing shadow rate measures. The paper first examines the validity of the shadow short rate proposed by Krippner (2011-2015) from the perspective of the Euro area alternative monetary stance measure. In addition, we also consider the shadow rate as a measure indicating liquidity and financing conditions in the two periphery EA countries, Italy and Spain, that endured significant financial stress during the crisis. A criterion for the validity of the shadow short rate measure is determined by its ability to properly identify the monetary policy shock within the standard monetary vector autoregressive (VAR) analysis, based on Sims (1992). Finally, the unconventional monetary policy in the Euro area is considered from the perspective of restoring economic activity, its impact on prices, and improving financing conditions in the most distressed countries. With this, Chapter 3 attempts to provide the answers to questions 2 to 4. However, as it was the case in the second paper, there are remaining caveats preceding the analysis conducted in this chapter. Namely, the performance and reliability of the results produced by the standard VAR analysis depend on the trade-off connected to a number of variables included in the system. Related to this, excluding an important variable from the analysis may lead to biased results due to the missing information being secluded to the system’s error terms, on which the identification of monetary policy shock essentially relies on. On the contrary, including too many variables does not allow proper statistical inference on the estimated parameters due to the degrees of freedom problem. Therefore, the results obtained in this kind of an analysis will highly depend on the subjective choice of the set of variables that in the eyes of the practitioner best represent the economic activity and price dynamics. Furthermore, the scope of interest, considering the effects of unconventional monetary policies, is from the perspective of a central bank practitioner much wider than the observed impact on the set of variables included in the standard VAR system.

The fourth paper proposes a framework for the analysis of monetary policy transmission in the Euro area that bridges the information deficiency gap described above by augmenting the standard VAR analysis with factors governing the common dynamics of a large set of macroeconomic and financial time series. In contrast to the second paper where only one shadow rate measure is considered, based on its empirical performance related to the US data, we estimate the factor augmented VAR (FAVAR) model by alternating the choice of three different alternative measures proposed by the literature. In particular, we compare the ability of consistent identification of the Euro area monetary shocks for the Economic Measure of Stimulus introduced by Krippner (2014, 2015), and two respective shadow short rate measures obtained from the benchmark term structure models proposed by Wu
and Xia (2016) and Krippner (2011-2015). The special feature of the FAVAR framework is its ability to translate the responses of factor variables to a monetary policy shock back to the responses of each variables contained in the original data set. This characteristic is utilized for revisiting the initial assessment of the effectiveness of unconventional policies provided in paper 3. Chapter 4 therefore elaborates in detail on research questions Q4, Q7 and Q8.

Data and main methodological concepts

The main concepts examined in this dissertation are derived from the various sorts of yield curve modelling applications. In particular, the workhorse specification used throughout all three papers is the Arbitrage-free Nelson and Siegel model (1987) with imposed Black (1995) framework for the short rate approximated in continuous time. This concept was introduced by Krippner (2011-2015) and it is often denoted the Shadow/ANSM or Krippner/ANSM model. The Shadow/ANSM model is outlined in details within Section 1 of this dissertation. In the first paper the Shadow/ANSM is used for extracting the information on the expected path of the short rate with the purpose of decomposing the Euro area bond yields onto the expectation and term-premium components. In the second paper, Shadow/ANSM is used to estimate the shadow short rate series for the overall Euro area and individual member countries of interest, whereas in the third paper the Shadow/ANSM model is used to derive the Economic Stimulus Measure. The yield curve data used for estimation of the model is obtained from two data sources. The individual country zero-coupon government bond yield data and the Overnight-Index Swap data, used in all three papers, is extracted from the Bloomberg database. The composite yield curve data related to triple-A government bonds is extracted from the ECB’s Statistical Data Warehouse. A detailed description of the yield curve data with corresponding Bloomberg data series tickers are available within the relevant papers were the data is used.

As already outlined above, for the purpose of measuring the effects of the unconventional monetary policy and its transmission in the Euro area, the structural VAR and FAVAR analyses are performed. In the former case, the examined macroeconomic data corresponds to the real GDP and GDP deflator, where both series for all geographic areas are extracted from the Eurostat database. In the context of FAVAR analysis, 129 macroeconomic and financial time series are considered and obtained from the Eurostat and ECB SDW databases, with a detailed description of the data secluded to Appendix D.

Scientific contribution

This dissertation offers several important scientific contributions from both, the empirical monetary policy modelling aspect and in the context of analysing the unconventional
monetary policy in the Euro area.

To the extent of literature considered, this work is the first to explicitly examine the channels through which the monetary policy decisions are reflected in the financial markets and offers a model based result of the effects of key non-standard measures on the Euro area bond markets. In addition, the unconventional monetary policies and financial market responses are considered in the context of potential spill-over effects, caused by the external monetary policy decisions.

While the literature on alternative monetary policy measures is rapidly growing for the US and to a lesser extent for the UK’s and Japan’s country cases, literature on the usefulness of the shadow rates and other alternative measures for summarizing the Euro area monetary policies at the ZLB remains, is at the time of writing practically non-existent. With respect to that, this dissertation is the first to examine macroeconomic responses to monetary policy shocks, obtained either via the Euro-area Economic Stimulus Measure or via the Euro-area shadow rate. Furthermore, this dissertation also considers the shadow rates in the light of individual member countries which offers a quantitative indication on how a common monetary policy shock is translated into particular country’s financing and liquidity conditions. In that sense, this work introduces a framework for analyzing the heterogeneity of monetary policy transmission in the Euro area.

With respect to the empirical monetary policy modelling, this dissertation demonstrates the proper estimation of expected short path in a low interest environment, a concept important for assessing the ability of monetary policy to influence market expectation. In addition, it is a rare example of application of the Structural FAVAR model to analyse the effects of the Euro area monetary policy and a unique case in using this approach to directly compare the competing alternative stance measures proposed by the literature. The merits of the FAVAR approach that are revealed by the literature are empirically tested as well as its ability to overcome the deficiency pertained to the standard monetary analysis. In that respect, the dissertation proposes the most suitable modelling framework to analyse the effects of standard and non-standard monetary policies on a wider range of variables of interest.

**Structure of the dissertation**

The dissertation is structured as follows. Chapter 1 elaborates in detail on problems that this dissertation addresses and provides its contextual relevance. Chapter 2 presents the first empirical paper of the doctoral dissertation, entitled Impact of Monetary Policy Decisions on Euro Area Yields. Chapter 3 proceeds with examining the usefulness of shadow short rates in studying the effects of unconventional monetary policies within the second empirical paper entitled Shadow Short Rate and Monetary Policy in the Euro Area. The comparison of competing alternative monetary stance measures within a consistent frame-
work for monetary policy analysis is presented in Chapter 4 with the underlying paper entitled Comparison of Alternative Monetary Stance Measures for Euro Area: Evidence from the FAVAR. The core text of the dissertation is followed by a summary of the main findings, policy implications and a proposal for future research. The dissertation concludes with the list of references. The appendix includes sets of results not shown in the main part of the dissertation and the extended abstract in the Slovene language.
1 OVERVIEW AND CONTEXTUAL PLACEMENT

The history has shown that the conventional monetary wisdom undergoes substantial shifts in relation to exceptional economic events. This chapter describes changes that occurred in the monetary policy conduct and its empirical modelling since the onset of the global financial crisis and persistently low global interest rate environment. In that respect, it contextually places the dissertation in the current economic situation and develops a new perspective according to which monetary policy should be modelled and analysed. Section 1.1 briefly describes basic principles of the monetary policy decision-making process and instruments in the pre-global financial crisis period (hereafter pre-GFC); Section 1.2 shows how monetary policy conduct has changed since the onset of the crisis; Section 1.3 describes the instruments that the ECB introduced in response to the global financial crisis (hereafter GFC) and discusses the institutional differences between the ECB and other central banks, in particular the US Federal Reserve (FED); Section 1.4 offers a descriptive analysis of macroeconomic effects of the ECB’s monetary policy during the combined period of the GFC and zero lower bound and speculates about the future policy prospects; Section 1.5 discusses complications related to empirical modelling of monetary policy; and Section 1.6 contextually connects the dissertation articles.

1.1 Conventional monetary policy

The usual monetary policy conduct before the GFC could be described in line with the conventional monetary wisdom established after WWII. Namely the Keynesian revolution shifted the focus of central banking activity from preventing the financial panics to stabilization of the real economy. The stable monetary policy was initially characterized by the downward sloping Phillips curve (Phillips, 1958), representing the trade-off relationship between inflation and unemployment. The great inflation of the seventies reoriented the goal of monetary policy to primarily ensuring price stability as the money was perceived to be neutral in the long-run from the perspective of economic activity (Lucas, 1973). However, very high social costs of disinflation process reintroduced the role of monetary policy in stabilizing demand shocks and short-term real business cycles without endangering long-term price stability. The years between 1980s till 2008 therefore represent the period in which the output and price volatility were significantly reduced in the developed economies and is commonly denoted the Great Moderation period (Stock and Watson, 2002).

The most renowned prescription for optimal monetary policy that follows the conventional wisdom of the Great Moderation period was established by Taylor (1993). The Taylor rule defines interest policy rates as a linear combination of inflation and output gap. In other words, in the pre-GFC period, a central bank would first gauge the current state of inflation and real economy relative to the objectives and then accordingly set the
policy rate so as to maximize the social welfare. The information provided by the policy rate would then be incorporated into a wider range of financial market segments and corresponding interest rates which would either stimulate or slow down economic activity depending on the prevailing interest rate environment.

In case of the ECB, the above has been made operational by regular provision of the monetary base aligned with estimated Eurosystem’s weekly liquidity needs. Commercial banks could then bid for additional liquidity at rate not smaller than minimum bid rate decided by the ECB (the Main Refinancing Operation rate or the MRO rate). In that case, the MRO can be perceived as the Eurosystem policy rate under direct control of the ECB. The MRO settings before 2008 strongly resemble the decision-making process and conventional wisdom established by the Great Moderation period that sets the policy rate according to the inflation targets and prevailing output gap. This kind of monetary process is demonstrated in Figure 1. Panel (b) compares the MRO rate and the most elementary Taylor approximation:

\[ r(t) = \pi(t) + \alpha Y_G(t) + \beta \left( \pi(t) - \pi^* \right) \]  

Where \( Y_G(t) \) represents the difference between the actual and potential output, \( \pi \) and \( \pi^* \) are respectively the inflation rate and inflation target, and \( \alpha \) and \( \beta \) are relative weights assigned to stabilization of output and inflation. Taylor rule approximation in Figure 1 assigns \( \alpha = 0.5 \) and \( \beta = 1.5 \) in line with the ECB’s primary price stability objective (see Section 1.3).

This kind of formulation of monetary policy is of course an oversimplification of the actual monetary policy decision-making process. Namely the actual policy rate setting often differs from the Taylor rule as central banking mandates and objectives may vary over time and with the decision-making process usually taking into account more than two macroeconomic variables. In addition, the Taylor rule approximation is essentially based on estimated categories (i.e. the potential output) and data subject to revisions and it therefore does not necessarily provide the most reliable and timely information.

Nevertheless, the most basic Taylor approximation produces fairly similar dynamics to the actual MRO rate before 2008 proving that the policy decision-making process was conducted predominantly along the path of minimizing social costs of output and inflation deviations. In other words, in line with the general monetary wisdom prevailing in the period from 1980 till 2008, the key ECB policy rate settings can fairly accurately be summarized by a linear combination of output and inflation gaps.

Furthermore, panel (C) depicts relatively straightforward transmission of monetary policy to financial markets in the period before 2008. The first series considered is the spread between Eonia rate and 10-year German government bond yield. The Eonia rate repre-
sents the average rate at which banks provide overnight loans to each other. The 10-year German government bond yield is used as a proxy for longer-maturity lending in the Euro area and could be used as a measure of the neutral rate, that is, the non-inflationary and non-stimulatory interest rate. The spread between the two rates should therefore indicate the path of monetary policy beyond the short-term business cycles. The common dynamics of the MRO rate and Eonia/10-year spread before 2008 suggests that market expectations about the future monetary policy followed the actual policy decisions. In other words, monetary policy decisions were able to steer market expectations and were therefore able to affect a wider range of interest rates in the expected direction.

Figure 1: Monetary policy and stabilization conditions

(a) Output and inflation gap (in %)

(b) Taylor rule approximation (in %)

(c) Key rates (in %)

Source: OECD, ECB Statistical Data Warehouse, author’s calculations.

The second series in Panel (C) represents the spread between the 1-month Euribor rate and Euro Overnight-Index-Swap (OIS) rate. The first one represents the rate charged on interbank loans with duration of one month and often represents the anchor for a wider range of loans issued to the general public. The OIS in turn represents a contract according to which one party pays another the compounded Eonia rate in exchange for fixed rate at the end of the compounding period. As parties under OIS contract only exchange interest rate flows and not the principals, the OIS rates ignore the credit risk and offer a pure indication of market expectations about the future policy rate settings. Conversely the positive Euribor/OIS spread should point towards the piled-up counter-party risk (Curdia and Woodford, 2010a). The negligible spread therefore suggests that monetary policy in
the period before 2008 was appropriately translated in the credit channel and lending activity through which it essentially affected the real economy.

From the above we can conclude two things: (i) the monetary policy before 2008 could be described as one dimensional, that is, governed solely by inflation and output deviations from optimal targets and conducted through changes in the key policy rate; (ii) as the information of the policy rate was appropriately embedded in a wider range of interest rates, the MRO and Eonia rate offered a reliable measure of monetary stance in the Euro area.

1.2 Monetary policy after 2008

As it was commonly the case in past crises, the GFC erupting in 2008 re-institutionalized the central bank role of injecting extraordinary monetary base into systems that were craving for evaporated liquidity. The active involvement of central banks in preventing a persistent depression spiral following the financial collapse essentially caused the departure from the conventional interest rates policies and consensus established during the Great Moderation period. This becomes evident by observing the decision-making process after 2008 in Figure 1.

Namely, following the GFC in 2008 the standard Taylor rule (1993) does no longer provide the adequate monetary policy prescription. In example, with increasing inflation in 2010 we can observe a drop in the actual ECB policy rate. Operating the monetary policy through standard interest rate policies becomes even more complicated in the low interest environment, observed in the period from 2009 onwards, where despite the recommended further reduction of the policy rate by the standard Taylor rule, the maneuver space to do so was extremely limited or even became practically infeasible due to the implicit zero lower bound (hereafter ZLB) on interest rates.

Furthermore, even if the reduction of policy rates would theoretically be feasible, the channels of monetary transmission would very likely be hindered. This becomes evident by observing the spread between the Eonia rate and the 10-year government interest rate. The spread now moves in the opposite direction from the MRO rate, suggesting that the reduction of policy rate does no longer produce the expected dampening effect on longer-term yields through the expected stimulatory monetary policy in the future. The distortion of the credit channel could further be drawn from the dramatically different behaviour of the Euribor/OIS spread that plummeted in 2008 which points towards highly increased credit risk. In other words, the key policy rate reduction would very likely produce only limited impact on financial markets and consequently on the real economy. This implies that in the period after 2008 the information on credit aggregate and financial market aspect in general should also enter the decision-making process along with inflation and output gap that are conventionally considered. The latter seems to be reaching a
wider consensus among practitioners as Taylor (2008) himself recommends the extension of the Taylor rule with information on Euribor/OIS spread.

With the above, we can draw two important implications in describing the monetary policy in the Euro area after 2008: (i) the key policy rates such as the MRO or Eonia no longer provide reliable measure of the monetary stance; (ii) monetary policy conduct becomes multidimensional in terms of both, the relevant information considered in the decision-making process, and in terms of the central bank tools, expanding beyond the standard interest rate policies. A clear shift in monetary policy conduct and use of the instruments beyond key policy rate can probably best be illustrated by observing the ECB’s balance sheet in Figure 2. While the movement of the key ECB policy rate remained limited due to the lower bound, the ECB’s balance sheet more than doubled in the years between 2008 and 2015 compared to the average size observed in before 2008. Hence, this should imply that the ECB sought options for additional policy accommodation in form of unconventional policies, that is, beyond additional interest rate cuts. The non-standard measures follow the practice and policies deployed by many other central banks in developed economies and can in a broader sense be divided in three categories.

**Forward guidance**

The first one can be described as the forward guidance and it refers to the central bank’s official statements on future economic outlook and expected policy path communicated to the general public. The forward guidance does not represent a policy dimension that was uncommon in the conventional times, however there was a prevailing notion under which the minimum communication was perceived as the most prudent strategy. In contrast, the global financial crisis and in particular the low interest environment resemble the period of distinctly more explicit forward guidance reflecting specific and narrow quantitative policy targets set for the much more distant future horizon. So how does the forward guidance work and how does it provide additional policy accommodation when interest rates cannot further be reduced? Considering the traditional economic doctrine formally described in the standard New-Keynesian macroeconomic models, people’s expectations on future monetary developments play a crucial role in how monetary policy is translated into a wider spectrum of economic decisions such as consumption, saving, investment, employment, and others (Curdia and Woodford, 2010b). In other words, the movement in an overnight rate and its current level are of little relevance in affecting the economy if not accompanied with an appropriate change in expectations about future paths of the key policy rate. Namely, in the period with the constrained short term interest rates the forward guidance becomes particularly relevant in attempt to appropriately steer long-term interest rates, asset prices and exchange rates through shifts in an anticipated expected path of future policy settings. Hence, the fact that the monetary policy before 2008 did manage to affect consumption and demand in the way it did with only modest
communication shows that the key policy rate settings did in fact provide the anchor for the expected monetary policy path and had an impact on a wider set of interest rates and yield curve (Woodford, 2012).

Furthermore, Curdia and Woodford (2010b) and Eggertsson and Woodford (2003) show that forward guidance is not only relevant for the period where current policy rate is constrained but it should especially be considered as a monetary policy tool when this constraint is expected to continue to bind monetary decisions also in the future. The argument follows the result from the standard New-Keynsian macroeconomic models according to which the expected increased balances of income and inflation in future create incentives for expenditure now. That is, the aggregate conditions at the expected lift-off from a lower bound have a particularly significant effect on current consumption and saving decisions. In that manner, to achieve a desirable accommodative effect on the real economy now, a central bank should use the forward guidance to commit to unchanged interest rates also at the perceived lift-off, that is, when standard Taylor rule prescription becomes operational again. In other words, in the environment of a binding lower bound it is essential that forward guidance indicates a shift towards the history-dependent monetary policy, that is, a policy that does not necessarily operate in line with stabilization conditions prevailing in future. In that respect, the forward guidance should affect the economy in two ways. Namely, the expectations of looser monetary policy should mitigate the effects of interest rates higher than recommended by the stabilization conditions in the period of binding lower bound constraint. At the same time a publicly communicated intention to implement monetary policy in the history-dependent way should enforce commitment upon central banks to conduct monetary decisions in line with the past conditions in time when there is no motivation for that from the conventional Taylor rule perspective. The latter is important since by ignoring th past commitments market participants would see no reason to consider central bank’s statements as a credible source of information for future monetary policy.

**Credit and quantitative easing**

In a similar spirit, the forward guidance itself would most probably not produce any significant effect without explicitly stating the monetary measures a central bank intends to undertake to achieve the accommodation it wishes markets to anticipate. In addition, by just committing to loose monetary policy at the point of lift-off will not be sufficient to offset the effects of the higher than recommended interest rates in the zero lower bound period. Therefore, the forward guidance should also be accompanied with the actual tangible measures in the period where there is limited space for key policy rate reduction. This was commonly achieved through a balance sheet expansion which encompassed the measures that in a broader sense fall either under the category of **credit easing** or under the category of **quantitative easing**. The credit easing can operationally be
implemented in two ways. In the first case a central bank eases financial conditions by acting as a mediator on targeted dysfunctional markets by acquiring private sector assets. The second set of measures associated with the credit facility can be described by operations through which central bank’s deposits are used to provide long-term loans to commercial banks (Kozicki et al, 2011). In a low interest environment this is achieved either by extending the maturity span at which loans can be provided to banks or by expanding the list of eligible assets against which the funding can be provided. The extension of a central bank’s credit facility to longer maturities at fixed rate represents a fairly direct way of lowering long-term interest rates. In addition it is capable to affect asset prices to the extent that the institutional prudent framework, concerning the interest rate miss-match, allows translation of this funding to bond markets. However, these measures in many occasions and in particular in the Euro area case expose the central bank to significant credit risk as it becomes the major counterparty to the banking sector. With that, the credit easing measures can be classified as non-standard to the traditional doctrine according to which central banks should follow prudent policies with minimal credit and interest rate risk (Cukierman, 2013).

The latter can in turn be associated with quantitative easing programs which represent an expansion of monetary base by acquiring government assets with longer maturities, therefore, beyond the short-term risk-free government securities (i.e. FED’s “bills only” tradition). Quantitative easing can operationally be implemented either by increasing central bank’s reserve balances or through the so called operation twist under which the balance sheet composition of the central bank changes by selling short-term assets and replacing them with longer-term assets. According to Woodford (2012), the categorization of operation twist measures under quantitative easing is not appropriate and should instead be considered as the debt management operation and for this reason the effectiveness of operation twist should be examined in a way distinct to classic monetary policy analysis. Hence, this section only focuses on quantitative easing associated to asset purchases that are financed through an increased reserve balance item on the liability side of a central bank’s balance sheet. The quantitative easing should improve economic conditions by creating positive wealth effects through higher prices, reduced government bond yields should motivate investors to reallocate their portfolios to riskier high-return assets and put downward pressure on a wider range of yields, it should place upward pressure on inflation, and support the forward guidance and long term commitment to inflation targets and low interest rates (Kozicki et al, 2011).

There are however opposing arguments related to effectiveness of quantitative easing in the period of financial crisis and zero lower bound. Namely, the pure Keynesian view argues that once the increased balance reserves and monetary base drag short term interest rates to zero, quantitative easing becomes ineffective as there is no opportunity cost for holding reserves, meaning that there is no guarantee that the excess liquidity will translate
to increased expenditure. This phenomenon is commonly known as “the liquidity trap” which in monetarist view is too narrow concept that perceives short-term interest rates as the only relevant category for consumption. But the quantitative easing during the zero lower bound is essentially composed of longer-term asset purchases, where reserves created for these types of assets are now capable of affecting many other interest rates that are still relevant for the final expenditure when short-term interest rates remain fixed. In addition, regardless of the type of assets for which reserves are created, the increased monetary base should in principle always be propagated to other money aggregates as long as money multiplier stays stable. In line with the principle of the long-run money neutrality the increased monetary base should therefore eventually translate to an increase in general price level and consequently to expanded nominal expenditure. As Woodford (2012) explains, this causality and immediate positive effect on economy will only be achieved as long as the money base increase is perceived as permanent. In contrast, if increase in monetary base is perceived as temporary, meaning that after the lift-off the policy would return to the conventional Taylor rule stabilization, the quantitative easing would lead to the “irrelevance result” obtained by Krugman et al (1998) and Eggertsson and Woodford (2003). In other words, the quantitative easing policy will remain anemic from the perspective of the real economy if not accompanied by a proper forward guidance that would convince markets to believe that monetary policy will remain expansive even when maneuver space for short-term interest rates reappears. Therefore, when short-term interest rates hit zero lower bound the monetary policy need not necessarily be impotent as central banks can at any point in time control the expected path of a short rate with explicit forward guidance in combination with the right set of credit and quantitative easing to reinforce its commitment to it.

1.3 Overview of monetary measures introduced by the ECB

Since 2008 the ECB has introduced several non-standard measures to complement its standard interest rate policy. In general, these measures can be divided into credit and quantitative easing programs as follows: Credit easing:

- Full allotment program;
- Long-term refinancing program (LTRO);
- Covered Bond Purchasing Program (CBPP);

Quantitative easing

- Securities Market Program (SMP);
- Outright Monetary Transactions (OMT);
- Asset Purchasing Program (APP).
These measures and communication surrounding them can best be discussed in the chronological context according to which the crisis in the Euro area developed. The first stage of the crisis essentially represents the outburst of a financial crisis which was reflected in the intense banking crisis and mounted counter-party risk. To address the consequent liquidity needs and to relax precautionary holdings, the ECB initially changed variable tenders to unlimited liquidity provisions (the full allotment) at pre-determined tenders. In non-technical terms this means that commercial banks could access any amount in refinancing operations at a fixed rate. These steps were initiated in October 2008 and can be characterized as the first detachment from the standard altering of MRO rate as they also included an expanded list of assets eligible for collateral in the Eurosystem credit operations and enhanced liquidity provision through extension of longer-term refinancing operations (LTROs) from 3 months to 1 year. In addition to enhanced liquidity facilities for commercial banks, in May 2009, the ECB introduced the Covered Bond Purchase Programme (CBPP1), which was specifically designed to ease credit conditions of private sectors and restore activity in private debt markets. Namely, covered bonds are issued by the banks to refinance long-term loans to private sector, often related to real estate purchases (Thimann and Winkler, 2013). However, the CBPP1 eventually materialized in relatively small value of 61 billion EUR, which at that time amounted to around 2.5% of covered bond market. A sense of an indecisive commitment towards unconventional policies and engagement in asset purchases could also be noted in the communication strategy employed by the ECB at that time. For example, at the time incumbent president Trichet stressed, on several occasions, the importance of continuous monitoring of newly deployed measures in order to avoid potential adverse effect that might arise from unconventional policies lasting for too long, which implicitly implied a probable phasing out of the measures in a short-term period.

The second stage of the crisis characterizes the sovereign crisis towards which some Euro countries were drawn in 2010. The period can be connected to the increased market expectations of Greek sovereign default with possible knock-on effects on Portugal, Ireland, Italy and Spain. This eventually pushed the corresponding sovereign yields to unsustainable levels from the perspective of debt servicing and brought the sovereign market activity to a standstill. Even though the sovereign crisis evolved extremely rapidly, the ECB initially introduced only one additional non-standard measure to directly address sovereign debt issues. In contrast to the CBPP1 program, the modalities of the Securities Markets Program (SMP), introduced in May 2010, clearly expressed the ECB’s active involvement in corporate as well as in the public debt markets. The communication strategy, however, did not change significantly as the non-standard measures remained characterized as temporary in nature rather than a new reality. Moreover, the SMP was eventually entirely sterilized due to newly raised inflation fears, where its complete absorption was already announced at its official release as to not affect the Eurosystem’s monetary stance.
It was not until 2012, when the sovereign and financial crisis re-intensified significantly, that the ECB clearly expressed its commitment to complement its standard monetary policy conduct with unconventional measures of an arbitrary large volume and time span. The latter can most notably be observed in the speech of President Draghi (June 2012), who among others indicated that the ECB would do anything within its mandate to preserve the common Euro area (ECB, 2012a).

In that light, the third stage of the crisis resembles re-awakening of the Covered Bond Purchase Program (CBPP2), the extension of LTRO to 3 years, and most importantly the Outright Monetary Transaction program (OMT). Under the OMT program the Eurosystem’s central banks obtained an option to buy government issued bond conditioned upon a set of structural conditions that a country which issued the bonds had to undertake. The measure was introduced as a response to the speculation on disintegration of the Euro area. The OMT differs from the SMP and other measures as it resembles a strong commitment to unconventional monetary operations by explicitly stating that OMT implies no “ex-ante” quantitative limits on its realization. The OMT has so far not been utilized by any of the member states, however, the literature argues that its presence alone had a potential of stabilizing the financial markets (see i.e. Altavilla et al (2014) or Thimann and Winkler (2013)).

The last stage of the crisis is largely connected to deflationary risk and spans the period from 2013 onwards. The period marks the low interest environment with main policy rates essentially hitting their lower bound in 2014 or in case of the deposit rates even dropping to negative values for the first time. As far as the key monetary policy expectations are concerned, Filardo and Hofman (2013) relate a significant drop in the Euro Overnight Index Swap rate (EONIA) in the second half of 2012 to a distinct forward guidance policy. As far as the existing non-standard measures are concerned, the period denotes the suspension of the SMP sterilisation and extension of long-term refinancing operations to very long maturities (VLTRO). An important innovation in dealing with the stagnating economy in the third stage, however, is the introduction of quantitative easing (QE) measures that could match the ones observed in policies employed by the FED, Bank of England, and Bank of Japan since the beginning of the financial meltdown in 2008. Namely, in September 2014 the ECB announced the extension of Covered Bonds Purchase Program (CBPP3) to all maturities (ECB, 2014). But most importantly, in January 2015, the large asset purchase intentions were even further stipulated by introducing the Expanded Asset Purchase Programme (EAPP) that among others included central government bonds of all maturities with announced combined monthly purchases amounting to EUR60 billion. In addition, the EAPP was announced to be carried out at least till September 2016 or until the sustained inflation path is recognized by the ECB (ECB, 2015). The EAPP program differs from previous non-standard measures both in terms of its realized size and accompanying communication strategy. In that sense the
EAPP comes closest to the actual definition of quantitative easing policy which implies an active use of a central bank's balance sheet with the intention to influence financial market prices and overall yield curve (Rodriguez and Carrasco, 2014).

1.3.1 ECB policy response versus other central banks

This section puts the ECB’s policy response in perspective of measures undertaken by other central banks. The comparison is particularly focused on differences to the FED which took the leading role in introducing unconventional policies following the emergence of the global financial crisis in the US economy. The measures taken by the FED could however closely be related to those introduced by the Bank of England or Bank of Canada, whereas the unconventional monetary policy operated by the Bank of Japan has been the standard practice since 2002 and was not constructed as a response to the global financial crisis.

But before discussing the differences in responses of the ECB and the FED, it is important to understand the institutional features to which the respective central banks adhere to and channels through which the crisis was propagated in corresponding economies. Namely, the primary objective of the ECB, set by the Treaty on the Functioning of the European Union, is to maintain price stability (hereafter the TFEU). In contrast, the spectre of the FED’s objectives is wider and apart from the stable prices also encompasses activities related to achieving maximum employment and moderate long-term interest. Another important institutional difference is the tools through which the monetary policy shall be conducted. The TFEU prevents the ECB from conducting any activities on the primary sovereign markets, whereas the secondary market interventions are allowed in line with the objective of price stability. Compared to the FED case where monetary policy almost entirely relies on open market operations related to government debt securities, the role of the ECB in debt markets is somewhat limited. In addition, the key to understand the nature of the respective non-standard policies by the ECB and the FED is the distinction in the financial structure of corresponding economies. Namely, almost 70% of the Euro area non-financial corporate debt (between 2002 and 2014) was financed through bank lending, while 30% of debt financing was relied on financial markets and other earnings. In the US case the relation is reverse, where only about 30% of debt came through bank financing and 70% refers to funds obtained on financial markets. It is not surprising then that the primary source of distress in the Euro area at the onset of the crisis came from the mounted liquidity and counterparty risk, while in the US it was predominantly characterized by dropping asset prices and eroded financial wealth (Cukierman, 2013).

Although the Euro area and the US economy experienced almost parallel declines in output and asset prices as a consequence of a global financial shock in 2008, the responses
of the ECB and FED differed in terms of timeliness and magnitude. Considering first the usual conduct of monetary policy, the FED brought down its key interest rate, the Federal Funds Rate (FFR), to near zero already by December 2008 from levels exceeding 5% in 2007. In contrast, the first response to the crisis by the ECB in 2008 was an interest rate increase, followed by a gradual reduction of the ECB’s MRO rate, which was further interrupted by two separate hikes in 2011 (see Figure 2). The reasons for this deviation in key policy rate dynamics could indeed be sought in the differing mandates of the ECB and FED. With price stability being the ECB’s primary and formally only objective, the speed at which the key policy rate could be dropped remained limited. Similarly, the estimated future inflation risk prevented the ECB from increasing the inflation expectations, which, as it was already discussed in Section 1.2, would importantly support the effectiveness of the non-standard measures.

Figure 2: Key policy rates and the ECB’s balance sheets

(a) Key policy rates (in %)  
(b) ECB balance sheet - selected items

In that manner, the comment of the former ECB’s president Jean-Claude Trichet upon the increase of key policy rates in April 2011 strongly emphasized the importance of the anchored medium term inflation at 2% and a need to address the potential influence of the ample liquidity in the system on increasing prices (ECB, 2011). Similarly, the elevated price level, mostly driven by commodities, was addressed by additional 25 basis point increase in the policy rate amid the peak of the sovereign crisis. In contrast, in the case of the more flexible dual mandate inherited by the FED the price risk was for the most part of the crisis downplayed compared to the additional slip in output and financial wealth. In that respect, the FED immediately complemented its interest rate cuts with quantitative easing programs active forward guidance policy anchoring the long-term inflation expectations.

However, as mentioned in the beginning, apart from differing mandates and relative importance given to the anchored inflation expectations, the distinction in policy responses
should be considered from the perspective of shock driving the crisis related to either the bank-based or market-based financing structure of the economy. This is best resembled in the non-standard measures introduced by respective central banks and the consequent balance sheet composition. As in case of the FED the greatest source of risk to be addressed in the initial stages of the crisis was a huge loss of wealth, the goal of non-standard measures was flattening of the yield curve. This was attempted by inducing additional quantitative easing in form of either large asset purchasing programs or operation twist activities. The first should reduce long-term yields by putting upward pressure on long-term asset prices, whereas in the case of operation twist the spread is reduced by using short-term bonds for financing the purchases of long-term bonds. On the other hand, the primary source of risk interpreted by the ECB was a liquidity shortage originating from the non-transparent and piled-up counter-party risk. The ECB’s balance sheet in initial stages, therefore, in large part consisted of long-term refinancing operations and extension of corresponding eligible assets (see Figure 2). The non-standard measures related to securities programs, CBPP1 and SMP, for example, amounted to only a maximum of 11 % of the ECB’s total assets in 2011. In contrast, securities held for monetary purposes represented nearly 90 % of the FED’s balance sheet with 61 % amounting to government debt securities (Rodriguez and Carrasco, 2014).

With development of the crisis, composition of the ECB’s balance sheet and the pace at which it had grown changed. In the first years of the crisis (2008-2011) the ECB’s balance sheet grew on average by 22 % per year, whereas in the pre-crisis period the average growth rate had been 11 %. The FED’s balance sheet expanded much faster with yearly average rate amounting to 38 %. After the intensification of sovereign crisis and marginalized inflation risk the ECB fully engaged in monetary expansion through unconventional measures, which is reflected in all time high 71 % yearly increase of its balance sheet in 2012.

As far as the risk related to increased balance sheets and their exit strategy is concerned, the temporary nature of ECB’s initial non-standard programs allowed a shrinkage of its balance sheet by more than 40 % by 2014, mainly due to an early repayment options embedded in the long-term refinancing programs. In contrast, a large portion of the FED’s large asset purchase programs encompassed securities between 5 and 10 years duration, meaning that the consolidation of the balance sheet has only been allowed with the selling-off strategy or actual maturity of these assets. However, as described above, the relatively late engagement of the ECB in quantitative easing (with tapering not expected to take place before 2017) is yet to increase the ECB’s balance sheet by assets related to securities and with the actual risk being absorbed in considerably latter stages compared to the FED.

From the perspective of setting a structural change as a response to the sources of the
financial crisis, the ECB’s non-standard measures, in particular the OMT, imposed some degree of structural reforms on governments making use of it. In contrast, the FED’s quantitative easing can to a large extent be perceived as a wealth-preserving policy and a continuation of eased monetary standard prevailing in the US since 2002. However, as mentioned earlier, funding provided by the OMT has never actually been utilized by any of the Euro countries up to date.

1.4 An insight into the effectiveness of the ECB’s monetary policy

Based on the above we can summarize that central banks resorted to the non-standard measures to restore the functioning of financial intermediation in monetary transmission and to provide further stimulus to the real economy at the ZLB. In particular, the credit easing facilities should in principle ease funding conditions for firms through expanded bank lending, improve market liquidity in impaired market segments and provide general reduction of interest rates. Similarly, higher asset prices, achieved through quantitative easing measures, should strengthen bank balance sheets and consequently ease credit conditions and lower cost of debt servicing (IMF, 2013). Moreover, even though the measures related to quantitative easing are targeted at specific assets they should in principle help decrease a wider spectrum of interest rates by properly anchoring the inflation expectations and by pushing investors in the direction of riskier higher-return assets.

Finally, quantitative easing policy should boost domestic consumption through a wealth effect induced by higher asset prices (Kozicky et al, 2011). This section verifies these in principle impacts in a model-free overview of the effectiveness of the ECB’s unconventional monetary policies from the perspective of financial markets and real economy. In addition, as the global financial crisis affected member countries and sectors in the Euro area differently, we offer an insight into potential re-distributional effects of the non-standard measures.

Financial and macroeconomic development

Probably the most obvious way to start the analysis of financial impact of non-standard measures is to observe interest rate pass-through and dynamics in cost of borrowing. Figure 3 shows that the key policy rate reductions and unconventional measures between mid 2012 and 2014 was not translated in reduction of the actual lending rates in the Euro area periphery, represented by Spain and Italy. The lending rates in Euro area core were successfully reduced, however, the decrease was not proportional to 95 basis point reduction in the key policy rate between 2009 and 2014. A more pronounced drop of lending rates was only attained in the second half of 2014 and arguably with introduction of CBPP3 program, where observed decrease was in this case consistent across the entire Euro area.
The eventual wider decrease in lending rates observed after 2014 is also consistent with eased credit availability and borrowing conditions. Panel (b) of Figure 3 represents the survey based difference between the positive and negative answers given by small and medium enterprises (hereafter SMEs) on general availability of bank financing, willingness of banks to grant credit, and the share of actually approved applications (right axis). The share of granted credit to SMEs achieved the highest level in the second half of 2015, after a persistent negative sentiment on the loan availability was being reported by the surveyed SMEs for the most part of the documented period of the crisis (2009-2013). The improved credit conditions are also visible in the reversal of deleveraging process which, according to the activity of outstanding bank loan volume vis-à-vis non-financial corporations, seemed to come to an end in 2014. The above figure therefore suggests that considerable positive effects of the ECB’s monetary policy could only be observed in 2015 with restored banking intermediation and potentially re-initiated production activity as a consequence of finalized deleveraging process for firms.
Figure 3: Banking channel
(a) Cost of borrowing (in %/mio EUR)

(b) Credit availability - Survey based

Source: ECB Statistical Data Warehouse.

But the reawakening of the bank lending channel is only one part of the story. As discussed earlier, the ECB undertook several purchasing programs that were specifically targeted at impaired corporate and sovereign debt markets. Figure 4 panel (a) depicts the amount outstanding and gross issuance of corporate debt securities. Despite steadily increasing corporate bond price index (and lower interest rates) the new issuance of corporate debt securities exhibited consistent downward trend throughout the whole documented period. This shows that debt securities market had not been used to compensate for the tighter credit conditions and proves suggestions showed for the bank lending channel on deleveraging and low demand for new funding. Despite that, panel (a) suggests that operation of
issuing new debt and servicing the existing one significantly improved for the non-financial corporations, especially in the period between 2013 and 2015, when growth of corporate bond index was the fastest. Similar conclusions can be drawn for sovereign debt. Panel (b) depicts snapshots of composite Italian and Spanish yield curves at the end of 2011, 2013 and the beginning of 2015. The downward shift in yield curve argues in favour of the OMT and renewed SMP programs introduced in 2012. A reduction of almost 200 bps in 10-year yields indicates a significant improvement in long-term borrowing costs and significant reduction in risk premium for countries most affected by the sovereign crisis.

*Figure 4: Debt markets*

(a) Corporate debt securities

![Graph showing corporate debt securities]

(b) Sovereign debt (in %)

![Graph showing sovereign debt]

Source: ECB Statistical Data Warehouse.
A first glance on wealth and consumption implications of the ECB’s policy can be offered by observing the equity price dynamics. A significant impact that the global financial crisis had on the equity wealth can presumably best be observed by 54% decrease in Euro area blue chip index (Euro stoxx) between 2007 and 2009. However, following the stronger commitment to non-standard measures and clearer shift towards a more assertive monetary policy in the second half of 2012, the Euro stoxx index recovered at rapid pace with peak attained in April 2015, when EAPP program came into effect. Italian and Spanish stock indices grew by approximately 75% between 2012 and 2015, whereas the representative German stock index grew even faster with April 2015 value being 10% higher than the peak pre-crisis value in 2007. Despite that, the ECB’s stock price-misalignment indicator shows no sign of overvaluation in the European stock markets with price-earning ratio being entirely aligned with economic fundamentals and significantly lower than in the US case.

The latest crisis also revealed a significant role that housing market plays in the structure of the European economy. Housing can be considered as an important source of households’ and firms’ wealth, it determines the value of collateral against which the debt can be raised, and it represents a hefty portion of bank balance sheets. Panel (b) shows that the most distressed countries (Italy and Spain) in the Euro area endured significant wealth erosion coming from the housing market. In example, house prices in Spain dropped by 30% between 2010 and 2013. Although the stop of a further decrease in Spain and significant increase in German residential prices seem to coincide with the re-intensification of unconventional monetary policies in the second half of 2012, the overall effect across the Euro area remains dispersed and ambiguous.
Additional light on effectiveness of the ECB’s monetary policy during the combined GFC-ZLB period can be shed by observing the development of inflation expectations with respect to the monetary policy objective. Namely, in case of inflation expectations above the target, investors will tend to demand a higher nominal yield to obtain the desired real return throughout the repayment period. In contrast, expected future deflation may motivate a consumer to delay spending to future period when prices will be lower. Therefore, the efficient monetary policy will embed proper measures that keep inflation anchored at the target. Inflation expectations for the Euro area can be proxied by the 5-year inflation-linked swap five years ahead. Its dynamics, depicted in Figure 5, points towards
inflation fears that were often raised by the ECB before 2013 and consequent hesitant implementation of unconventional monetary policies. Namely, in the period before 2012, the inflation expectations persistently hovered approximately 50 bps above the 2% target rate. However, since 2013 till 2015, the inflation expectations fell from 2.4% to 1.5%. This significant drop has often been mentioned as a major driver that led to introduction of the extensive asset purchasing program in 2015. Following the introduction of EAPP the downward expectation dynamics was indeed reverted, however, the effect was short lived as in 2016 the inflation expectations again dropped to the record low of 1.36%.

From the perspective of real economy, the Euro area experienced a significant correction in the general price level in 2009 with a move to deflationary territory. Following the introduction of first non-standard measures, the inflation picked-up to on average 20 basis points above the target in 2011. With re-intensification of the sovereign crisis and the risk of currency union disintegration the downward price pressure reappeared. In the beginning of 2015 the Euro area re-entered deflation area. The general price fluctuations in the documented period were, however, to a large extent driven by external factors that are not under direct influence of the ECB’s monetary policy, for example oil prices. By excluding prices related to energy sector from the general price level one can observe less drastic downward pressures and volatility with the inflation at the time of writing firmly standing at approximately 1%. In any case, from the perspective of effectiveness of monetary policy and usual monetary transmission channel, the impact of non-standard measures on general price level seems to be subdued.

Considering the real economic activity, panel(b) of Figure 6 suggests that the first non-standard measures (i.e. CBPP1) did manage to revert the drop in the initial stage of the crisis which was largely characterized by the liquidity shortfall and increased counter-party risk. The second considerable reduction in the Euro area economic activity is related to the sovereign and single currency crisis. With a more assertive communication strategy and the decision to purchase sovereign debt securities, the downward spiral was successfully contained in 2013 followed by accelerated GDP growth coinciding with introduction of the TLTRO and EAPP programs. However, by observing the individual GDP series one can see that the crisis affected individual countries asymmetrically. Namely, Italy and Spain endured much stronger stress in the first two stages of the crisis and consequently recovered from it much slower.
In that respect, the monetary policy response between 2008 and 2015 very likely had dispersed effect, both from the perspective of individual countries as well as the sectors in the Euro area. Therefore, the section that follows presents the distributional effects of the ECB’s monetary policy during the GFC-ZLB period.

**Redistributional effects**

The ECB policy is to a large extent decided centrally, but aimed to address heterogeneous Euro area economies. In that respect, the low interest environment has inevitably caused redistribution of interest rate incomes and expenses, both at the level of individual coun-
tries as well as sectors. The largest beneficiaries of the low interest environment seem to be individual Euro area governments. The average debt servicing costs have for the Euro-area governments decreased from 4.5% to 3% in 2013 (or EUR 130bn had the debt stayed at the 2007 level), where the benefits of lower borrowing rates and debt-servicing costs have been larger in the Euro area periphery.

Similarly as in the case of local governments, the non-financial sector also benefited from the bond purchasing programs. In general, net interest payments for the Euro area corporations decreased by EUR 31bn in the period from 2007 to 2012. However, these profits have in a large part been observed only by big companies that were able to access debt markets also at the peak of the crisis. The benefits have been less obvious for smaller companies that have predominantly relied on the banking sector (Dobbs et al, 2013).

In contrast to government and corporate sectors, gains for banking sector were smaller and widely dispersed. In general, the interest rate income banks received on loans declined much sharply (2.1 percentage points) than the deposit rates (0.9 percentage points) at a relatively low level in the pre-crisis period (2.9%) as compared to the e.g. US and UK economies. In contrast, the effective interest rate margins for the US companies increased (interest income on loans less deposit rate liabilities) putting them comparatively in front of EA banks. In the Euro area, however, banks fared differently among individual member countries. For example, Italian and Spanish banks consumed 60% of the initial LTRO program, where a substantial amount of obtained liquidity was transferred into high yield government bond assets at the expense of reduced loan amount issued to households and corporate sectors. With that the interest margins for periphery Euro area banks increased (Collignon, 2013).

Large redistributional effects can likewise be observed for households and insurance companies. These sectors are related as countries with highest savings ratios in the Euro area commonly employ policy incentives related to insurance and pension schemes with guaranteed rate of return. For example, in Germany and Austria more than 80% of saving plans in the pre-crisis period incorporated this sort of arrangement. As these companies are commonly prevented from investing in risky high yield assets, many insurance companies, savings corporations, and households experienced considerable losses in these countries (Belke, 2013).

1.5 Evaluating monetary policy in the GFC-ZLB period

The previous section offered an insight into the development of a macroeconomic and financial environment during the GFC-ZLB period. However, by solely observing how particular variables evolved over time provides little evidence of the role of the ECB and its effectiveness during the crisis. For example, even though the asset price increase, demonstrated in Figure 4, chronologically follows the introduction of some non-standard
measures, it is very hard to separate the impact of the ECB from broader macroeconomic developments, simultaneous fiscal measures, evolving risk appetites, changes in inflation expectations, and potential spill-over effects of other central banks’ initiatives. Although this identification issue is not unique to the period after 2008 it gets exacerbated with the crisis and the introduction of unconventional monetary policies. Namely, the impaired financial and banking intermediation alters the way and the extent to which monetary policy gets transmitted to the real economy. Similarly, policies that seem to be effective in reducing uncertainty and restoring confidence in crisis period may have had little effect in a non-crisis period. Besides, as already discussed in Section 1.2, the effects of unconventional policies are generally diffused to the lagged impact they have at the actual implementation and to the more immediate effects through the expectation channel. These non-linearities importantly hinder assessment of the baseline to which the effects of unconventional policies could be compared to. In addition, measuring the state of economic and financial conditions that would prevail in absence of the monetary measures is further complicated considering the ongoing nature of the crisis and new sources of adverse shocks that occurred after the initial were resolved (Section 1.3 discusses separate stages of the crisis in Euro area).

In addition to the above, a necessary pre-condition for proper identification of a monetary policy shock remains an appropriate evaluation of monetary stance at each particular moment in time. Namely, the GFC-ZLB reflects a shift from one-dimensional to a multi-dimensional monetary policy. That is, as opposed to solely pursuing output and inflation stabilization through changes in key policy rates, monetary policy in the GFC-ZLB is designed to address several issues by using several monetary policy tools instead of just standard interest rate policy. The first part of this Section proposes ways to quantify the monetary stance in the GFC-ZLB period, whereas the second discusses how monetary policy effects are to be assessed once the monetary stance measures are provided.

1.5.1 Measuring the monetary policy stance

The above discussion has shown that in a conventional period the short term interest rates strongly resembled desired inflation and consumption choices and consequently provided a good measure of monetary stance and its expected future path. In contrast, short rates in the GFC-ZLB period no longer reflect the consumption paths and their severely limited movement, constrained by a lower bound, might wrongly lead us to believe that the monetary policy at that time remained somewhat inactive. But an obvious indicator of a different reality is the largely increased ECB’s balance sheet that reflects the introduction of various types of non-standard measure. An important question for the modelling of the monetary policy in the ZLB therefore is how to properly quantify a monetary stance and its expected future path when short-term rates no longer provide reliable information.
In the past, an already considered summary measure can be found in the quantity of money supply. In the above discussion it was stated that credit and quality easing result in money growth through the standard money multiplier relation. However, as past empirical evidence and central banking experience show, the money growth tends to produce counter-intuitive responses of macroeconomic variables due to the distorted transmission channels during financial distress. Namely we can perceive demand for money and its base (central bank’s reserves) as the inverted function of short term interest rates. When the latter are brought down to their lower bound, opportunity costs of holding reserves become zero and demand for money reserves become infinitely elastic. Increasing supply of money in that case therefore no longer produces any impact on inflation and output (Woodford, 2012).

A somewhat similar measure that could be considered is a growth of a central bank’s balance sheet. However, recent empirical evidence, e.g. Francis et al (2014), suggests that using balance sheet growth in place of a policy rate is not sufficient to represent intensity and various scopes of alternative measures being introduced. In addition, from the pragmatic point of view, the balance sheet growth only provides meaningful variation when non-standard measures are still operational. However, the GFC-ZLB period includes several runs of a monetary policy shifting from conventional to unconventional, which would imply that balance sheet growth does not allow continuous representation of monetary measures in that period. The third option would be to simply shift the focus from the short-term interest rates to longer-term interest rates, but this would lead to a noisy measure of a monetary stance as longer-term interest rates can apart from the expected short path be decomposed to a term, liquidity and risk premium (Krippner, 2015a).

An alternative would be to use information embedded in a yield curve which represents interest rate term structure and its dynamics thorough time. Empirical evidence has shown that the level and the shape of a yield curve should in principle reflect financial market’s perception of the current state of the monetary policy and expectation about its future development (Estrella and Rubin, 2006). Namely, in the most simplistic case we can consider long-term interest rates to reflect the compounded return of a risk-free rate plus residual risk compensation over the contract period of long-term interest. The spread between long-term and short-term interest rates will indicate investors’ expectations about the future path in relation to current and future economic and inflationary developments, that is, the objectives that central banks essentially pursue to stabilize. In normal times we can therefore assume that the yield curve would be upward sloping, indicating that in a response to growing future output and inflation a central bank would seek to close the gaps by increasing short term interest rates. In contrast, the flattened yield curve suggests that markets predict future short rates to fall as economic activity is expected to slow down. Recent experience has shown that the level and the shape of a term structure
offer a very reliable prediction of a future economic downturn as in the wake of the last six recessions, documented for the US economy (including the global financial crisis erupting in 2008), one could observe inverted yield curves (short-term interest rates surpassing long-term yields).

From the perspective of this dissertation, a special appeal of the yield curves lies in the fact that they are highly responsive to monetary policy, regardless of the form that monetary measures take. That is, whether monetary policy is deployed through key policy rate movement, asset purchases or credit easing, it will always be embedded in the market setting of interest rates along the maturity span. However, to be able to understand how the market perception of a monetary policy stance might evolve over time, one has to properly model the term structure relations of interest rates. In the literature the most commonly used models to estimate a yield curve are the ones corresponding to the class of the Gauss Affine Term Structure Model (hereafter GATSM). These models assume that short rates evolve randomly with normal Gaussian distribution and a mean reversion tendency. To illustrate this point better, Figure 7, panel (a), simulates 100 potential future paths for the March 2015 short rate, based on estimated parameters of a particular subclass of GATSM that will be used in the following chapter of this dissertation. We can see that all simulated paths tend to evolve in the same direction (in this case upwards) toward a specific future value. That is, they might move up or down, but they always tend to mean revert to a specific long-horizon value. At each particular horizon we can imagine that simulated points (expected future short rates over a period corresponding to the horizon) are distributed normally. With a longer horizon, the distribution becomes wider as random innovations aggregate over time, meaning that paths can potentially take more extreme values at longer-horizons. Extracting distribution means at each horizon for each respective path yields the average expected path of a short rate. In that respect the average short path represents the expected compounded return from investing in the short rate up to each particular horizon or in other words the most simplistic yield curve estimation.

However, while the application of the GATSM framework might be relatively straightforward in conventional times, in the financial crisis period and in particular in a low interest environment the application and general use become subject to important complications from both, the theoretical and the practical point of view. Namely, in a low interest environment, the Gaussian specification of future evolution of short rates results in a non-negligible probability of interest rates developing well below their lower bound. These realizations would in the presence of a physical currency be inconsistent with the general economic wisdom as they would allow arbitrage opportunities of borrowing funds at negative interest rate and holding it in cash. From the practical point of view, not accounting for a lower bound could lead to model estimates that have never been observed in the past and are in that respect materially different from the actual observations. An
illustration of this is presented in panel (b), Figure 7, which represents expected short rate developments in March 2015. In this case, a considerable portion of expected short rate distributions is now represented by negative values, including the longest horizons of 7- and 10-years. The implied probabilities of significantly negative interest rates will imply severe misspecifications relative to the observed data. This is depicted in panel (c), where the estimates of the GATSM model, both in level and shape, no longer provide reliable fit to the actual data.

Figure 7: From GATSM to Shadow/GATSM

Therefore, to be able to extract reliable information from a yield curve also in a low interest environment, linear Gaussian term structure models have to be adjusted for the lower bound. While there has been an extensive literature dealing with this matter in recent and past years, the highest tractability of recovering term structure near zero lower bound seems to be recognized to somewhat familiar approaches of Krippner (2011-2015) and Wu and Xia (2016). Returning to panel (b), intuitively their mechanism now relies solely on simulated short paths truncated at a lower bound value (i.e. zero). This is achieved by redefining the short rate process as:

\[ r(t) = \max(0, r(t)) \]  

where \( r(t) \) is the shortest rate of a yield curve adjusted for a lower bound and is represented
as an option of holding physical currency at zero return against investing in a shadow short rate \( r(t) \), that is the rate that can evolve to arbitrary positive or negative values. The mechanism implies investors prefer to keep surplus fund in cash rather than investing it at negative rates. In that manner, the short rate and its evolution, \( t + \tau \), to future horizons \( \tau \) represents solely the choices that are available to investors in real life (Krippner, 2015). The shadow part of the yield curve is represented by GATSM which therefore represents a special case of the general lower-bound adjusted term structure modelling framework (hereafter ZLB/GATSM or Shadow/GATSM model). This is evident from the panel (a) of Figure 7, where in the case of interest rates sufficiently above the lower bound, the average expected short paths produced by the GATSM and ZLB/GATSM, respectively, completely coincide. Conversely, in the 2015 case, one can see that the average expected short path produced by the ZLB/GATSM properly fit the downwardly bounded short rates, whereas for the longer horizons average short path of the ZLB/GATSM consistently develops above the GATSM as the mean calculation is based only on the positive values, while in the case of GATSM distribution, mean calculation also involves negative values.

Related to the short path distributions, the ZLB/GATSM is also able to capture another important aspect of realistic representation of yields in the low interest environment. Namely, the recent experience of Japan and US show tendency of interest rates to maintain near-zero values for a prolonged period, once their movement is bounded by the lower bound. This can happen for two reasons that have amplifying effect on each other. To preserve a credible monetary policy, a central bank might want to stick to its past commitments not to lift key policy rates even when current stabilization condition suggests so. Conversely, if these kind of commitments had not been made, credit and quantitative easing would in line with Woodford (2012) very likely not produce desirable effects in a short period and a low key policy rate would have to be maintained for prolonged time. In any case, the just described stickiness will be accounted for by reduced volatility of expected short paths in a truncated distribution as opposed to the GATSM where volatility will remain unchanged, irrespective of whether the model is estimated for a lower bound period or conventional monetary times.

The ZLB/GATSM therefore continues to provide close fit to the observed data (panel (d)) and allows us to extract useful information from the reliable estimates of model parameters. In addition, by perceiving the ZLB/GATSM from the perspective of its option and shadow components (the mechanism is illustrated in panel (a), Figure 8) it allows us to derive several useful concepts for gauging the monetary stance and expectations in the zero lower bound period. In that respect the option curve will represent the expected payoff cumulated over all horizons or interest rate maturities \( t + \tau \). The expected payoffs will reduce with a reduced probability of negative interest rates with longer maturities. In contrast, the shadow part of a yield curve can be perceived as its hypothetical realization that would materialize, had its movement not been constrained by lower bound, which
could happen in a world without a physical currency. The interest rate of the shortest maturity, the shadow short rate \( r(t, 0) \), by analogy represents the hypothetical realization of a central bank’s policy rate which should, by allowing the arbitrary negative dynamics, continue to represent the monetary stance also in the zero lower bound period. In that respect it should provide a summary measure of all monetary policies, alternative and conventional, used by a central bank. Moreover, by looking at the average expected path of a shadow short rate one could obtain financial market expectation on future evolution of monetary policy. As from the already discussed conceptual view negative values are unlikely to be observed in the future, the quantity to be considered should refer to the truncated by zero average expected short path (hereafter the effective short path) \(^1\). The truncation of negative values of the average expected shadow rate path will therefore properly account for the delayed lift-off and stickiness of the interest rates in line with the discussion above. In addition, the ZLB/GATSM allows us to reliably estimate the neutral rate and therefore consider current measures from the perspective of monetary policy beyond business and financial cycle. Higher detachment of the neutral monetary policy from the current stance would in that sense imply intense counter-cyclical monetary policy. In other words, a larger difference between the neutral rate and average effective short path will represent a higher monetary stimulus (Effective Monetary Stimulus).

\[ \text{Figure 8: Gauging monetary stance} \]

\[ \text{(a) Shadow curve and option effect} \]

\[ \text{(b) Policy measures} \]

\[ \text{Source: Author’s calculations.} \]

1.5.2 Identification of monetary policy impact

Once the monetary stance has properly been quantified, an important question that remains is how to separate the impact of monetary policy measures from other influences affecting macroeconomic and financial conditions. In other words, to assess the effectiveness of unconventional monetary policies, a practitioner would need to estimate counter-factual macroeconomic and financial categories that would prevail in the absence of monetary pol-

\(^1\)At the time of writing some of the euro area rates have already fallen to negative values, meaning that monetary policy may no longer be necessary truncated at zero but the truncation parameter could also undertake negative values.
icy. As unconventional monetary measures took various form (forward guidance, quantity and credit easing, and interest rate policies) and were designed to tackle specific issues, estimation of monetary policy impact needs to be examined partially (separately financial and macroeconomic conditions) using different analytical methods.

The impact on financial markets and intermediation can for instance be examined through the effects on the long-term yields. However, long-term interest rates may be affected by multitude of factors. A preferred method to distil effects of the non-standard measures is by using an event-study analysis (IMF, 2013). The event-study analysis relies on observing yield changes in a very narrow time window following an announcement of particular non-standard measures. Official announcements relate to intended future asset purchases, but can also be used to represent reinforcement of past policy commitments or as a tool to communicate a future policy path and a macroeconomic environment. With respect to analysing the impact of forward guidance, therefore, the event-study analysis can properly be elaborated to disentangle channels through which asset purchases are transmitted to financial markets. In a broader sense asset purchases affect financial yields through various channels. By indicating a permanent shift in monetary policy through asset-removal, which increases asset prices by decreasing their relative supply, or by ensuring liquidity for a particular financial instrument and therefore make them more appealing to investors. This is important as it enables us to separate between the forward guidance effects operating through an expectation channel, as opposed to the value of quantitative easing, operating through asset-removal or liquidity channel (a portfolio channel). The distinction between different channels can operationally be made either by simultaneously observing effect on various market segments (e.g. corporate bonds markets versus OIS yield curve representing policy expectations), or by observing changes in the estimated expected path of the short rate provided by the term structure model as described above.

The accuracy of the event-study analysis in capturing the effect of monetary policy essentially relies on the level of surprise carried by announcements. Namely, the announcements are in many cases at least partly expected. In that respect, the even-study analysis might misestimate the true effect of the non-standard measures if it does not properly account for the surprise element. The analysis performed by the IMF (2013) suggests that this can be done by observing simultaneous changes in 1-year future rates, which should resemble policy moves to come. In principle, the higher futures rate change is associated with a larger surprise effect. Another way to approach this particular issue is to supplement the event-study analysis with regression analysis based on the announcement date dummies. Instead of capturing the maximum one-off effect, a regression analysis of this sort would provide an estimate of persistent effect on yields with properly accounting for the anticipation component. Table 1 briefly describes the recent empirical studies examining the effects of the non-standard measures on yield changes.
Table 1: Empirical studies on bond yield changes

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Market</th>
<th>Impact on yields and dominating channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joyce et al (2011)</td>
<td>Event-study</td>
<td>UK</td>
<td>-10 bps, portfolio channel</td>
</tr>
<tr>
<td>Christensen &amp; Rudebusch(2012)</td>
<td>Event-study</td>
<td>UK</td>
<td>-80 bps, portfolio channel</td>
</tr>
<tr>
<td>Doh &amp; Conolly (2012)</td>
<td>Regression</td>
<td>US</td>
<td>Yield reduction, portfolio channel</td>
</tr>
<tr>
<td>Ueda (2012)</td>
<td>Event-study</td>
<td>Japan</td>
<td>-10 bps, expectation channel</td>
</tr>
<tr>
<td>Christensen &amp; Krogstrop(2014)</td>
<td>Event-study</td>
<td>Swiss</td>
<td>-30 bps, expectation channel</td>
</tr>
<tr>
<td>Kang et al (2014)</td>
<td>Event-study</td>
<td>EA</td>
<td>Increase in yields, expectation channel</td>
</tr>
</tbody>
</table>

After examining the impact on financial markets and intermediation, the question that probably matters the most to the policy-makers and practitioners is the effectiveness of unconventional monetary policies from the perspective of real economy. In normal times, empirical effects on macroeconomic variables are commonly extracted by examining monetary transmission in vector-autoregressive (VAR) models. The so called monetary VAR model in its most basic form examines dynamic relations among an output variable, inflation, and policy rate. As the standard key policy rate no longer provides reliable information on monetary stance in the GFC-ZLB period, it should in this case be replaced by one of the alternative measures presented above (e.g. shadow short rate or economic measure of stimulus). By imposing a proper structure on monetary VAR model one can then identify monetary shock within the VAR system. To briefly describe what is meant by identification and placing the structure on our system, we can imagine that the most basic monetary VAR model represents an economy as follows:

\[
AX_t = BX_{t-1} + \epsilon_t
\]

\[
a_{11}Y_t + a_{12}\pi_t + a_{13}r_t = b_{11}Y_t + b_{12}\pi_t + b_{13}r_t + \epsilon_{y_t}
\]

\[
a_{21}Y_t + a_{22}\pi_t + a_{23}r_t = b_{21}Y_t + b_{22}\pi_t + b_{23}r_t + \epsilon_{\pi_t}
\]

\[
a_{31}Y_t + a_{32}\pi_t + a_{33}r_t = b_{31}Y_t + b_{32}\pi_t + b_{33}r_t + \epsilon_{r_t}
\]

(3)
Where \( [Y \pi r] \) represent output, inflation and alternative policy rate, \( A \) is a matrix of contemporaneous coefficients with \( [a_{11} a_{22} a_{33}] = I \), \( B \) is a matrix of lagged coefficients, and \( [\epsilon_{Yt} \epsilon_{\pi t} \epsilon_{rt}] \sim N(0, I) \) is a vector of zero mean white noise structural innovations. But the system defined by 3 is infeasible as it violates the pre-condition on uncorrelated innovations and regressors necessary for the validity of OLS estimator. What can be estimated instead is the following reduced-form system:

\[
X_t = \frac{A^{-1} B X_{t-1} + A^{-1} \epsilon_t}{F X_{t-1} + u_t}
\]

(4)

where \( F \) is a matrix of reduced-form coefficients and \( u_t \) is a matrix of reduced-form residuals. Note however that within the reduced-form system we can no longer distinctly identify shocks as covariance of residuals is no longer an identity matrix \( VCV(u) \neq I \) (i.e. \( u_t \) is linear combination of structural shocks \( \epsilon_t \)). To get back to the original structural shocks we need to uncover the matrix \( A^{-1} \) as \( \epsilon_t = A^{-1} u_t \). As we know that \( \epsilon_t \epsilon_t' = I \) we can do that by solving for \( VCV(u) = (A \cdot \epsilon')^{-1} (A \cdot \epsilon)^{-1} = A^{-1} A^{-1'} \):

\[
\begin{bmatrix}
\sigma_{11} & \sigma_{12} & \sigma_{13} \\
\sigma_{21} & \sigma_{22} & \sigma_{23} \\
\sigma_{31} & \sigma_{32} & \sigma_{33}
\end{bmatrix}
= \begin{bmatrix}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{bmatrix}
^{-1}
\begin{bmatrix}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{bmatrix}
^{-1'}
\]

(5)

As \( VCV(u) \) is a symmetric matrix the above system now contains 6 equations and 9 unknowns and can therefore not be resolved. To identify the system we therefore need to impose a proper restriction. As our purpose is to uncover monetary shocks, the restrictions has to follow the economic intuition. In that respect, the restrictions most commonly follow one of the following three forms:

- **Recursive or short run restrictions** according to which monetary policy shock affects other variables in the system only with lag (\( A \) becomes lower-triangular matrix);
- **Long-run restrictions** according to which the cumulative effect of the monetary policy shock on an output variable is zero in a long-run;
- **Sign-restrictions** which imply an a-priori by theory determined direction of causation of monetary shock on a particular variable or a set of variables.

With one of the above restrictions we can therefore uncover monetary policy shock from the estimated reduced-form VAR model. Finally, this enables us to estimate the counterfactual state of economic conditions that would prevail in the absence of monetary policy and therefore answer the most important question which is how effective the ECB’s unconventional monetary policy was in restoring the real economic activity. Operationally this can be done by re-expressing our VAR system as follows:
\[ X_1 = F X_0 + A^{-1} \epsilon_1 \]
\[ X_2 = F X_1 + A^{-1} \epsilon_2 = F(F X_0 + A^{-1} \epsilon_1) + A^{-1} \epsilon_2 = F^2 X_0 + F A^{-1} \epsilon_1 + A^{-1} \epsilon_2 \]
\[ \ldots \]
\[ X_T = F^T X_0 + (F^T A^{-1} \epsilon_0 + \ldots + F A^{-1} \epsilon_T - 1 + A^{-1} \epsilon_0) \]

Equation (6) therefore at each point in time redefines our VAR system as a sum of all past structural shocks. In that respect, by excluding monetary policy shock, which we obtained through one of the alternative monetary policy measures, we can at each point in time assess the size and direction in which unconventional monetary policy has affected macroeconomic variables. With this we can offer a judgement on what economic conditions would be absent the monetary policy and whether non-standard measures were large enough to offset the adverse shocks affecting the Euro area economy.

Although other applications have been used as e.g. structural and semi-structural models, the SVAR methodology described above has by far been the most extensively utilized tool for the modelling of monetary policy. Table 2 briefly summarizes past empirical results on effectiveness of unconventional monetary measures on the real economy.
<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Country</th>
<th>Main results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baumeister &amp; Benati (2010)</td>
<td>TVP-SVAR</td>
<td>US</td>
<td>GDP (↑ 2.4%) inflation (↑ 1.6%)</td>
</tr>
<tr>
<td>Fuhrer et al (2011)</td>
<td>SVAR (cholesky)</td>
<td>US</td>
<td>GDP (↑ 2.4%) inflation (↑ 1.6%)</td>
</tr>
<tr>
<td>Chung et al (2011)</td>
<td>DSGE</td>
<td>US</td>
<td>GDP (↑ 2.4%) inflation (↑ 0.4%)</td>
</tr>
<tr>
<td>Chen et al (2015)</td>
<td>SVAR (sign)</td>
<td>US</td>
<td>GDP (↑) inflation (↑)</td>
</tr>
<tr>
<td>Wu &amp; Xia (2016)</td>
<td>SFAVAR (cholesky)</td>
<td>US</td>
<td>unemployment (↓ 1%)</td>
</tr>
<tr>
<td>Baumeister and Benati (2010)</td>
<td>TVP-SVAR (sign)</td>
<td>UK</td>
<td>GDP (↑ 2.4%) inflation (↑ 1.8%)</td>
</tr>
<tr>
<td>Bridges &amp; Thomas (2012)</td>
<td>SVAR (Long-run)</td>
<td>UK</td>
<td>GDP (↑ 1.5%) inflation (↑ 1%)</td>
</tr>
<tr>
<td>Kapetanios et al (2012)</td>
<td>SVAR (sign)</td>
<td>UK</td>
<td>GDP (↑ 2%) inflation (↑ 1.5%)</td>
</tr>
<tr>
<td>Chen (2015)</td>
<td>SVAR (sign)</td>
<td>EA</td>
<td>GDP (↑) inflation (↑)</td>
</tr>
<tr>
<td>Baumeister &amp; Benati (2010)</td>
<td>TVP-SVAR (sign)</td>
<td>EA</td>
<td>GDP (↑ 1%) inflation (↑ 0.8%)</td>
</tr>
<tr>
<td>Lenza et al (2010)</td>
<td>Bayesian-VAR</td>
<td>EA</td>
<td>GDP (↑ 1.5%) inflation (↑ 0.1%)</td>
</tr>
<tr>
<td>Giannone et al (2012)</td>
<td>Bayesian-VAR</td>
<td>EA</td>
<td>IP (↑ 2%)</td>
</tr>
<tr>
<td>Peersman (2011)</td>
<td>SVAR (sign)</td>
<td>EA</td>
<td>IP (↑) inflation (↑)</td>
</tr>
<tr>
<td>Baumeister &amp; Benati (2010)</td>
<td>TVP-SVAR (sign)</td>
<td>Japan</td>
<td>GDP (↑ 1.1%) inflation (↑ 0.8%)</td>
</tr>
</tbody>
</table>

### 1.6 Contextual placement of the doctoral dissertation

The main outtakes of the Chapter 1 can be summed up under the following points. As it was the case with other crises in the past, the severe impact of the global financial crisis on world economies essentially forced central banks to change their daily policy conducted. This change could best be described as a shift from one-dimensional to multi-dimensional monetary policy, where the multidimensionality refers to both, the central bank mandates and the ways in which monetary policy is implemented. The single price stability mandate of the ECB was informally complemented by other objectives, including maximum employment, risk mitigation and credit spread reduction. In similar fashion, the exhaustion of the key policy rate reduction called for introduction of historically unprecedented monetary measures. Recent empirical evidence and economic theory suggests that these unconventional measures can only be effective if they work in a close interaction with one another. That is, the credit facilities and quantitative easing will be of little impact without appropriate forward guidance and commitment to the easier monetary policy, whereas the commitment will not be perceived as credible if not supported by the actual
tangible measures.

The question that remains open is to what extent has the monetary policy in the Euro area been conducted in line with these theory based recommendations. As we have seen the institutional framework to which the ECB adheres is rather restrictive and the primary price stability objective potentially limits the extent to which the unconventional measures can interact. In addition the Euro area crisis developed in three stages and impacted individual countries differently. In that respect the non-standard measures had to be accommodated to a particular source of risk (depending on the stage of the crisis) and targeted at the most distressed countries. In example the sovereign and currency crisis brought special attention to intra-euro credit spreads, a matter that conventionally does not fall into the domain of monetary policy. With this kind of novelties being introduced into the monetary policy sphere it is not clear what the impact of the non-standard measures on monetary transmission would be.

Chapter 2 attempts to address the questions just raised. In particular, it analyses the effect of the non-standard measures on the Euro area financial yields. Moreover, it separately considers individual non-standard measures and communication surrounding them, to observe whether different non-standard measures have unique or measure-specific impact on the monetary transmission. A special emphasis of Chapter 2 is to assess how successful did the ECB steer monetary policy expectations what implications did this have for the effectiveness of the non-standard measures. Related to the matter of risk mitigation and intra-euro spread reduction, the analysis also explores individual country perspective and impact of the non-standard measures on risk premiums. However, solely producing a low interest environment does not necessarily ensure an accommodative monetary stance. The analysis of financial and macroeconomic developments in the Euro area (see Section 1.4) revealed an ongoing deleveraging and restructuring process in the banking as well as in the non-financial sector. The efficiency of the monetary transmission channel and the financial sector pass-through in the period before 2015 began to be questioned. The speculation about the inefficient monetary transmission channel are further supported as lower interest rates have not been reflected in an increased bank lending activity.

Therefore, in order to draw suitable policy implications it is essential to examine the effectiveness of unconventional policies from the perspective of real economy. Chapter 3 therefore directly deals with the matter of impact of the non-standard measures on the core macroeconomic variables. Based on the observed heterogeneities in monetary transmission revealed in Chapter 2, it separately considers macroeconomic impact on the selected Euro area periphery countries and the Euro area core. The core contribution of the Chapter 3 is the distinction between financial and macroeconomic stabilization effects of the unconventional monetary policies in the individual Euro area countries.

However, the combined GFC-ZLB period did not only alter the daily monetary policy
conduct and our understanding of its effects, but it also brought important complications from the empirical modelling of the monetary policy perspective. In other words, the appropriate modelling framework is a necessary pre-condition for drawing credible policy implications and judgements on effectiveness of unconventional monetary policies. The dissertation as a whole, but in particular Chapter 4, offers innovative proposals on how to compactly model the monetary policy stance with respect to multidimensional monetary policy and directly deals with the matter of identification in the period of the GFC-ZLB.
2 IMPACT OF MONETARY POLICY DECISIONS ON EURO AREA YIELDS

2.1 Outline and past literature

This chapter analyses the impact of non-standard measures on the Euro area financial yields. There are several reasons why practitioners should care how financial markets are affected by monetary policy. Namely, asset prices strongly resemble market expectations on future monetary policy and with that essentially condition the effectiveness of non-standard measures. Next, asset prices importantly determine wealth of economic agents, state of banks’ balance sheets, costs of raising new funds and servicing of existing debt. Falling asset prices can therefore significantly impair normal functioning of monetary transmission. In addition, most investment and consumption decisions influencing aggregate demand depend on long-term yields. From a central banking point of view it is therefore very significant how monetary measures are translated to an entire yield curve and not just its short-term part. In fact, the ECB introduced several non-standard measures that were directed at providing additional credit and financial easing through Euro-area debt markets. In that respect it is reasonable to expect that the impact of the ECB’s unconventional monetary policy would first be resembled in financial yields as opposed to macroeconomic effects that might only be revealed with significant lag and in the mean time be affected by a multitude of external factors. For these reasons the Euro area debt markets seem to be an obvious starting point for analysing the effectiveness of unconventional monetary policy. In particular, this chapter will seek to provide an answer to the following two of the research questions postulated in the introduction:

• How can we properly model monetary policy expectations in the ZLB environment?

• What was the role of the ECB in averting the consequences of the global financial crisis and how credible this role was in the eyes of the financial markets?

The financial yields can in a broader sense be affected either by steering the financial market expectations about the future monetary policy - commonly denoted as policy signalling - or by influencing the relative supply of assets held by the private sector - denoted the portfolio allocation effect. In the context of the non-standard measures introduced between 2008 and 2014, the signalling effect could be perceived as the markets’ recognition of the central bank’s commitment to maintain future short-term interests near zero, whereas the portfolio allocation is associated with a reduced bond term premium due to an increased demand for medium-to-long-term debt securities and their close substitutes. This kind of decomposition follows the pure expectation theory according to which long-term yields reflect expected return that could be earned by investors from rolling the short-term risk-free asset over a given horizon, and a residual return, reflecting the risk associated with the time component and investors’ reluctance towards holding an asset.
with longer duration. Moreover, as the investors care about the future, both effects should take place immediately after central bank’s announcement of the large-scale asset purchases at the future date. Namely, by communicating its intention to the public, central banks may provide the forward guidance to financial markets about future commitments and at the same time indicate the future stock of a particular asset.

Disentangling the two channels plays an important role in understanding how monetary measures get transmitted to financial markets and carries potential policy prescriptions for the volume and monetary tools to be used. For example, in case of the muted signalling channel, the central bank might need to reconsider its communication and forward guidance strategy, whereas in the case of non-operational portfolio channel the volume of measures and targeted assets might be an issue. To differentiate between the two channels our analysis decomposes the Euro area financial yields into term premium and the expected short rate path using term-structure modelling techniques. We relate changes in term premium to portfolio channel and the expected short path to signalling of future monetary policy. To isolate the impact of the ECB on financial markets from other influences, the decomposed yield changes are analysed within one day surrounding the announcements of the ECB’s unconventional policies.

Analysing the impact of monetary policy on financial markets in the manner just describe has a long lasting tradition in the existing literature. In the pre-crisis period the event-study methodology was used to analyse the effects of the announced policy rate changes on financial markets. For example, Kuttner (2001) examines the impact of target FED rate on bond yields. The analysis uses data from futures market to decouple expected and surprise changes. The results suggest that the anticipated policy changes have effect close to zero on bond yields, in contrast to an unanticipated change, where impact is large and highly significant. Similar results were obtained for stock market prices in analysis by Bernanke and Kuttner (2005). Gürkaynak et al (2005) employ high-frequency event-study analysis to examine the explanatory power of policy rate changes on intra-daily asset price data. They found that a single factor, i.e. FED fund rate, is not sufficient to explain bond yield changes induced by the monetary policy announcement. Instead, accounting for the future policy path is necessary for capturing entire asset price variation. With respect to the latter, they show that statements, captured by a future policy path factor, have much greater impact on longer-term yields than on the short-term interest rates.

Knowing that the long-term interest rates can predominantly be influenced by a future policy path rather than short rate movements becomes especially important in the crisis and the ZLB period with introduction of measures beyond key policy rates. In fact, according to the New Keynesian models, non-standard measures can only be effective to the extent they change expectations regarding the future policy path (Eggertsson and Woodford, 2003). However, these models are derived based on a restrictive assumption of
no financial frictions. In reality, assets are imperfect substitutes, meaning that changing relative supply of a particular asset will have material effect on its price, which opens floor for the portfolio balance effect. The basis to model both channels, signalling and portfolio, could be found in Kim and Orphanides (2007) and Kim and Wright (2005), who by fitting a term-structure model to the US Treasury yields, find that large portion of the long-term yield declines in the pre-crisis period could be ascribed to fall in term premium.

Conversely, Christensen and Rudebusch (2012) utilize this approach in the ZLB time and find that following the FED's announcements of eight major QE programmes, yields for the US 10-year Treasury bond reduced by 89 basis points in total, where the majority of the reduction is attributable to downward revised expectations about the future short-term interest rates. In contrast, their results for the UK indicate that QE announcements affected the financial markets through the portfolio allocation channel as the majority of the 10-year gilt decline could be ascribed to the reduction of the corresponding term premium. A similar portfolio rebalancing effect was found by Christensen and Krogstrup (2014) for the Swiss long-term government bond yields, following the Swiss National Bank announcements of extending the central bank reserves without any long-term asset purchase programmes.

Standard monetary policy application of the term-structure models and yield curve decomposition commonly follows a conventional doctrine according to which monetary policy impacts an economy through risk-free rate and its policy path (Woodford, 2003). However, many, recently employed, non-standard measures at least partly address also the risk premium. In that light, the term structure models could be used to decompose yields to the expected path and risk premium as suggested by Cochrane and Piazzesi (2005) and Cochrane and Piazzesi (2008). Similar approach was used by Kim and Singleton (2012) who find that significant portion of the Japanese long-term yield dynamics during the ZLB is governed by the risk premium.

In addition to term-structure modelling and observed decomposed yield changes on announcement day, the event-study techniques also include regression based methods to analyse the impact on financial yields. For example, Rogers et al (2014), Wright (2012) and Haitsma et al (2015) regress daily yield changes on a selected measure of monetary surprise. In both cases the event-study analysis is used, the approach already introduced by Gagnon et al (2011), which focuses on examining the long-term government bond yields on a day before and a day after the particular QE announcement. Joyce et al (2011) and Gagnon et al (2011) apply VAR model with the set of exogenous variables controlling for external influence to examine the impact of central bank induced reduction in the debt stock on excess return and term premium.
Our study focuses on the announcements of seven respective programmes devised by the ECB’s Monetary Policy Committee in an attempt to provide additional stimulus to the Euro area economy. The announcement dates were selected in a way to encompass the unconventional policies with active engagement in the securities markets. At each particular announcement date we examine the impact of the ECB’s monetary policy on the Euro area yields in a one-day window surrounding the announcement of the program. This type of event study analysis offers a convenient way for examining the effects of monetary policy decisions by isolating the role of the ECB from other external influences. Furthermore, by estimating the term structure model that respects the zero lower bound, proposed by Krippner (2011-2015), in real time, we can attribute changes in the Euro-area yields to the change in expected short rate and to the change in the corresponding term premium. By doing so, we are the first to our knowledge to examine the channels through which the monetary policy operates in the Euro area and to provide model based results of the effects of key monetary policy decisions on the Euro-area bond markets.

From the perspective of the overall Euro area our results are broadly in line with the recent studies (e.g. example Rodriguez and Carrasco (2014), Kang et al (2015) and Rogers et al 2014), according to which the announcements of the ECB’s monetary policy decisions did not produce a far reaching effect on financial markets, or at least not the one that could have been observed in case of the FED or to a lesser extent in case of the Bank of England. For the measures introduced before 2014 the Euro area bond yields increased. Reasons for this counter-intuitive response can be twofold. First, as argued by Rogers et al (2014), non-standard measures introduced by the ECB have largely been targeted to crisis countries and aimed at reducing intra-Euro sovereign spread, which led to vastly heterogeneous effect across the Euro. Second, institutional framework of the EU prevented the ECB to employ unconventional policies in volume and a level of commitment comparable to other central banks, e.g. the FED or Bank of England. In that manner, Kang et al (2015) argue that the hesitant communication strategy, stressing the temporary nature of the non-standard measures potentially led some market segments to interpret announcements as bad news by linking the non-standard measures explicitly to extraordinary economic times. This is supported by the fact that overall reduction of yields in the entire Euro area coincide with the first large scale asset purchase programs in 2014 and the ECB’s permanent commitment to non-standard measures.

Beyond this introduction, the structure of the paper proceeds as follows: Section 2.2 presents the preferred modelling strategy to obtain a term premium and expected short rates from the observed Euro area yield curve; Section 2.3 provides the event study analysis of the effects of key monetary policy decisions; Section 2.4 compares impact on the Euro area periphery and core; Section 2.5 performs sensitivity analysis; Section 2.5 concludes.
2.2 Modelling strategy

To fully develop the event study analysis on bond prices surrounding the policy announcement dates, we employ a dynamic term structure modelling framework. Namely, this framework allows to explicitly model the expectations component for instantaneous risk-free rate and residual term premium. In particular, the three-factor Affine Nelson-Siegel model (ANSM) adjusted for the lower bound presents our preferred modelling choice as it provides a meaningful interpretation of the estimated parameters. The choice follows the course of similar event study analyses, e.g. Christensen and Rudebusch (2012), Ichise and Ueno (2013) and Christensen and Krogstrup (2014) who also show relative superiority of the ANSM framework compared to the other yield curve models or simple random walk with respect to forecasting performance and general fit to the actual data. Further, our focus is put on the announcement of non-standard programs that were introduced as the alternative or complement to the standard policy rate due to its limited space for further reduction. In a low interest environment standard yield curve models become theoretically and empirically inconsistent as they allow fitted yields to evolve to negative values with material probability greater than zero. Therefore, in order to prevent arbitrage opportunities and improbable yield curve fits we have to account for the lower bound on interest rates. Throughout the paper we utilize the modification of ANSM proposed by Krippner (2011-2015) that enforces the lower bound on interest rates and offers an arbitrage-free approximation of the framework proposed by Black (1995). The latter imposes the mechanism which defines the actual short rate at time $t$ as the shadow rate $r_t$ that would prevail in absence of the zero lower bound, and a call option offered to investors to hold physical currency with zero return, when the shadow rate evolves to negative values:

$$ g(t) = r(t) + \max(-r(t), 0) $$

(7)

The mechanism described by Equation (1) recognizes the existence of physical currency by implying an option to investors to be compensated with payoff $-r(t) = |r(t)|$ for investing at a negative rate $r(t)$. That is, whenever a shadow rate $(r(t))$ undertakes a negative value, the actual rates will be zero as $r(t) = -r(t) + \max(-[-r(t), 0]) = -r(t) + r(t) = 0$. Considering conventional financial wisdom, a corresponding forward rate expression can be obtained as an expected compounding return from investing in $r(t)$:

$$ f(t, \tau) = \frac{E[r(t+\tau|x(t))]}{f(t, \tau)} + \frac{E[\max-r(t+\tau), 0|x(t)]}{z(t, \tau)} $$

(8)

where $f(t, \tau)$ is shadow forward rate of a given maturity $\tau$ and $z(t, \tau)$ is the corresponding
forward rate option effect. Krippner (2011-2015) provides a closed form analytical solution for the forward rate curve adjusted for the lower bound in continuous time. For the estimation purposes, forward rate curve enters the state space representation as measurement equation and can in its most generic form, that is, a most general case without any structure on the parameter imposed, be represented as:

$$f(t, \tau) = r_L + [f(x_t, \tau) - r_L] \cdot f(t, \tau) \cdot \Phi \left[ \frac{f(x_t, \tau) - r_L}{\omega(\tau)} \right] +$$

$$+ \omega(\tau) \cdot \frac{1}{\sqrt{2\pi}} \exp \left( -\frac{1}{2} \left[ \frac{f(x_t, \tau) - r_L}{\omega(\tau)} \right]^2 \right) \quad (9)$$

where $\Phi[\cdot]$ stands for a unit normal cumulative density function and $\omega(\tau)$ stands for the volatility function. The corresponding state equation is defined as the Ornstein-Uhlenbeck’s continuous analogue of the AR(1) process for the state variables:

$$x_t = \theta + \kappa[\theta - x_{t-1}] + \sigma \quad (10)$$

Where $x_t$ is $N \times 1$ vector of state variables, $\theta$ is a vector of long-term state constants, $\kappa$ is a mean reversion matrix, and $\sigma$ is a volatility matrix. Important to note here is that the above evolution of state variables is defined under the physical $P$ measure process. The $P$ measure refers to the actual expected values adjusted by individual investor’s risk perception. In complete and arbitrage-free markets, however, it turns out that there exists a risk-neutral measure $Q$, which essentially summarizes all investors’ risk premia. Under this measure, the resulting expected returns on all assets, therefore, equal the risk-free rate. Hence, the process $P$ first has to be adjusted for the risk in order to be able to explain the forward rate term structure. A bridge to risk-adjusted process for state variables is a linear market price of risk, which is according to Krippner (2015) defined as a time varying function of a constant $N \times 1$ component of risk $\gamma$ and $N \times N$ component $\Gamma$ that relates market price of risk to each state variable. Accounting for the market price of risk expressed as $\Pi(t) = \gamma + \Gamma x_t$, provides the risk-adjusted parameters $\tilde{\kappa} = \kappa + \Gamma$ and $\tilde{\theta} = \tilde{\kappa}^{-1}(\kappa, \theta - \gamma)$. A closed-form analytical solution for $f(x_t, \tau)$ is governed by a closed-form analytical expressions for $f(x_t, \tau)$ and $\omega(\tau)$, which are defined by state variables $x_t$ and parameters $\tilde{\kappa}$, $\tilde{\theta}$, $\sigma$, and $r_L$. Equations (2)-(4) present a non-linear state-space model which is estimated by the Extended-Iterated Kalman filter procedure. A standard term structure relation is used to obtain interest rates $R(t, \tau)$ from forward rates $^2$:

$^2$Note that the integral solving for interest rates does not have a closed-form analytical solution due to a cumulative Gaussian distribution contained in the forward rates. Numerical integration with constant time-to-maturity increments $\delta \tau$ is used instead: $\frac{1}{\tau} \sum_{j=1}^{\tau} f(t, j \Delta \tau) \Delta \tau$
The shadow short rate $r(t)$ from equation (1) is within this framework extracted from the shadow part of the $R(t,0)$ and can be defined as a linear function of state variables $x(t)$:

$$
R(t,\tau) = \frac{1}{r} \int_{\tau}^{\tau} f(t,u)du \quad (11)
$$

$$
r(t) = a_{0} + b'_{0}x(t) \quad (12)
$$

The structure described by (1)-(6) represents the most flexible and general form of the lower-bound Gauss Affine Term-Structre Model, commonly denoted as Shadow/GATSM. However, as stated in the beginning of this section, a subclass of GATSM defined as Shadow Arbitrage-free Nelson-Siegel Model (ANSM) has proven to be the most parsimonious representation for our purpose and many other macro-finance related tasks. In particular, since we are interested in the bond market information from the perspective of the event study analysis of the ECB non-standard measure announcements, the model fit will be of particular importance and we therefore proceed our empirical estimation with the three unobserved factors (Shadow/ANSM(3) model). Other applications may prefer lower factor orders at the expense of model fit, Krippner (2015). The Shadow/ANSM specification imposes a structure on general Shadow/GATSM parameters, which enables state variables to obtain a convenient economic interpretation. Intuitively, the three unobserved factors in the ANSM case can from the yield curve perspective, be perceived as the Level ($L$), Slope ($S$), and Curvature ($C$) factors, where in relation to macro-finance the Level and Slope have proven to exhibit a considerable causal relation to inflation and output growth, respectively (see Krippner (2008) and Diebold (2015)). In addition, the ANSM representation deals with another limitation of the most general GATSM specification, namely the inability to account for the small-sample bias common to the estimation of the dynamic term structure models. The latter usually tend to produce estimates biased towards a system displaying a far less persistence that the interest rates actually exhibit. In our application this would mean that the future short rates would be expected to revert to their mean too quickly. The small-sample bias is commonly treated by providing a longer data span and by imposing a unit-root process on the most persistent factor, which is essentially what the ANSM structure does. In general, the Shadow/ANSM specification incorporates the following set of restrictions:
whereas the remaining parameter set is free to vary. Once our specified Shadow/ANSM(3) is estimated we can extract the estimate of a term premium for each given time point and for a given maturity as follows:

\[
TP_t(\tau) = \tilde{y}_t(\tau) - \frac{1}{\tau} \int_t^{t+\tau} E(r_s) ds
\]

where \(\tilde{y}_t(\tau)\) represents a fitted bond yield for a given maturity and \(\frac{1}{\tau} \int_t^{t+\tau} E(r_s) ds\) is a risk neutral-component of a yield, identical to all bonds, regardless of issuer, and it represents the average expected short rate over a given horizon. The term-premium is therefore defined as the residual risk component of investing in a bond of a given maturity \(\tau\) as opposed to a roll-over strategy of investing at instantaneous risk-free rate for a period \(t + \tau\). Finally, conditioned on the estimated state variables, the expected path of the risk-free short rate over a given time horizon is defined as the zero truncated expected path of the shadow short rate:

\[
\tilde{E}_t [r(t+\tau)|x(t)] = max \left\{ 0, \tilde{E}_t [r(t+\tau)|x(t)] \right\} = max \left\{ 0, x_1(t) + x_2(t) \cdot \exp(-\phi \tau) + x_3(t) \cdot \phi \tau \exp(-\phi \tau) \right\}
\]

2.2.1 Shadow/ANSM vs ANSM

Equation 14 shows that a proper decomposition of yields will essentially rely on the accuracy of the estimated expectation component, which is numerically obtained as a conditional forecast of a short rate. In other words, how reliably the channels, through which the monetary policy affect the asset prices, are recognized will depend on forecasting performance and general goodness of fit provided by our model. As already mentioned, the ANSM model, not accounting for the interest rate lower bound, is theoretically inconsistent as it allows arbitrage opportunities. This empirically manifests itself in the low interest environment, when the linear nature of the ANSM model, does not prohibit a
positive probability of yields evolving to negative rates.

However, the notion of linearity in terms of the ANSM model carries another important implication, namely the assumed constant volatilities of interest rates throughout the entire period. This is in contrast to empirical stylized facts related to the stickiness of interest rates, observed for economies with an extended zero lower bound environment, e.g. Japan or the US. In that respect, ignoring the stickiness of short rates would in the ZLB period assume a relatively rapid increase of interest from the ZLB which would in turn lead to a consistent understatement of the term-premium. In fact, the bias just described was empirically confirmed for ANSM models related to the US and Japan data by Ichine and Ueno (2013).

Conversely, the Shadow/ANSM accounts for the ZLB and properly incorporates the distinctly implied reduced volatility of interest rates in a low interest environment and should therefore provide a valid representation of term structure consistently through the entire period. To put this discussion into perspective of the Euro area we fit the Euro area yield curve, consisting of Euro triple-A zero-coupon sovereign bonds, by respectively applying Shadow/ANSM(3) and ANSM(3) models to the end-of-month yield data spanning the period from January 1995 to June 2015 and including maturities of 0.25, 0.5, 1, 2, 5, 7, and 10 years. Table 3 compares Shadow/ANSM to ANSM model and their respective goodness of fit measures, whereas the individual parameter estimates are deferred to the Appendix A.

<table>
<thead>
<tr>
<th>Table 3: Goodness of fit for Shadow/ANSM and ANSM</th>
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<tbody>
<tr>
<td>Maturity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>0.25</td>
</tr>
<tr>
<td>0.5</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>5</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

Source: ECB Statistical Data Warehouse, Author’s calculations.

From the perspective of forecasting performance and the accuracy of estimating the expectation component of a bond yield, we can see that the Shadow/ANSM provides a better cross-sectional fit for 0.25, 5, and 10 year maturities as the difference between yields predicted by the models and actual data, captured by the RMSE statistics, is smaller than in the case of ANSM model. Conversely, the ANSM model provides more accurate predictions of 1, 2, and 7 year yields. Although the forecasting performance for
the shortest rate is the most important for the purpose of our analysis, we can hardly say that Shadow/ANSM is any superior to the model not accounting for the ZLB. This result may not be that surprising considering that the two term structure models entirely coincide when interest rates are sufficiently above zero and the fact that the sample is dominated by the period when ZLB was not binding. In fact, the key ECB policy rate (see Section 1.3) was reduced four times between 2012 and 2014, eventually reaching the binding value of 0.05%.

Therefore, by solely observing the goodness of fit of estimates, we might not see the actual merits of employing the Shadow/ANSM as opposed to the basic ANSM model. Instead, Figure 9 reveals how the expectation component of the 10-year yield and its corresponding term premium diverge between the two models, once the ZLB becomes binding. As shown by Ichue and Ueno (2013) for the US and Japan, the basic ANSM model tends to consistently underestimate the term premia due to overestimating the projected short rate over the next 10 years. As already outlined, an implication of constant volatility of the short rate in baseline ANSM fails to properly account for the rigidity of short rate movements in the near zero lower bound environment. Consequently, the baseline ANSM projections imply a quick reversion of short rates from the zero lower bound, which in turn makes them empirically inconsistent with the actual observed data. In our case, this bias would be reflected on a rather small portion of the examined sample. However, as it was revealed in Section 1.3, this period coincides with the introduction of the first non-standard programs that can actually classify as quantitative easing. In that respect, setting up a consistent modelling framework is of particular importance from the perspective of accurately examining the impact of the first large asset purchase program introduced by the ECB and in the context of future research of European monetary policy that is very likely going to involve a prolonged period of binding lower bound.

Figure 9: Decomposition of 10-year yield

(a) Expected short rate over next 10 years

(b) 10-year Term Premia

Source: ECB; author’s calculations.
2.3 The impact of non-standard measures on EA interest rates

In this section we perform the event-study analysis to examine changes in the core Euro area bond yields upon the announcements of non-standard programs. To isolate the role of the ECB in the period between 2008 and 2015, we estimate the impact of selected policy announcements on the yields over a one-day interval. In line with that, our event study analysis works along three major assumptions: 1) Each announcement is unveiled to the financial markets as a complete surprise; 2) Within a one-day interval, surrounding the announcement, there is no other news that could affect bond yields and interest rates; 3) Markets are efficient in the sense that economic agents update their information set at the announcement of particular measures and not at their actual realization. The first carries a potential threat of understating the actual impact of policy announcement as the economic agents might have anticipated the unveiling of the policy program beforehand and adjust their portfolios accordingly. Similarly, a potential downward bias is carried with the second assumption. Namely, setting up a one-day window surrounding the announcement poses a trade-off between having a period too short to fully resemble the impact of a newly introduced policy measure on one side, and on the other having the contaminated effect on yields due to other information that might emerge with having a window larger than one day. Nevertheless, even though our analysis might not offer a point precision of estimated impact of MP announcements on the interest rates, it can provide a good insight into how financial markets have perceived the ECB’s monetary policy and its credibility in the combined period of the global financial crisis and the zero lower bound period. In addition, the results obtained in this section are directly comparable to the well-known results obtained for the cases of FED (see Gagnon et al (2011), Christensen and Rudebusch (2012)), Bank of England (see Joyce et al (2011)), and Swiss national Bank (see Christensen and Krogstrup (2011)).

Our event study analysis focuses on seven announcement dates related to the unveiling of non-standard programs with a potential to directly or indirectly affect bond markets. In particular, for the purpose of our analysis we assume that bond yields can be affected in two ways, either through the monetary policy signalling channel or through the portfolio rebalancing effect. Namely, in line with the expectation theory (Cochrane, 2001), the yields of a particular maturity can be decomposed into the compounded expected short rate (resembling a roll-over investment into the risk-free short rate), and a term premium indicating additional return investors require for accepting a longer-term yield. Therefore, a policy signalling channel operates when central bank’s commitment to easier policy is recognized and investors revise their expectations about the future short rate accordingly. In contrast, the portfolio balance channel comes to effect when central bank’s policy actions are resembled in an altered supply related to particular asset market segments. The announced purchases or promised liquid market for certain securities will, according
to portfolio balance channel bid up their prices and consequently reduce their yields. Moreover, as Gagnon et al. (2011) explain, the altered supply should not only affect the securities it corresponds to, but it is also reasonable to expect to have the effect on the overall yield curve and other closely related assets. The size of the spillover effect will depend on the degree of market segmentation and the extent to which assets of differing maturities are perceived as substitutes.

The first announcement included in the analysis does not include asset purchase interventions per se, but the program involving an expanded list of assets eligible for collateral in Eurosystem credit operations and enhanced liquidity provision of longer-term refinancing announced in October 15th, 2008, represented the first non-standard response to the global financial turmoil and offered a clear indication of easier monetary policy in the future. Conversely, a stronger portfolio rebalancing effect and its spillover to sovereign yields could potentially be expected in case of the CBPP1 program, announced in May 2009. The next announcement date included in the analysis resembles the ECB’s first direct engagement in the government debt markets with an introduction of the SMP program in May 2010. The OMT and CBPP2 programs are included as the measures reflecting the re-intensification of sovereign crisis and a clear shift to a more assertive communication strategy, already discussed in Section 1.3. The CBPP3 and EAPP programs are the policy measures most comparable to Large Asset Purchase Programs deployed in the US and the UK and are therefore expected to have the clearest dampening effect with respect to both, policy signalling and the portfolio rebalancing channel. All seven non-standard programs and their respective announcement dates are summarized in the table below:
<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Event</th>
<th>Announcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>October 15, 2008</td>
<td>Liq. prov</td>
<td>GovC decides to expand the list of assets eligible as collateral and to enhance the provision of longer-term refinancing.</td>
</tr>
<tr>
<td>II</td>
<td>May 7, 2009</td>
<td>CBPP1</td>
<td>Decision that the Eurosystem will in principle purchase euro-denominated covered bonds issued in the Euro area.</td>
</tr>
<tr>
<td>III</td>
<td>May 10, 2010</td>
<td>SMP</td>
<td>GovC decides to conduct interventions in the Euro area public and private debt securities markets.</td>
</tr>
<tr>
<td>V</td>
<td>September 6, 2012</td>
<td>OMT</td>
<td>GovC decides on the modalities for undertaking Outright Monetary Transactions (OMTs) in secondary markets for sovereign bonds in the Euro area.</td>
</tr>
<tr>
<td>VI</td>
<td>September 4, 2014</td>
<td>CBPP3</td>
<td>President Draghi announces CBPP3 program.</td>
</tr>
<tr>
<td>VII</td>
<td>January 22, 2015</td>
<td>EAPP</td>
<td>GovC announces an expanded asset purchase programme with combined monthly purchases of corporate and sovereign bonds in amount of EUR60 billion.</td>
</tr>
</tbody>
</table>

Source: ECB Monetary policy decisions, 2016.*

To get a glimpse on the impact that each monetary policy decision, described in Table 4, had on the Euro area interest rates, we first conduct a model-free inspection of the yield changes on the ECB announcement dates. The yields that we examine correspond to the Euro-area Overnight Index Swap rate (OIS) and the Euro-area yield curve consisting of triple-A zero coupon sovereign bonds. The Euro area OIS can be considered as a contract according to which one party pays another the marginal lending rate compounded over a particular horizon in exchange for a fixed interest rate at the end of the period. The Euro OIS rates can in that sense represent a close proxy for monetary policy expectation, subject to its own term premium, and can therefore offer a first glance to what extent can changes in yields be attributable to the policy signalling. Since OIS rates are by

4The Euro area yield curve data is calculated by the ECB and is available at: https://www.ecb.europa.eu/stats/money/ycc/html/index.en.html. The yields for Euro OIS rates, Germany and Spain refer to the respective Bloomberg zero-coupon yield curves.
their nature primarily driven by market expectations related to short rate path and risk of how it might be changed, we additionally examine government bonds that tend to be more sensitive to asset purchases (which among others included operations on secondary sovereign market) and portfolio effect. To minimize the influence of credit risk and to capture only the movement that conventionally speaking can be related to monetary actions, for time being, only triple-A rated bonds are examined.

The respective yield changes for 2- and 10-year maturities are reported in Table 5. The first thing to note is that the key non-standard measures introduced before 2014 did not manage to provide the expected negative effect on the benchmark OIS and composite EA yields. This supports the discussion developed in Section 1.3 arguing that the extent and depth of the ECB unconventional policies might have, from the perspective of financial markets, been considered as somewhat disappointing, especially when compared to some other large asset programs unveiled by either FED or BoE in that period. Reasons for a more reserved response could be found in the institutional framework and the single mandate of price stability to which the ECB has to adhere. In that light, the temporary nature of the non-standard measures, which was repeatedly emphasized in the communication strategy surrounding the announcements before 2014, had very likely led markets to perceive a future turn to a tighter monetary policy. In fact, this perception became even more implicit with the two hikes of the main refinancing rate in 2010 and 2011 that is amid the operating and active non-standard policies.

A significant expected downward impact on the overall yields was only achieved with the actual quantitative easing incorporated in the CBPP3 program, and even more so in the EAPP program, with the total diminishing effect amounting to 16 basis points for the 10-year composite EA yield. Examining particular events individually, a little less segmentation and some degree of common component driving the yield changes can be observed from a relatively consistent Euro OIS and composite EA yields spread. An indication that this common component could be the result of a signalling effect, according to Gagnon et al (2011), could be a small difference in change of 2-year yields compared to a 10-years yield change, observed for SMP, OMT, and CBPP2 and CBPP3 programs. Conversely, a relatively stronger effect on yields for longer durations noticed in cases of CBPP1, CBPP2 and EAPP programs might point towards a stronger portfolio balance effect. However, as the yield changes can manifest themselves through two channels operating in the opposing direction, a model decomposition of yields is necessary to offer a more accurate discussion.
Table 5: Basis point change in EA yields on the MP announcement over a one-day window surrounding MP announcements

<table>
<thead>
<tr>
<th>Announcement</th>
<th>Euro OIS 2-year</th>
<th>Euro OIS 10-year</th>
<th>EA govt. debt 2-year</th>
<th>EA govt. debt 10-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/10/2008 Liq. Prov.</td>
<td>-23</td>
<td>-5</td>
<td>-7</td>
<td>8</td>
</tr>
<tr>
<td>07/05/2009 CBPP1</td>
<td>-4</td>
<td>25</td>
<td>-2</td>
<td>16</td>
</tr>
<tr>
<td>10/05/2010 SMP</td>
<td>2</td>
<td>16</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>06/10/2011</td>
<td>8</td>
<td>7</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>06/09/2012 CBPP2</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>04/09/2014 OMT</td>
<td>-6</td>
<td>-1</td>
<td>-6</td>
<td>-4</td>
</tr>
<tr>
<td>22/01/2015 CBPP3</td>
<td>-2</td>
<td>-11</td>
<td>-3</td>
<td>-12</td>
</tr>
<tr>
<td>EAPP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Bloomberg, ECB, author’s calculations.

To decompose yields to a corresponding term-premium part and an average expected path we perform a rolling estimation of the K-ANSM(3) model (Section 2.2) in real time, that is on the day before and on the day after the announcement. The real time estimation is needed for an alignment with the assumption of each monetary policy announcement being a complete surprise. In that way, the expected path of short rate is always calculated based on the information that markets have up to a particular moment of interest. Table 6 reports the decomposition of Euro OIS rates and composite EA government bond yields with the duration of 10 years.
Table 6: Decomposition of core EA 10-year yield change (basis points)

<table>
<thead>
<tr>
<th>Euro OIS rate</th>
<th>Announcement</th>
<th>MP exp. next 10 years</th>
<th>10-year term premium</th>
<th>Residual</th>
<th>Actual 10-year yield change</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/10/2008 Coll. &amp; liq. Prov.</td>
<td>-11</td>
<td>2</td>
<td>4</td>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>07/05/2009 CBPP1</td>
<td>24</td>
<td>-1</td>
<td>2</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>10/05/2010 SMP</td>
<td>12</td>
<td>-1</td>
<td>6</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>06/10/2011 CBPP2</td>
<td>8</td>
<td>-2</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>06/09/2012 OMT</td>
<td>12</td>
<td>-5</td>
<td>2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>04/09/2014 CBPP3</td>
<td>-6</td>
<td>5</td>
<td>0</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>22/01/2015 EAPP</td>
<td>-16</td>
<td>11</td>
<td>-6</td>
<td>-11</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EA composite government bond yields</th>
<th>Announcement</th>
<th>MP exp. next 10 year</th>
<th>10-year term premium</th>
<th>Residual</th>
<th>Actual 10-year yield change</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/10/2008 Coll. &amp; liq. Prov.</td>
<td>-9</td>
<td>3</td>
<td>14</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>07/05/2009 CBPP1</td>
<td>17</td>
<td>0</td>
<td>-1</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>10/05/2010 SMP</td>
<td>8</td>
<td>-1</td>
<td>1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>06/10/2011 CBPP2</td>
<td>14</td>
<td>-2</td>
<td>0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>06/09/2012 OMT</td>
<td>2</td>
<td>-3</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>04/09/2014 CBPP3</td>
<td>-14</td>
<td>8</td>
<td>3</td>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>22/01/2015 EAPP</td>
<td>-80</td>
<td>68</td>
<td>-1</td>
<td>-12</td>
<td></td>
</tr>
</tbody>
</table>

Source: Bloomberg, ECB Statistical Data Warehouse, author’s calculations.

Yield decomposition shows that, although rather small, the ECB’s unconventional policies, announced before 2014, did in fact manage to reduce the term-premium for the EA fixed income securities with the longest durations. However, the dampening term-premium was largely offset by the expected increase in the ECB’s main refinancing rate over the next 10 years. This is a natural continuation of the discussion on hesitant ECB policy responses in the initial stages of the crisis, which is resembled in the fact that the monetary policy announcements in that period were not perceived as a credible signal of a policy change, but rather as a reactionary policy with an expected correction in the near future. We can observe the strongest expected policy rate increase in year 2011, coinciding with the ECB
reports on the upside inflationary risk and consequent decision to increase the MRO rate to 1.5%. To even further steer the expectations about the tighter monetary policy, the SMP program was terminated in 2011 and not renewed. As reported in Section 1.3, the record turned in mid-2012 and at the start of the 2013. The price instability was now perceived in light of deflationary risk, consequently changing the communication strategy towards full engagement of the ECB in preserving the currency union and towards a permanent nature of the non-standard measures. The policy shift gradually gravitated towards a full quantitative easing path in line with the large asset purchase programs already taking place in other developed economies since the initial stages of the crisis. The resulting consequence was the average 10 basis point decrease in the expected short rate over the next 10 years for CBPP3 announcement, and further average 48 basis point decrease upon the introduction of EAPP, where the signalling effect is averaged over both types of the fixed income securities reported in Table 6. Regardless of the policy shift, the way in which the asset prices respond to introduction of non-standard measures in Euro area seems to primarily be determined through the policy signalling channel.

2.4 Country perspective and different monetary policy objectives

The event-study analysis performed in the previous section was based on a rather traditional perception according to which credit and default risks are thought to be matters isolated from the domain of a standard monetary policy conduct (Drechsler et al, 2014). In that matter, using the Euro-area OIS rates or triple-A government bond rates seem to represent a natural way to analyse monetary transmission and is in parallel to studies conducted for the US, UK or Japan (Rogers et al, 2014). And indeed, the correlation between banking sector and sovereign risk was perceived negligible even in the first two years of the global financial crisis. However, as shown by Fratzscher and Rieth (2015) with the single currency crisis that came to effect in 2010 the two-way causality between the sovereign spreads and bank credit risk significantly intensified (concretely, a 100 basis point increase in sovereign spreads should on average be translated in a 40 bps increase in bank risk), where this feedback loop has been in particular exposed for the most distressed countries. In that manner, intra Euro-area sovereign default risks could no longer be ignored by the monetary policy. As already discussed in Section 1.3, the additional dimension of monetary policy was specifically addressed by some specific non-standard programs, i.e. the SMP and OMT. In particular, president Draghi stressed on several occasions, the importance of narrowing intra-euro sovereign risk spreads for normal functioning of monetary transmission (ECB, 2012).

Specificities of the Euro area and non-standard measures that were directly aimed at reducing default and risk premium imply that monetary policy should be measured differently than it is the case for other economies. That is, by solely observing the impact of unconventional monetary policies on risk-free assets we might get a wrong idea about
the actual nature of non-standard measures. To get the real impression on tightness or
expansion of monetary policy, a cross-country analysis has to be considered instead. Table
7 presents the one-day changes in the Spanish and Italian sovereign yields and respective
spreads relative to the German yields.

Table 7: Basis point changes of 10-year sovereign yields over a one-day window surrounding
MP announcements

<table>
<thead>
<tr>
<th>Announcement</th>
<th>Germany Yield</th>
<th>Spain Yield</th>
<th>Spain Spread</th>
<th>Italy Yield</th>
<th>Italy Spread</th>
<th>Risk premium Italy</th>
<th>Risk premium Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liq. Prov.</td>
<td>-2</td>
<td>-7</td>
<td>-3</td>
<td>-5</td>
<td>-1</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>CBPP1</td>
<td>21</td>
<td>11</td>
<td>15</td>
<td>5</td>
<td>9</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>SMP</td>
<td>15</td>
<td>-47</td>
<td>-44</td>
<td>-31</td>
<td>-28</td>
<td>37</td>
<td>28</td>
</tr>
<tr>
<td>CBPP2</td>
<td>16</td>
<td>-92</td>
<td>-25</td>
<td>36</td>
<td>-12</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>OMT</td>
<td>9</td>
<td>-77</td>
<td>-77</td>
<td>-50</td>
<td>-50</td>
<td>-21</td>
<td>-22</td>
</tr>
<tr>
<td>CBPP3</td>
<td>-1</td>
<td>-22</td>
<td>-17</td>
<td>-19</td>
<td>-14</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>EAPP</td>
<td>-15</td>
<td>-20</td>
<td>-21</td>
<td>-20</td>
<td>-22</td>
<td>-0</td>
<td>-0</td>
</tr>
</tbody>
</table>

Source: Bloomberg, ECB Statistical Data Warehouse, Author’s calculations.

The first thing to note is that the Italian and Spanish yields are, as opposed to the German
case, impacted in the expected decreasing direction for all non-standard programs but the
CBPP1. The absolute impact was in general much larger for the periphery EA countries
which reflects the targeting nature of non-standard measures. Largely diminishing periphery
Euro-area spreads relative to the core indicate that the non-standard measures
reverted flight-to-quality flows, which could imply reduction in risk premia through the
increased confidence and revival of periphery sovereign markets. To formally examine how
the term premium of periphery countries was affected by the selected non-standard mea-
ures, the technique used for yield decomposition has to be slightly reconsidered. Namely,
for the purpose of the term structure estimation we assumed that short rates were dis-
tributed according to the risk-neutral probability measure Q (see Section 2.2), which in
case of the expectation theory coincides with the true measure P. In other words, we
assumed that investors did not demand any risk related premium for holding long-term
sovereign assets and that the entire excess return could be ascribed to term premium
instead. To extract the risk premium associated with sovereigns, issued by periphery
countries, we have to therefore extract the true expected short path process (under P
dynamics) and subtract it from the risk-neutral one (Q dynamics) (Piazzesi, 2010):

\[ Risk\_premium = E_t^Q [r(t + \tau)|x(t)] - E_t^P [r(t + \tau)|x(t)] \] (16)

where \(E_t^Q\) represents expectations at time \(t\) under risk-neutral probability measure, \(E_t^P\)
represents expectation operator under actual distribution, and \( r(t + \tau) | x(t) \) is future development of short rate \( r \) over horizon \( \tau \), conditional on the current state of latent factors \( x(t) \).

By observing risk premium changes on announcement days in Table 7 we can see that the OMT program produced significant stabilization effects on periphery Euro sovereign markets. In case of Spain and Italy, the ECB’s announcement to intervene in primary sovereign markets in case of considerable default treat reduced sovereign credit risk by more than 20 basis points on the announcement date. However, the OMT program seems to be an isolated case as the other non-standard measures did not produce desirable risk premium reduction. This means that the reduction in intra-euro spreads had to come through the signalling channel indicating permanent expected reduction in short part of the yield curves for the periphery countries. The dominating channel of low future short rates is formally revealed by yield decomposition presented in Table 8 (the decomposition is conducted in the same manner as in the previous section). The CBPP3 and EAPP programs therefore implied monetary expansion for the overall Euro area, where long-lasting low interest policy was recognized also by both, the core Euro area and periphery sovereign markets.

Table 8: Basis point changes of 10-year sovereign yields over a one-day window surrounding MP announcements

<table>
<thead>
<tr>
<th>Announcement</th>
<th>Spain</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exp. short path</td>
<td>Term premium</td>
</tr>
<tr>
<td>Liq. Prov.</td>
<td>-13</td>
<td>5</td>
</tr>
<tr>
<td>CBPP1</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>SMP</td>
<td>-50</td>
<td>2</td>
</tr>
<tr>
<td>CBPP2</td>
<td>-9</td>
<td>0</td>
</tr>
<tr>
<td>OMT</td>
<td>-63</td>
<td>-13</td>
</tr>
<tr>
<td>CBPP3</td>
<td>-20</td>
<td>-1</td>
</tr>
<tr>
<td>EAPP</td>
<td>-16</td>
<td>-4</td>
</tr>
</tbody>
</table>

Source: Bloomberg, ECB Statistical Data Warehouse, Author’s calculations.

2.5 Sensitivity analysis

Non-standard measures as monetary policy surprise

The strategy used in Section 2.3 to uncover monetary policy shocks resides on some rather restrictive assumptions. In line with notion that asset prices can only be affected by monetary policy surprises (see e.g. Gürkaynak, 2005) the analysis was based on the short enough window that should in principle enable identification of an unanticipated monetary action and its separation from other influences. But in reality it would not be
unreasonable to expect that monetary announcements would have been at least partly anticipated, with news being gradually unveiled to the markets and influenced by policy actions of other central banks and the general macroeconomic environment (Rogers et al., 2014).

For example, in Section 1.3 we argued that compared to the ECB, the FED responded to the crisis far more aggressively and promptly after the landmark set by the financial breakdown of the Lehman Brothers. In that manner, it can be assumed that the early response of the FED might have led other financial markets around the world to believe that similar measures would be revealed also by other central banks around the world. In other words, prompt and aggressive reaction put FED in a position of leading the markets and setting the norm for the other central banks. Table 10 represents a one day change in decomposition of the composite Euro area government yields surrounding the FED’s announcements of large asset purchase programs. The detailed description of FED decisions is available in Table 9.

Table 9: FED’s LSAP announcements

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Event</th>
<th>Announcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>November 25, 2008</td>
<td>Initial LSAP</td>
<td>FED announces buying of up to $500 billion of mortgage-backed securities (MBS).</td>
</tr>
<tr>
<td>II</td>
<td>December 1, 2008</td>
<td>Chairman speech</td>
<td>Chairman Bernanke indicates that the FED could purchase long-term Treasury securities.</td>
</tr>
<tr>
<td>III</td>
<td>December 16, 2008</td>
<td>FOMC statement</td>
<td>FOMC indicates possibility to buy long-term Treasury securities.</td>
</tr>
<tr>
<td>IV</td>
<td>January 28, 2009</td>
<td>FOMC statement</td>
<td>Announces extended MBS buying and mentions possible long-term Treasury purchases.</td>
</tr>
<tr>
<td>V</td>
<td>March 18, 2009</td>
<td>FOMC statement</td>
<td>Fed will purchase an additional $750 billion in agency MBS and announces buying of $350 billion in long term Treasuries.</td>
</tr>
<tr>
<td>VI</td>
<td>August 12, 2009</td>
<td>FOMC statement</td>
<td>FED announces gradual slowing down of the pace of QE and announces final purchases for October 2000 instead of September.</td>
</tr>
<tr>
<td>VII</td>
<td>November 4, 2009</td>
<td>FOMC statement</td>
<td>Amount of agency debt capped at $175 billion instead of the $200 billion previously announced.</td>
</tr>
</tbody>
</table>

Source: FOMC Monetary policy releases, 2016.

The EA yield decomposition reveals that the large scale programs, announced by the FED, did in fact produce considerable spillover effects on the Euro area debt markets. The yield change, cumulated over the announcement dates up to March 2009, amounted to little less than 60 basis points. The major part of the yield change can be ascribed to the expected monetary policy easing in the future. The reduction of yields, however, only appears to be in place until the first ECB announcement of asset purchases in May 2009.
Following the CBPP1 announcement, the spill-over effects essentially died off, which is not surprising as the Euro area financial markets, at that point, had the first actual ECB asset purchasing programs in place, meaning that the FED announcement did no longer provide the anticipating component or anchor for the monetary policy expectation. What is more significant to observe is that once the FED did no longer provide a direction for the EA markets, the responses of EA yields to ECB’s CBPP1 program operated in opposite than the expected direction. Namely the yields increased in EA core as well as in the EA periphery (see Table 7). This could potentially offer an indication that the ECB’s non-standard measures were overshadowed by the FED policies and that in the eyes of the financial markets they did not meet the level of intensity and timeliness set by the FED. In other words, we can argue that the expectations about CBPP1 program were formed beforehand and were influenced by external policy conditions.5

Table 10: Impact of FED QE announcements on EA yields (change in basis points)

<table>
<thead>
<tr>
<th>Announcement</th>
<th>MP exp. next 10 year</th>
<th>10-year term premium</th>
<th>Residual</th>
<th>Actual 10-year yield change</th>
</tr>
</thead>
<tbody>
<tr>
<td>25/11/2008</td>
<td>-13</td>
<td>6</td>
<td>-2</td>
<td>-9</td>
</tr>
<tr>
<td>01/12/2008</td>
<td>-23</td>
<td>10</td>
<td>-1</td>
<td>-13</td>
</tr>
<tr>
<td>16/12/2008</td>
<td>-18</td>
<td>6</td>
<td>-3</td>
<td>-15</td>
</tr>
<tr>
<td>28/01/2009</td>
<td>-9</td>
<td>0</td>
<td>-3</td>
<td>-12</td>
</tr>
<tr>
<td>18/03/2009</td>
<td>-9</td>
<td>1</td>
<td>0</td>
<td>-8</td>
</tr>
<tr>
<td>12/08/2009</td>
<td>1</td>
<td>0</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>04/11/2009</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

Source: Bloomberg, ECB Statistical Data Warehouse, Author’s calculations.

An insight in the surprise element of monetary policy can be presumably drawn by observing yield dynamics in extended periods surrounding the announcements. Namely, in line with the previous event-study results of Kuttner (2001), Bernanke and Kuttner (2005), Joyce et al (2011) and others, a considerably persistent effect on asset prices could only be attained through monetary policy surprises. Figure 10 depicts the dynamics of the Euro area (composite triple-A bonds) and Spanish yields 60 trading days before and after a particular announcement. The largest and most persistent shift in yield dynamics can be observed in case of the OMT program. As already outlined in previous section, 5We treat monetary surprises in relation to the central bank’s intentions. Namely, one could argue that the disappointment of financial markets reveals an unanticipated tighter than expected monetary policy, but this would be counter-intuitive to the nature of the CBPP1 which was introduced as monetary expansion tool.
the effect remains limited to the Euro area periphery. Conversely, the SMP and CBPP2 produced only a short-lived expected effect on Spanish sovereign yields which was followed by a strong reversion to increasing yield dynamics in the extended period following the announcement. In case of the Euro-area core the largest and most persistent shift could be observed for the first two CBPP programs which could be connected to the reversal in safety flows. In contrast to earlier measures, the EAPP produces consistent effects through the entire Euro area with considerable and persistent reduction in sovereign yields being observed for both the Euro-area core and periphery.

*Figure 10: Sovereign yield dynamics in 60-day window surrounding announcements (in %)*

(a) Euro-area core  
(b) Spain

Source: Bloomberg, ECB Statistical Data Warehouse.

However, concluding on a surprise component based on the extended window surrounding the announcements could potentially lead to a noisy measure contaminated by other influences and general macroeconomic developments. To formally extract a surprise component, the majority of the literature resort to observing parallel change in futures rates as proposed by Kuttner (2001). The idea follows the notion that futures prices reflect the market expectations of future policy rates (Piazzesi and Swanson, 2008). In that manner, changes in futures rates to a monetary policy announcement represent contribution of the surprise component incorporated in change of a key policy rate. With respect to unconventional policies and ZLB period, however, policy rates can no longer be used to estimate the surprise component as a contribution of futures change to the movement of policy rate.

Nonetheless, even though the surprise component cannot be estimated point wise, the size of the change in futures rates can offer an indication on the extent to which the announcements of non-standard measures were unexpected. But since in the ZLB period the short-term interest movement is bounded we focus on one year ahead Euribor futures rates, which should reflect a change in short to medium-term policy path rather
than current stance. Having said that, the unchanged futures rates would in principle suggest that the monetary policy announcements were entirely anticipated beforehand. Table 11 shows that futures rates have indeed changed at every announcement for period after 2009 for which the data series is available. However, the mean one day absolute change for period 2009-2015 were surpassed only in case of the CBPP2 program, where rates increased by 10 bps (1.2 standard deviation) suggesting the unexpected monetary tightening connected with the safety flow reversion. For the other measures the change is broadly in line with mean sample indicating that the announcements of monetary policy surprises did not carry an extraordinary surprise element and were at least in part anticipated by markets. In that respect, the monetary policy impact estimated by the event-study analysis should be interpreted with caution as the true effect of non-standard measures is very likely understated.

Table 11: One day changes (in bps) in one year ahead futures rates

<table>
<thead>
<tr>
<th></th>
<th>SMP</th>
<th>CBPP2</th>
<th>OMT</th>
<th>CBPP3</th>
<th>EAPP</th>
<th>Mean</th>
<th>St. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-year ahead futures</td>
<td>4</td>
<td>10</td>
<td>4</td>
<td>-5</td>
<td>-4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: ECB Statistical Data Warehouse, Author’s calculations.

Event-study and expectation theory

Aside from monetary announcements being unveiled as a complete surprise, the event-study analysis assumptions to the large extent worked along the expectation theory, according to which the investors only care about the size of a yield that particular asset is carrying. To the extent that money and bond holdings are imperfect substitutes, this allowed us to assume that the anticipated money holdings obtained from future central bank’s asset purchases would be invested in other, perhaps riskier assets that are expected to maintain the desired amount of yields. In that manner asset purchases would reduce wider spectre of yields in the economy. In other words, we expected the portfolio effect to be an operating channel for sovereign bonds also in case of CBPP programs, which were primarily aimed at reducing corporate yields. But in reality investors might not be that quick in adjusting their portfolio and size of the earned yield might not be the only driver for investment decisions. A deviation from the pure expectation theory could for example be reflected by the preferred habitat theory according to which investors not only care about the return, but also rank assets according to the preferred maturity (Piazzesi, 2010). In that sense, investors with an explicit preference for particular maturities might not be willing to switch to a longer-part of the yield curve unless term premium is sufficiently high. This could potentially carry important implications for our analysis.
For example, as modalities of CBPP programs only included corporate bond purchases up to maturities of 3 years, investors might have sought additional return only in sovereign markets with a comparable maturity, whereas the long-term markets may have stayed unaffected. To verify this, the event-study analysis is replicated on sovereign yields up to 3 years maturity. Table 12 shows that results for the 3-year yield, qualitatively speaking, stays unchanged in comparison to changes in 10-year sovereign bonds. Monetary policy signalling stays the prevailing channel of monetary transmission and sign of changes at each announcement almost entirely agree with the results obtain for the 10-year bonds. Slight changes in the size of the response can be observed in case of Spain. The impact of SMP program induces 30 basis points larger reduction in 3-year yields, whereas in case of the CBPP3 and EAPP the effect gets attenuated.

Table 12: Changes of 3-year sovereign yields over a one-day window surrounding MP announcements (in basis points)

<table>
<thead>
<tr>
<th>Announcement</th>
<th>ECB 3-A</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exp. short path</td>
<td>Term premium</td>
</tr>
<tr>
<td>Liq. Prov.</td>
<td>-2</td>
<td>-17</td>
</tr>
<tr>
<td>CBPP1</td>
<td>4</td>
<td>-1</td>
</tr>
<tr>
<td>SMP</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>CBPP2</td>
<td>12</td>
<td>-2</td>
</tr>
<tr>
<td>OMT</td>
<td>11</td>
<td>-5</td>
</tr>
<tr>
<td>CBPP3</td>
<td>-15</td>
<td>9</td>
</tr>
<tr>
<td>EAPP</td>
<td>-15</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: ECB Statistical Data Warehouse, Bloomberg, Author’s calculations.

Sensitivity to window length

Another aspect of sensitivity of the event-study analysis could be related to the choice of window in which the impact on yields is being examined. For example Christensen and Rudebusch (2012) and Christensen and Krogstrup (2014) explore yield changes in a 2-day window surrounding particular announcements in order to account for the learning process, which might be longer in relation to the measures that were unfamiliar to the markets in the pre-crisis period. Table 13 shows that results are robust to the two-day window.
Table 13: Changes of 10-year sovereign yields on the MP announcement over a two-day window (bps)

<table>
<thead>
<tr>
<th>Announcement</th>
<th>ECB 3-A</th>
<th></th>
<th></th>
<th>Spain</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exp. short path</td>
<td>Term premium</td>
<td>Actual change</td>
<td>Exp. short path</td>
<td>Term premium</td>
<td>Actual change</td>
</tr>
<tr>
<td>Liq. Prov.</td>
<td>-17</td>
<td>11</td>
<td>-6</td>
<td>-14</td>
<td>1</td>
<td>-14</td>
</tr>
<tr>
<td>CBPP1</td>
<td>12</td>
<td>-2</td>
<td>11</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>SMP</td>
<td>7</td>
<td>-2</td>
<td>5</td>
<td>-45</td>
<td>0</td>
<td>-45</td>
</tr>
<tr>
<td>CBPP2</td>
<td>37</td>
<td>-4</td>
<td>32</td>
<td>-10</td>
<td>0</td>
<td>-10</td>
</tr>
<tr>
<td>OMT</td>
<td>7</td>
<td>3</td>
<td>10</td>
<td>-92</td>
<td>1</td>
<td>-92</td>
</tr>
<tr>
<td>CBPP3</td>
<td>-10</td>
<td>8</td>
<td>-2</td>
<td>-29</td>
<td>9</td>
<td>-19</td>
</tr>
<tr>
<td>EAPP</td>
<td>-71</td>
<td>63</td>
<td>-8</td>
<td>-33</td>
<td>13</td>
<td>-20</td>
</tr>
</tbody>
</table>

Source: ECB; Bloomberg database; author’s calculations.

2.6 Conclusion

This chapter is focused on providing the answer to two research questions stated in the introduction of this dissertation. With the crucial role that future monetary policy prospects play in the effectiveness of unconventional policies the first question was related to the methodological issue of how to properly capture and estimate monetary policy expectations. This question becomes particularly important in the low interest environment with the short-term yield movement being bound by the ZLB. Monetary expectations were modelled using ZLB-adjusted Affine Nelson-Sigel model proposed by Krippner (2015a). As the accuracy and fit to the observed yield is crucial for this application the methodology relied on 3 latent factors driving the short rate dynamics and its future path. For the period when the lower bound became effective in the Euro area we show how ignoring the ZLB can lead to consistent overestimation of expected future short path and consequently to underestimation of term premium. Using a standard Gaussian term structure models therefore fails to account for the reduced volatility and stickiness of short-term yields in the low interest environment.

The methodology for modelling the monetary expectations is then used for the detailed analysis of yield responses to the non-standard measures introduced by the ECB. In particular the analysis addresses the research question related to the examination of the role of the ECB in averting financial impairment and the perception of this role by financial markets. The result of the event-study analysis suggests that the non-standard measures affect euro-area financial markets predominantly through the monetary signalling chan-

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6Chapters 3 and 4 present application in which accuracy might be traded for the purpose of obtaining intuitive monetary concepts.
nel, whereas the portfolio balance effect remains rather modest. Based on that result, the policy proposal to achieve the desired effects on the euro-area debt markets could be achieved either by introducing a formal forward guidance with explicitly stating future policy commitments or by increasing the span and volume of non-standard measures to attain stronger impact on portfolio balance channel. The event-study analysis show that the non-standard measures introduced before 2014 did not produce the expected reduction in Euro OIS rates and risk-free sovereign yields. Namely, with re-intensification of the currency and sovereign crisis the non-standard measures were highly targeted at most distressed countries and corresponding sovereign risk premiums, an objective that conventionally speaking does not fall under monetary policy. In that sense, the Euro area bond markets exhibited heterogeneous impact on yields, with a tighter stance in the core Euro area reverting safety flows and significant reduction in periphery area sovereign yields. In particular, the strongest stabilizing effects can be observed for the OMT program, where the announcement alone (the OMT has so far not been materialized) reduced risk premia in Spain and Italy by more than 20 basis points. In contrast to measures introduced before 2014, the more explicit forward guidance expressing the permanent nature of unconventional policies and the extended large asset purchase program produced a considerable reduction in expected monetary policy path and yields in general across the entire Euro area.

The results of the event-study, however, have to be interpreted with caution and within the limitations of this kind of an analysis. Namely, it is based on rather restrictive assumptions especially related to the notion that the non-standard measures were unveiled to the financial markets as a surprise. The robustness analysis showed that in the majority of the cases the non-standard programs had potentially been at least partly anticipated before their actual announcements. In that manner, the investors potentially already performed some adjustments to their portfolios beforehand which would lead to underestimation of the portfolio balance effect and yield change on the announcement date. Moreover, the event-study is essentially static analysis of monetary policy impact. It therefore does not offer the insight on the persistence of monetary policy effects and potential learning process that might take place in financial markets. We attempt to address these limitations in Chapter 3.
3 SHADOW SHORT RATE AND MONETARY POLICY IN THE EURO AREA

3.1 Outline

This paper complements and improves the analysis conducted in the previous chapter in several ways. Most importantly, the analysis is put into a dynamic perspective where both, the financial as well as the macroeconomic aspects are considered. The analysis is focused on determining dynamic relations between macroeconomic variables, country-specific financing conditions, and measures of monetary policy. The stance on individual country financing conditions and the Euro area monetary policy is gauged based on the shadow short rate extracted from the ZLB-adjusted term structure model in line with the discussion in Section 1.5.

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 for combining of 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 the 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. First, we provide an analysis of macroeconomic effects of monetary policy in the Euro area using the SSR of Krippner (2015). The choice of SSR measure is supported by the recent literature and stylized results obtained for the US, according to which the shadow rate measure extracted from the Krippner’s ZLB term structure framework is revealed as the most robust and intuitive measure of monetary stance (see i.e. Francis et al (2014) or Krippner (2015b)). 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 literature, which allows a direct comparison with monetary policy shocks identified using a conventional 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 differently 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 also arise 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 the 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 Euro area. 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 (2016) 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. Lemké and Vladu (2014) consider the estimation of the SSR for the Euro area using the framework of Wu and Xia (2016). Borstel et al. (2015) use the SSR to evaluate the effects of the ECB policy measures on bank lending rates and mark-ups in the Euro area. Using the same Krippner’s (2015) SSR measure, our analysis in contrast studies the effects of monetary policy on output and prices. With this contribution in mind this chapter directly addresses the following research questions postulated in the Introduction:

- How effective were the non-standard measures introduced by the ECB in improving financing conditions?
- How effective were the non-standard measures introduced by the ECB in restoring the real economic activity?
- How did a common monetary policy affect individual member countries in the Euro area?

The structure of the paper proceeds as follows. Section 3.2 summarizes the findings of the recent research and results obtained from the other empirical country cases, Section 3.3 offers a brief overview of the ZLB - Term Structure mechanism and presents the shadow short rate data for the Euro area, Section 3.4 offers a standard VAR analysis of macroeconomic effects of monetary policy shocks, identified from the SSR. Section 3.5 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 3.6 concludes.
3.2 Term Structure Modelling 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 (2016). 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 (2016) 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 the absence of unconventional policy actions.

Analogous to the Wu and Xia (2016) 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 (2016) 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 (2016) shadow rates exhibits a structural break and parameter instability at the onset of the crisis. Conversely, Krippner’s shadow rate estimates favour 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 (2016) 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 (2016) 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 has 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 a 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 Reserve 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 an 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 in relation to perceived shifts of the level of the interest rate lower bound. In contrast, our paper focuses on macroeconomic responses rather than on the effects on financial markets.

3.3 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 $\tau$, denoted as $R(t, \tau)$ can then be defined as:
\[ R(t, \tau) = R(t, \tau) + Z(t, \tau) \] 

(17)

Where \( R(t, \tau) \) represent a shadow yield curve that does not account for the 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.\(^7\) 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.\(^8\) For comparison, the SSR is also estimated for two core Euro area countries, Germany and France.

In case of the overall Euro area the interest rate of the 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 the period from May 2008 till December 2013 and supplemented by data on German government bond yields for the 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 a 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 the Bloomberg government bond yields data. The data for Germany and France spans the period from January

\(^7\)We are grateful to Leo Krippner for providing us the estimates.

\(^8\)Other periphery countries are not included in the analysis due to data limitations.
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 of which were implemented through government bond purchase programs and were therefore directly targeting sovereign bond markets.

**Figure 11: Shadow short rate estimates for individual countries and the Euro area**

![Shadow Short Rate in %](image)

Source: Bloomberg database; author’s calculation.

The respective country-specific shadow short rates (SSRs) are depicted in Figure 11. 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 an OIS based estimate of 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 the 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 3.5 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 the 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 the 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 3.5.

3.4 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 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 also contains 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. We denote such a VAR as the Shadow VAR. The details of the statistical specification of estimated VARs are deferred to Appendix B, 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

\footnote{The data are seasonally adjusted. The Euro area data refers to EA12 aggregate.}
is expected that an unanticipated tightening of monetary policy would lead to (delayed) declines in output and the general price level.

Figure 12 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.

Figure 12: Impulse responses of output and prices to a monetary policy shock in the Euro area

Notes: Shaded areas represent 95% confidence intervals.

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 11 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 also affected by sovereign risk factors. Nevertheless, we can assume that they summarize 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 Appendix B. Here we reproduce the main responses and compare them to the Euro area results in Figure 13. 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 13: Standardized impulse responses to SSR shock

| Source: Author’s calculations. |

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.

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.

10 Note that a magnitude of impulse responses must be interpreted with additional caution, as it has been 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 an over-expansionary or an 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 remains valid.
3.5 Transmission of (unconventional) monetary policy measures across the Euro area

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 11, 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 stressed 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 into 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 the 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 a 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. Structural shocks are again identified by the Cholesky decomposition of the variance-covariance matrix of the estimated reduced form VAR innovations.\footnote{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 11 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 SSR 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-specific SSR cannot be identified. From the point of view of our modelling framework the policy stance of the EA core is most directly determined by the ECB and reflected in the EA SSR.\footnote{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}}
The results of the impulse response analysis are for easier comparison both for Italy and Spain presented in Figure 14. Results for Italy and Spain individually, with confidence intervals for impulse responses are deferred to Appendix B. The left panel of Figure 14 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 the theory and comparable to those for the Euro area as a whole (see Figure 12). 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 the 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 B2). 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 of the 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 points on impact.

Exogenous shocks to the country-specific SSRs are quite persistent and exhibit a great degree of similarity between Italy and Spain (see bottom right of Figure 14). 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 it can be observed from Figures B2 and B3, statistically insignificant. This is an indication that the sovereign crisis in the Euro periphery might have only had 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 the real GDP and country-specific SSR. The results of historical decomposition are

sensibility of our benchmark identification approach.
presented in Figure 15, which at the bottom, for the sake of comparison, also reports the corresponding historical decomposition of the Euro area GDP and the Euro area SSR.\footnote{The results for the Euro area historical decomposition are from the Euro area VAR we used to produce the impulse response analysis in Figure 12.}

*Figure 14: Standardized impulse responses to Euro area and country-specific shadow rate shocks*
significantly relaxed in 2010 and between the second half of 2011 and the 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. Conversely, stimulative effects can be observed for Italy, coming into effect in 2013, while for the case of Spain, unconventional monetary programmes seem to have no effect on the Spanish GDP.

These results are in line with the results of the 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 the case for Spain, we observed insignificant effect on output. From the historical decomposition we can also see there was insufficient monetary stimulus provided in 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 too 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.

A relatively too small stimulus is mechanically demonstrated in Figure 16. The figure depicts a detailed breakdown of the sum of past monetary shocks determining the realization of the Euro GDP series in 2014. In other words, we can observe how much do monetary shocks originating in the past still influence the level of the real GDP at a selected moment in time, in our case March 2014 (a technical description is provided in Section 1.5.2). What we can observe from the Figure 16 therefore is that although monetary policy of the ECB has in a large part of the period provided a positive contribution to the development of the GDP, the size of the response does not seem to be large enough to offset the severe adverse shocks observed at the onset of the global financial crisis (landmarked by the Lehman Brothers collapse) and at the peak of the sovereign crisis in Europe. In that respect, it can be concluded that in the absence of the non-standard measures the real GDP would materialize at lower values than it had, however, the monetary policy has still remained too restrictive from the perspective of notably restoring the economic activity to pre-crisis levels.
Notes: The figure represents the evolution of SSR and GDP series with respect to non-systemic components of variables included in VAR system. In that context, the red bars could be interpreted as contributions of Euro area common monetary policy shock to the development of SSR, left panel, and GDP series, right panel, at each particular moment in estimation sample.
A rationale for why arguably large and extensive non-standard monetary programs did not suffice to completely offset the crisis impact 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 the 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 which 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, this has also strengthened the euro that appreciated considerably towards all major currencies. In addition to hindered liquidity transmission to the 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 an already deflationary environment, essentially preventing the real interest to fall and to affect the economy in an expansionary manner.

This means that while the 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.
3.6 Conclusion

This chapter examined the role of the unconventional monetary policy from the perspective of real economic activity and stabilization of financing conditions in the selected Euro area countries. However, the analysis of the monetary policy transmission in a zero-lower-bound environment represents a great challenge for applied macroeconomic research. One of the biggest is how to properly quantify the stimulus provided by the non-standard measures. 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 the Krippner’s shadow short rate estimated for the Euro area and the 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. With that, the analysis focused on the research question on how effective were the non-standard measures introduced by the ECB in improving financing conditions and the real economy. By examining the impact 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 the 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 the real economic activity, operating with significant time lags, could be identified only towards the end of 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.

Considering the methodological point of view, the VAR model proved to be a very flexible tool that enabled the exploration of dynamic effects of unconventional monetary policy at individual country level, both, from the financial and macroeconomic perspective. However, in an attempt to build a comprehensive framework for modelling monetary policy in the crisis and ZLB period it is important to recognize the shortcomings of the standard monetary VAR model. These are predominantly related to its low-dimensionality. Namely, due to preservation of the degrees of freedom, there are only a handful of variables that can be included in the analysis. In our case this would implicitly imply that
monetary policy decisions are based solely on observation of the prevailing states of GDP
and inflation. But from Chapter 1 we know that especially in the unconventional times,
the monetary policy can be affected by a multitude of factors. Not capturing this impor-
tant information within our system will potentially lead to biased results, as part of the
identified innovation in the SSR might partly reflect the systemic change. In example,
SSR may resemble response to shock in inflation if missing information refers to infla-
tionary expectations. In addition, the analysis considered only one alternative monetary
stance measure that may need more elaboration in terms of its modelling robustness and
examination of its validity to summarize the unconventional monetary policy in the Euro
area. These shortcomings are being addressed in detail in Chapter 4.
4 COMPARISON OF ALTERNATIVE MONETARY STANCE MEASURES FOR THE EURO AREA: EVIDENCE FROM THE FAVOR

4.1 Introduction

This chapter builds on the modelling limitations exposed in previous chapters with an attempt to construct a robust and a comprehensive framework for empirical modelling of monetary policy in the crisis and ZLB period. The first question in doing that is how to robustly quantify the monetary measures when the main policy rate remains unchanged and thus uninformative.

As it was shown in Chapter 2, Wu and Xia (2016) and Krippner (2011-2015) propose the extraction of the shortest rate from the fitted yield curve that properly accounts for the zero lower bound (ZLB). The short rate extracted from the ZLB-adjusted term structure model is free to evolve to arbitrarily negative values and is commonly denoted the shadow rate. The shadow rates, therefore, differ in how the traceability of the yield curve models and modelling of lower bound has been approached.

The shadow rates estimated by the Wu and Xia’s and Krippner’s specification, respectively, are for the US data compared by Francis et al. (2014) who show a relatively richer dynamics of the Krippner’s shadow rate measure for modelling the monetary policy. A potential drawback of both types of shadow rates, however, is their relative sensitivity to the model specification. Krippner (2014, 2015a), therefore, proposes an additional and a more robust yield curve measure, denoted the Economic Measure of Stimulus, which summarizes the difference between the neutral rate and interest rate expectations.

In this paper we consider the validity of the three measures, outlined above, for representing alternative stance rates for the Euro area. We do that by examining the consistency of the measures with respect to various policy events and by exploring their capability to properly identify the non-systemic part of the monetary policy in the Euro area Factor-Augmented Vector Autoregressive model, hereafter denoted the FAVOR.

The FAVOR model essentially relies on a rich set of information by using factors extracted from the large panel of macroeconomic and financial data as regressors in the VAR estimation. The idea of utilizing information from a handful of estimated factors, describing the common variation of macroeconomic variables, has a long tradition in various aspects of economic research and monetary policy analysis. The study by Sargent and Sims (1977) was seminal in introducing a dynamic factor approach into the business-cycle analysis. Similar applications were offered by Singelton (1980), Engle and Watson (1981), Stock and Watson (1989), and Quah and Sargent (1993). Most of the research just listed proposed a way of constructing the lead economic and business cycle indicators from a large
set of macroeconomic variables in a degrees-of-freedom preserving fashion. With that, dynamic factor models represented an alternative to the standard time-series econometric models that assumed a certain degree of a priori restrictions on macroeconomic relations. Stock and Watson (2002) were the first to blend both approaches together. They studied forecasting of macroeconomic time series based on a large set of predictors at disposal to a researcher. In order to do that, they augmented the vector autoregression (VAR) modelling, commonly used in time-series forecasting application, with a small number of factors summarizing the information from all candidate predictors. They show a significant improvement of the forecast performance relative to the benchmark VAR model, with gains being further increased with an extended forecasting horizon.

The most notable application of the factor-augmented VAR model in the monetary policy analysis was initially introduced by Bernanke and Boivin (2003) and further extended by Bernanke, Boivin, and Eliasz (2005), hereafter denoted BBE. They show that in comparison to the standard monetary VAR model, analysing monetary transmission through FAVAR produces empirical results that are far more reconciled with the monetary theory and general economic intuition. Furthermore, a special appeal of examining the effects of monetary policy through the FAVAR structure is that it allows the observation of impulse responses for more than a hundred time series, rather than just for the selected subset of variables included in the standard VAR application. This is essentially utilized by Boivin, Giannoni, and Mihov (2007) who tested the sticky price assumption by disentangling fluctuations in prices at sectoral levels and examining them in relation to different macroeconomic and monetary conditions.

Wu and Xia (2016) use the FAVAR to test the validity of their approximated shadow rate and to measure the impact of the monetary policy on the US economy during the zero lower bound period. They found that the shadow rate, extracted from their benchmark term structure specification, exhibited a similar dynamics to the one observed for the Federal Funds Rate in the conventional period, that is before 2009. Moreover, their results imply that without unconventional policies in place, the US unemployment in 2013 would have been higher by approximately 0.23%, whereas the industrial production index would have been lower by up to 2 percentage points.

The application of the FAVAR for the purpose of analysing monetary policy transmission in the Euro area is rather scarce. A rare exception to this is the analysis provided by Soares (2012) who shows similar results as those obtained for the US as far as the comparison with the benchmark VAR model is considered. Namely, the FAVAR model performs consistently better in terms of producing empirical results that are statistically more precise and in line with the conventional economic wisdom. However, to the best of our knowledge, no such research has been conducted so far for the purpose of analysing the impact of the ECB’s monetary policy in the extended period encompassing the global
financial crisis and the zero lower bound. With this paper we attempt to close this gap.

Our FAVAR model incorporates factors extracted from 129 Euro area macro and financial time-series and considers three different time periods. The structural analysis reveals that when used in place of a policy rate, the Economic Stimulus Measure and Wu and Xia’s shadow rate produce impulse responses that are complied with the conventional economic wisdom. In contrast, using Krippner’s shadow rate as a policy stance measure produces impulse responses that exhibit some degree of sensitivity towards a number of factors included in the FAVAR model and a time sample being considered. Examining the alternative measures from the perspective of the realized policy events, however, reveals counter-intuitive evolution and a tendency of understating the stimulus provided by non-standard programs in the case of Wu and Xia’s shadow rate. Finally, we deem the Economic Stimulus Measure as the preferred alternative monetary stance rate and use it to estimate the counter-factual quantities of output and price series that would have prevailed in the absence of the ECB’s monetary measures introduced in the period between 2008 and 2014. Our estimates show that, had the unconventional measures not been employed by the ECB, the Euro area industrial index would have on average been lower by up to 0.8% in the crisis period.

Related to the research questions stated in the introduction of this dissertation, Chapter 4 therefore specifically addresses the following problems:

- What is the adequate alternative monetary stance measure for the Euro area, once the key Euro interest rates become uninformative?
- What is the appropriate framework for assessing the effects of monetary policy and its transmission in the Euro area?
- How effective were the non-standard measures introduced by the ECB in restoring the real economic activity?

The structure of the paper proceeds as follows: Section 4.2 describes different alternative monetary stance measures considered for the Euro area; Section 4.3 examines the validity of the individual alternative stance measures through their ability to properly identify the Euro area monetary shock; Section 4.4 provides the counter-factual analysis; and Section 4.5 concludes.

4.2 Alternative monetary policy measures

With the prolonged period of the economy operating near the zero lower bound (ZLB) on interest rates, the central banks’ main policy rates become uninformative from the perspective of summarizing the monetary stance. As an alternative, several prominent research contributions, dealing with the matter of measuring the effects of monetary policy
advocate the use of the shadow short rates (SSR), derived from the ZLB-adjusted yield curve models. These models exploit the ZLB mechanism for the interest rates as defined by Black(1995), according to which, a yield curve can be decomposed as follows:

$$R(t, \tau) = R(t, \tau) + Z(t, \tau)$$ (18)

$R(t, \tau)$ represents a shadow yield curve that would prevail in the absence of the zero lower bound on interest rates, and $Z(t, \tau)$ represents an option of investing in a physical currency, which prevents the estimated short rates from evolving to negative values. The SSR rate is the interest rate of the shortest maturity, extracted from the shadow part of the yield curve and it is based on parameters estimated in the ZLB-adjusted framework. Several approaches have been proposed for approximating the interest rate term structure representation in a near-ZLB environment. Wu and Xia (2016) develop a closed form analytic solution by deriving a forward rate pricing formula in discrete time. For extraction of Wu and Xia’s SSR from the euro-area yield curve data, a 3-factor model with implicitly calibrated lower bound parameter is considered.  

Krippner (2015b) and Christensen and Rudebusch (2013), however, mention several caveats in interpreting Wu and Xia’s shadow rate as an alternative monetary stance measure. The critique is mainly developed in the context of considerable sensitivity of the estimated shadow rates to the time and maturity span of the yield curve data used, different values of imposed lower bound parameter, and an inconsistency with the realized monetary policy events.

Therefore, in addition to Wu and Xia’s benchmark shadow rate for the Euro area, we also consider a shadow rate, extracted from the yield curve model with forward curve approximated in continuous time as defined by Krippner (2011-2015). For the purpose of estimating shadow rates, Krippner (2015b) as a benchmark specification proposes empirical implementation with two latent factors and the estimated lower bound parameter. The restriction of the latent factors ensures economically meaningful interpretation of the shadow rate measure at the expense of the yield curve fit, whereas the estimation of the lower bound parameter, rather than its implicit calibration, should in principal provide better consistency with the monetary policy events.

However, any SSR measure is essentially an estimated quantity and it is detached from what economic agents actually observe, that is, current and expected interest rates subject to the ZLB constraint. This means, that while the SSR measure can offer an insight into the dynamics of how monetary policy evolves through time in the ordinal sense, making

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15 The Wu and Xia’s shadow rate series for the Euro area is available at: http://faculty.chicagobooth.edu/jing.wu/research/data/WX.html
accurate quantitative judgement on the provided monetary stimulus/tightening based on the level of SSR remains questionable. Namely, Krippner’s SSR, based on 2 factors and the estimated lower bound parameter, may show resilience towards a different model specification in the sense of its dynamics, but remains prone towards exhibiting significant sensitivity as far as the magnitude is concerned (Krippner, 2015b). This in turn makes the SSR series incomparable among different monetary systems as well as between the ZLB and non-ZLB period. In other words, the 100 bps reduction of the shadow rate in the non-ZLB period does not necessarily reflect the same monetary stimulus as the equivalent reduction in the ZLB period. Conversely, the Economic Measure of Stimulus (EMS), introduced by Krippner (2014, 2015a), allows this sort of comparisons and has been shown to be considerably more robust to different model specifications as compared to the SSR measure. The EMS essentially summarizes the current and expected path of the short rate with respect to the long-run interest rate, commonly denoted as the neutral rate that reflects neither stimulatory nor restrictive monetary policy. In the yield curve setting, the neutral interest rate can be proxied with the first latent factor under the correct set of restrictions on the term structure model. In particular the EMS measure is represented as the integrated difference between the long-run interest rate and expected path of the short rate over the specified long-term horizon. More precisely, as the EMS relates to the expectations of economic agents which historically observe only positive values of interest rates, the current and expected path of short rate needs to be truncated at zero, where the positive part of the expectation path is denoted as the "effective value" of the SSR. The mechanics of the EMS can best be illustrated by two respective time points depicted in Figure 17.

Figure 17: SSR and EMS - Euro Area

(a) July 2008

(b) July 2012

Source: Bloomberg database; Author’s calculations.

The EMS measure is defined by the total shaded area between the expected path of the short rate and the neutral rate. For the July 2008 case, the Euro-area SSR and its expected path exhibit only positive values, meaning that no truncation is needed to cal-
ulate the EMS. On contrary, in July 2012 only the effective part of the SSR is considered for monetary stimulus, since the observed interest rates can not fall below zero. This is particularly significant as, in contrast to the SSR measure, the EMS can account for the attenuated stimulus effect in the ZLB period that arises as a consequence of restricted movement of the medium- and long-term part of the yield curve. In addition to the accounted non-linearity, the comparability of the EMS is further ensured by the fact that both, in the non-ZLB as well as in the ZLB period, we essentially consider the same categories, the effective part of the SSR and the neutral rate, where the information on both is obtained from the same term-structure model. As these yield categories reflect monetary policy expectations, they can equally be affected by measures beyond key interest rate. Furthermore, the EMS contains a richer set of information as it embeds the whole shadow part of the yield curve as opposed to the specific point of the shortest maturity considered in the case of SSR. In other words, the EMS considers the current and future misalignments of monetary policy as relevant for economic agents’ decisions, as opposed to the SSR, where only the current prevailing gap between the short rate and the neutral rate is taken into account (Krippner, 2015b).

The comparison of the alternative monetary stance measures for the Euro area can further be elaborated by observing Figure 18. We use the published Wu and Xia’s SSR series, which is based on the Wu and Xia’s (2016) benchmark discrete time Shadow/term-structure specification with 3 factors and the lower bound parameter calibrated to 25 basis points. The depicted Krippner’s SSR and EMS time series are calculated using ZLB-adjusted ANSM model approximated according to Krippner (2011-2015) and with estimated lower bound parameter. 16 The yield curve data spans twelve different maturities (0.25, 0.5, 1, 2, 3, 5, 7,10, 15, 20, and 30 years) and it includes German government bond yields up to year 2005, concatenated with the Euro Area Overnight Index Swaps from 2006 to 2015 17.

Before selecting the preferred measures to enter the analysis of the Euro-area monetary transmission in the next Section, we discuss their characteristics from the perspective of their empirical robustness. First thing to note is the entirely parallel dynamics of the EMS measures, extracted respectively from 2- and 3-factor specification of the Shadow/ANSM model. This means that the EMS(2) and EMS(3) at any point in time agree on the direction of current and expected monetary policy.

However, a consistent divergence in terms of magnitude requires an additional discussion on which Shadow/ANSM specification provides more plausible estimates of the EMS in terms of absolute values. As already outlined, the EMS summarizes the monetary policy

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16 The calculations are based on the modified versions of Matlab code, available at Leo Krippner’s website: http://www.rbnz.govt.nz/research_and_publications/research_programme/profiles/3503824.html
17 Bloomberg yield curve series: F910 and S0133Z.
by putting current and expected interest rate in the perspective of neutral rate. The latter should, in line with the general monetary wisdom, predominantly be determined by the long-run fundamentals, resembled in output and inflation expectations, and less so by the prevailing monetary policy. How well these characteristics are summarized in the context of the yield curve modelling, will therefore depend on the extent to which the current monetary policy translates into dynamics of the Level factor variable that proxies for the neutral rate.

From the comparison demonstrated in Figure 18 it can be observed that the 3-factor specification better captures the attenuated effects as the added factor provides additional flexibility in terms of explaining the dynamics of short and medium term interest rates. Instead, in the 2-factor specification this dynamics is partially absorbed by long term yields which influence the cyclicality of the Level factor variable. In that respect, the EMS(3) represents the measure that is more consistent in both, empirical and theoretical context.

In contrast to the EMS, the alternative SSR measures exhibit considerable divergence when compared across different yield curve specifications. In recent literature, Krippner’s SSR, extracted from the 2-factor model (hereafter denoted as K-SSR(2)), and Wu and Xia’s SSR, extracted from the 3-factor model (hereafter WX-SSR(3)), have often been set as the benchmark alternative monetary stance measures for the US case. A considerable detachment of the two competing measures can first be noted at the end of 2012 with the somewhat counter-intuitive evolution of the WX-SSR, indicating a shift to restrictive policy following the introduction of the Outright Monetary Transaction program and more explicit ECB’s forward guidance on easier financing condition in the future. Furthermore, in the period between 2013 and 2014, we can also observe two respective runs of non-zero realizations of Wu and Xia’s SSR, where the positive values even exceeded market-observed data of Eonia rate. According to Krippner (2015b), the rationale for the counter-intuitive dynamics could be sought in the unjustifiably high level at which the lower bound parameter can potentially be calibrated in a yield curve model.

Therefore, Krippner as the benchmark yield curve framework for the SSR extraction proposes a specification under which the lower bound parameter is estimated. However, observing the K-SSR(3), extracted from the yield curve framework with a model-based lower bound parameter, reveals that the number of factors should also play a crucial role in explaining the tendency of understating the monetary stimulus. Namely, the K-SSR(3), in a large portion of the examined sample does not offer any richer dynamics than the Eonia rate, which is materially constrained by the ZLB. This means that, while the additional flexibility of the 3-factor ZLB-adjusted yield curve helped improve the empirical consistency of the ESM measure, it has a counterproductive effect in case of the SSR.
The reason for that can be found in the nature of the 3-factor model in finding a better fit to the data in ZLB. Namely, in the ZLB environment, a better fit to the data will be sought in the part of the yield curve that does not materially violate the calibrated or estimated lower bound and in that sense still exhibits plausible realizations. In that respect, the information of the shorter part of the yield curve is either down or up-weighted, depending on whether the observed yields are above or below the lower bound. Krippner (2015b) shows that greater flexibility in the 3-factor yield curve models is manifested in obtaining the better fit on the up-weighted part of the yield curve through the adjusted Slope factor. As the SSR rate is in the Arbitrage-free Nelson Siegel model obtained as the sum of the Level and the Slope factors, the sensitivity of the SSR in the 3-factor model becomes obvious. In contrast, the 2-factor specification produces SSR estimates that are consistent with actual policy events and exhibit robustness towards different modelling settings (time sample, maturity span, initial parameters, estimation technique) at the expense of the yield curve fit.
In the following section, we examine the benchmark measures from the perspective of their dynamic relation to macroeconomic variables and suitability for examining the monetary policy transmission in the Euro area.

4.3 Structural analysis

Apart from exhibiting a relative robustness to differing yield curve models and showing consistency with the monetary policy events, to be considered a valid alternative policy stance measure, our preferred SSR or ESM rates need to enable a proper identification
of the monetary policy shocks. Namely, a policy easing summarized by our policy measure should in line with the empirically and theoretically supported conventional wisdom manifest itself in positive responses of economic activity and general price levels; see Sims (1992), Wu and Xia (2016), Bernanke and Gertler (1996), and Bernanke, Eliasz, and Boivin (2005). Failing to recreate the monetary policy stylized facts would in turn mean that one has not been able to identify the monetary policy shock and the choice of policy rate should be reconsidered. We employ the factor-augmented vectorautoregressive (FAVAR) approach, introduced by Bernanke et al. (2005), to analyze the responses of macroeconomic variables to shock to our respective alternative monetary policy measures, presented in the previous section.

4.3.1 The FAVAR model

The idea of the FAVAR model is to use a small number of factor variables to summarize and exploit the information contained in a large number of macroeconomic and financial time series. The set of factor variables is then included in the VAR model along with the monetary policy measure. Compared to the standard monetary VAR analysis, the FAVAR approach has several notable advantages: Namely, in order to preserve the degrees of freedom needed for the proper inference on the estimated parameters, the standard VAR commonly consists of only a small number of variables. This inherently implies the assumption that monetary policy decisions rely solely on the information provided by the variables included in the VAR model. The information not incorporated within the included variables will therefore be secluded to the system’s error, which can potentially lead to misleading estimated responses of variables to identified monetary shock. An example of a counterintuitive increase of the general price level to a tightening monetary shock, in the literature commonly denoted the "price puzzle", is an example of this, which can in this fashion be explained by a lack of information on future inflation that is usually incorporated in a central bank’s decision making process, Sims (1992).

In addition to a reasonable choice of monetary stance measure, the scarce number of macroeconomic variables included in the standard VAR model also demands from a practitioner a proper judgement on the appropriateness of macroeconomic series to accurately represent the economic activity or the general price level. Namely, the real GDP level and the consumer price index alone, may not offer a complete indication of the economic activity and general price level prevailing in a particular economy. In contrast, augmenting the VAR model by a small number of factors that consistently summarize a large set of macroeconomic and financial time series could potentially solve for both, the omitted variable bias problem and the problem of properly identifying the channels of monetary transmission.

Moreover, the FAVAR model allows a simultaneous examination of effects of monetary
policy decisions on more than a hundred variables of interest. These are assumed to be driven by the following factor structure:

\[ X_t' = \beta f F_t' + \beta y Y_t' + w_t' \]  

(19)

Where \(X_t\) is the \(N \times 1\) informational vector of macroeconomic and financial time series that can be explained by \(K \times 1\) vector of unobserved factors and the observed factor \(Y_t\), where the latter is represented by one of the alternative stance measures, presented in Section 4.2. In this context, the number of observed variables \(N\), included in the informational vector, will be much greater than the number of explanatory factors, \((K + 1 \ll N)\). \(\beta f\) is a \(N \times K\) matrix of factor loadings, whereas \(\beta y\) is a \(N \times 1\) vector of loadings on policy rate. The joint dynamics of factor variables can be expressed with the FAVAR equation:

\[
\begin{bmatrix}
F_t \\
Y_t
\end{bmatrix} = \Phi(L) \begin{bmatrix}
F_{t-1} \\
Y_{t-1}
\end{bmatrix} + e_t
\]  

(20)

where \(\Phi(L)\) represents a lag polynomial of order \(d\), \(e_t\) is the reduced error term with a mean zero and covariance matrix \(Q\). \(Y_t\) is an alternative measure representing a policy rate, and \(F_t\) is the \(K \times 1\) vector of unobserved factors.

The unobserved factors are uncovered in the static fashion as the part of the space covered by the first \(K\) principal components of the dataset \(X_t\), that is not described by the \(Y_t\) \(^{18}\). This is achieved by following the recursive assumptions, according to which, the unobserved factors do not respond to a monetary policy innovation within the period. In that respect, the informational variables contained in the \(x_t\) are divided to the within a period pre-determined data, denoted "slow-moving variables", and to the data sensitive to contemporaneous policy shocks, denoted "fast-moving variables".

Macro factors are therefore assumed not to respond to the policy rate within a period and are thus constructed as \(\hat{p}c - \hat{b}_{pc,y} Y_t\), where \(\hat{p}c - \hat{b}_{pc,y}\) are coefficient estimated in regression \(\hat{p}c_t = b_p c \hat{pc}^* + \hat{b}_{pc,y} Y_t + n_t\). The \(pc\) and \(pc^*\) correspond to principal components, which are respectively extracted from the entire dataset and a subset corresponding to the slow-moving variables marked with "**". In equation (19), a particular element of \(\beta y\) then equals zero in case \(X_t'\) corresponds to a slow-moving variable and undertakes the non-zero values in case of the fast-moving variables. With respect to that, it is assumed that there is only a limited informational set provided by the fast-moving variables that is not

\(^{18}\)Instead of estimating factors separately in a static fashion, BBE (2005) as an alternative propose Bayesian likelihood techniques for simultaneous estimation of factors and equation 20. However, their results show that the potential gains of this approach do not seem to offset the computational burden accompanying the likelihood methods. In contrast to statistical factor models, Forni and Gambetti (2009) develop a structural dynamic factor framework.
accounted by the monetary policy rate.

Finally, the recursive assumption requires separate identification of structural innovation in the equation (20) corresponding to the monetary shock. This is done by re-expressing the reduced form residuals of the FAVAR as a product of a lower triangular matrix of the Cholesky decomposed residual variance-covariance matrix $Q$ and the matrix of structural innovations.

Our informational matrix $X$ incorporates 129 macroeconomic and financial time series collected from the Eurostat and the ECB’s Statistical Data Warehouse. In order to ensure stationarity we applied standard transformation procedures, whereas the seasonal adjustment was provided by the X-13ARIMA procedure. The latter procedure was also used for the data imputation on the portion of the data set exhibiting incomplete series in the period between 1995 and 2000. The balanced panel of original data, therefore, spans the period between 2000 and the end of 2014. We resort to quarterly frequency, with linear interpolation performed on originally monthly data. A detailed data description of the dataset is available in Appendix D.

4.3.2 Alternative policy rates as linear monetary stance measures

Before proceeding to the impulse response analysis, we first utilize the FAVAR model to test whether our alternative measures (Wu and Xia’s SSR, Krippner’s SSR, and the Economic Measure of Stimulus) exhibit constant dynamic relations with the macro-economic variables throughout the conventional and ZLB period. If true, the test should offer a first indication of whether a particular alternative measure could be used in place of a conventional policy rate in ZLB times. Namely, an appealing feature of the alternative stance measures, stressed in Section 4.2, is their co-movement with the conventional policy measures in periods with interest rates sufficiently above zero, on the one hand, and their ability to produce rich dynamics also in the low interest environment, on the other. This characteristic of alternative measures is best depicted in Figure 18, panel (b), where aligned movement of the Eonia rate and SSR measures can be observed in the period before 2009 and in 2011, when interest rates exhibited sufficiently positive values. On contrary, in the period of constant Eonia rate, due to a binding lower bound on interest rates, we can see the autonomous dynamics of the SSR rates. Replacing conventional rates with a valid alternative measure should, therefore, allow a linear interpretation of monetary policy shocks throughout the entire sample, spanning both the non-ZLB and ZLB period. Conversely, a considerable structural break in the coefficients corresponding to the FAVAR model, incorporating one of the alternative measures, would suggest that our policy measure of choice does not inherit ability to continuously summarize the monetary measures in the ZLB period.

We test for the change in the estimated FAVAR parameters at two potential break points.
The first one indicates the end of the year 2007 and captures the run-up to the global financial crisis, whereas the second date is set to the end of year 2009, reflecting the beginning of the sovereign crisis in the Euro area. To construct the test statistic we re-estimate the upper block of equation (20) as proposed by Wu and Xia (2016):

\[
F_t = \nu + \rho F_{t-1} + d_{(t<Dec2007)}\beta_0 Y_{t-1} + d_{(Dec2007<t<Dec2009)}\beta_1 Y_{t-1} + d_{(t>Dec2009)}\beta_2 Y_{t-1} + e_t \tag{21}
\]

Where \( F_{t-1} \) is the matrix of lagged factor values, \( Y_{t-1} \) is the matrix of lagged policy rates, \( d \) is a dummy variable undertaking value 1 either before, between, or after the designated break dates. The equation (14) is, as in the case of the impulse response analysis, being re-estimated with alternating monetary measures, where in addition to alternative policy measures we now also consider the Euro OIS rate (EONIA). The latter is used as a proxy for the Euro-area conventional rate for which we assume a distinct structural break to be revealed in the GFC-ZLB period. Following the above specification, the null hypothesis assumes no structural break in coefficients upon the determined breakpoints, \( H_0 : \beta_0 = \beta_1 = \beta_2 \). To test the null hypothesis the following likelihood ratio statistics is defined:

\[
(T - k)(\log|e_R e_R| - \log|e_U e_U|) \tag{22}
\]

With \( T \) representing the number of observations, \( k \) being the number of regressors, \( e_R e_R \) is the estimated covariance matrix with the imposed null hypothesis restriction, and \( e_U e_U \) is the covariance matrix of unrestricted regression. Table 14 reports the likelihood ratio statistics with its significance level for each policy measure considered and corresponding 2-, 3-, 5-, and 7-factor FAVAR specifications. The reported results suggest that the null hypothesis cannot be rejected at any significant level for the EMS measure as the policy rate, regardless of the number of factors included in the FAVAR. This means that a dynamic relation of the EMS measure to macroeconomic variables does not change considerably with respect to the designated breaking points, and can therefore successfully compensate for the information not captured by the conventional policy rate in the ZLB period.

In contrast, the hypothesis of stable parameters for models with shadow rate alternatives cannot be rejected only for the 2-factor specification. This means that the models beyond 2-factor specification and with a shadow short rate in place of a policy measure would most probably produce biased impulse responses of the key macro variables. In other words, reading off the reduction of the SSR at negative values would very likely not resemble the same monetary stimulus as the reduction at levels sufficiently above zero. However, compared to the conventional stance measures, as i.e. EONIA rate, the test statistics related to the shadow rate alternatives in general remain lower, especially when the lower
dimensional FAVAR specifications are considered.

| Table 14: Likelihood ratio statistics for structural breaks in parameters |
|-----------------|-----------------|-----------------|-----------------|
|                | WX-SSR | Krippner SSR | Economic Measure of Stimulus | Eonia rate |
| FAVAR(2)       | 14.56** | 6.77          | 9.22                      | 39.88***   |
| FAVAR(3)       | 15.56** | 18.12**       | 10.16                     | 41.94***   |
| FAVAR(5)       | 32.10*** | 32.66***     | 11.40                     | 32.64***   |
| FAVAR(7)       | 48.47*** | 31.68***     | 17.47                     | 43.36***   |

Notes: ***, **, * - indicate significance at 1 %, 5 %, and 10 %, respectively. The null hypothesis assumes the constant parameters throughout the entire estimated sample. On contrary, rejecting the hypothesis at significant level indicates a structural break in the system.

4.3.3 The impulse response analysis

For the purpose of the impulse response analysis, we separately consider three different time periods to capture the potential shifts in the Euro-area monetary transmission mechanism, outlined with the above structural break exercise. In that respect, the first period encompasses the whole time period for which the data is available, 1995Q1 - 2014Q4, the second indicates the common-currency union and the balanced panel of the original data, 2000Q2 - 2014Q4, and the third incorporates the combined period of the global financial crisis and zero-lower-bound (the GFC-ZLB period), 2008Q2 - 2014Q4. For each period we estimate three respective FAVAR models, each corresponding to a different alternative policy rate, presented in Section 4.2, the EMS(3), WX-SSR(3) and the K-SSR(2). To determine the appropriate number of factors to be included in the benchmark Euro-area FAVAR model we follow the Bai and Ng’s (2002) testing procedure which suggests that the Euro-area economy is properly represented by 7 unobserved factors, a result already obtained by Soares (2011).

The preferred factor specification is further justified by the proportion of variation that the factors included in the observation equation 19 explain for some of our key macro variables. From Table 15 it can be observed that the factor specifications corresponding to 2 and 3 factors, respectively, do not provide a meaningful representation of the Euro-area industrial production, as the estimated R-adjusted coefficient does not exceed 50 % for that variable. In order to observe the potential gains of adding additional information to the model and relative sensitivity of our alternative measures from the perspective of monetary transmission analysis, we (in addition to the 7-factor FAVAR) also estimate impulse responses for 2-, 3-, and 5-factor FAVAR with results secluded to Appendix C19.

19Lag orders for each specification are determined based on standard likelihood ratio statistics with the exception of GFC-ZLB period where lag order is set to 1 in order to enable proper inference on such a small sample.
The above structure of the modelling framework, which incorporates different time samples, factor specifications and alternative monetary measures in place of a policy rate, should in principal serve the following purposes: a) Out of the three alternative measures, proposed by the recent literature, determine the one that most reliably summarizes the monetary stance and at the same time enables identification of the Euro-area monetary shock; b) Observe the gains of adding the information to a monetary VAR analysis in describing the Euro-area policy transmission mechanism; c) Observe how the monetary transmission mechanism has changed with respect to the ZLB environment; d) Taking into account all previous points, offer a most suitable framework for modelling monetary policy consistently through conventional and ZLB periods.

Table 15: R-adjusted observation equation (2000Q2 sample)

<table>
<thead>
<tr>
<th></th>
<th>Industrial production</th>
<th>real GDP</th>
<th>HICP</th>
<th>Employment</th>
<th>exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-factors</td>
<td>0.42</td>
<td>0.85</td>
<td>0.60</td>
<td>0.55</td>
<td>0.75</td>
</tr>
<tr>
<td>3-factors</td>
<td>0.42</td>
<td>0.91</td>
<td>0.76</td>
<td>0.64</td>
<td>0.87</td>
</tr>
<tr>
<td>5-factors</td>
<td>0.57</td>
<td>0.95</td>
<td>0.90</td>
<td>0.72</td>
<td>0.87</td>
</tr>
<tr>
<td>7-factors</td>
<td>0.56</td>
<td>0.95</td>
<td>0.92</td>
<td>0.86</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Notes: The table reports the proportion of variation explained by predicting factors entering the observation equation as independent variables. The R-adjusted estimates are represented for selected aggregate variables that should in principle best resemble economic activity and prices.

Figure 19 depicts cumulative impulse responses produced by our preferred 7-factor FAVAR specification. The figure is divided into three panels, with panel (a) corresponding to the impulse responses estimated on the full data sample, 1995Q1 - 2014Q4, panel (b) depicts responses estimated on the common-currency sample, 2000Q2 - 2014Q4, and panel (c) refers to the period spanning the global financial crisis and low interest environment. In each period we depict the responses of the Euro-area industrial production index and the harmonized index of consumer prices (HICP), based on three separate FAVAR models, which, respectively, as a policy rate incorporate one of the benchmark alternative stance measures proposed by the recent literature (EMS(3), WX-SSR(3), and K-SSR(2)).

In Section 4.2 we discussed how dynamics of the SSR measure changes, depending on the number of factors that a yield curve model, from which the SSR is obtained, includes. To see how this changed dynamics is manifested in the monetary transmission analysis, we therefore also include impulse responses corresponding to the Krippner’s SSR, extracted from the 3-factor yield curve model (K-SSR(3)). In addition, the impulse responses of the baseline monetary VAR are included to observe the potential gains of augmenting the VAR model with latent factors for the purpose of the Euro-area monetary policy transmission analysis.
We first analyze the impulse responses from the perspective of comparing different alternative measures and their ability to identify the monetary shock in the Euro area. As a criterion of proper monetary shock identification we set the alignment of impulse responses with the conventional monetary wisdom. That is, an unanticipated monetary expansion should be closely followed by increases in output and prices, where monetary expansion is expressed as the 25 bps increase in the EMS case and 25 bps decrease in case of SSR measures. Different FAVAR specifications (related to changing time sample and a number of factors included), incorporating Wu and Xia’s policy rate (WX-SSR) produce responses that are broadly in line with the conventional monetary wisdom. In Figure 19, this is visible from the expected positive responses of the industrial production and HICP to innovation in WX-SSR rate for all time samples. The responses of the industrial production do, however, exhibit a considerable degree of persistence, which is inconsistent with the notion of the long-run money neutrality. In addition, as far as the magnitude of the price responses is concerned, the heterogeneity related to different time samples can be observed. Namely, the maximum price response to a 25 bps decrease in the WX-SSR drops from 0.14 percentage points, estimated for the full sample (panel (a)) to approximately 0.05 percentage points in the common-currency and ZLB periods (panels (b) and (c)).

The responses implied by the ESM are intuitive, but, as in the case of WX-SSR, a somewhat sluggish dynamics of the industrial production can be spotted, in particular for the overall and common-currency estimation period (panels (a) and (b)). Namely, the peak 0.28 percentage point increase (averaged over both time samples) in industrial production can be observed only 2 years after the 25 basis point increase in EMS. The delayed and persistent response of industrial production, however, is not unique to the alternative policy measures used in our analysis. In that respect, Soares (2012) shows that maximum impact of monetary policy shock on the Euro-area output, using a conventional policy rate, is attained 22 months after the initial shock. Similarly, Bernanke et al. (2005) show that a very persistent output response is an occurrence that is commonly revealed also in the US data.
Figure 19: 7-factor FAVAR impulse response comparison for alternative policy measures

(a) Full sample

(b) Common currency sample

(c) GFC-ZLB period

Notes: The figure presents the impulse responses of the Euro area industrial production index and HICP to an expansionary monetary shock, 25 basis point increase in the EMS and reciprocal decrease in the SSR measures. Panel (a) refers to the impulse responses obtained in the 1995Q1-2001Q4 sample, panel (b) refers to the 2002Q2-2014Q4 sample, and panel (c) refers to the 2008Q2-2014Q4 sample.
The impact of shock to EMS on prices is small and insignificant (original impulse responses with corresponding confidence intervals are available in Appendix C). A relatively small price response can be attributable to a rather limited impact that macroeconomic disturbance, such as monetary policy shock, has on disaggregated price fluctuations. In particular, Boivin et al (2007) for the US data show that the price dynamics is predominantly driven by sectoral disturbances, whereas only about 17% of fluctuations can be associated with the aggregated monetary shocks.

While the impact of monetary shock on prices remains relatively stable from the perspective of magnitude and the peak estimated response, some qualitative changes in dynamics can be observed, when different time samples are considered. Namely, in panels (a) and (c), reflecting the overall and GFC-ZLB period, the HICP responds immediately, with the peak response being attained 3 quarters after monetary policy innovations, followed by a slightly negative, but persistent negative impact that takes place after 10 quarters. In contrast, panel (b) reveals the initial short-lived puzzling response for the common-currency sample, where positive and a very persistent impact on prices is eventually achieved after 3 quarters. As the structural break analysis, reported in Table 21, reveals no significant change in estimated parameters for the FAVAR incorporating EMS, the explanation can again be sought in disaggregated price responses. Boivin et al (2007) point at a significant disperse reaction of sectoral price levels to aggregate monetary shock, where HICP categories that respond promptly and most flexibly correspond to sectors where produced quantities increase the least. The latter will essentially depend on the degree of competition and market power prevailing in a particular industry, which can potentially change in time, but the formal examination of this argument surpasses the scope of this analysis.

From Figure C5 (Appendix C), one can observe that sectors that seem to govern the dynamics of the aggregated consumer price level in the Euro area are the ones referring to the activities connected to goods, transport, energy, and clothing, as the responses of these categories qualitatively mimic the overall HICP response produced by the EMS. The sectors that exhibit most flexible price responses are related to food, housing, water, and electricity, where peak responses are attained between 3 and 5 quarters, with the dying-off effect taking place 12 quarters after the initial shock.

In contrast to the EMS and Wu and Xia’s SSR, the Krippner’s SSR (K-SSR(2)) exhibits some degree of sensitivity in estimated responses towards different factor and sample specifications of the FAVAR. Namely, from Figure C3 (Appendix C), a strong counter-intuitive negative response of industrial production to a shock in K-SSR can be observed, that seem to occur only with the 5-factor FAVAR specification. Likewise, the 7-factor FAVAR reports a strong expected increase in a price response estimated on the entire sample (Figure 19, panel (a)), while for the GFC-ZLB period a strong puzzling price effect is revealed (Figure 19, panel (c)). Inconsistency in responses pertaining different FAVAR
specifications suggests that the K-SSR(2) measure may not offer a reliable monetary shock identification. The exhibited dynamic relation to macro variables reconciled with the conventional economic wisdom in the case of WX-SSR, however, does not necessarily reflect its superiority towards the K-SSR(2) measure. Instead, the differing results of respective SSR measures further prove the discussion on sensitivity of SSR series, initiated in Section 4.2, according to which, the evolution of SSR series in the ZLB period will highly depend on a number of factors that a yield curve model from which SSR is estimated incorporates.

How divergent dynamics, resembled on a rather small portion of the examined sample in Figure 18, can affect the overall monetary transmission analysis, we illustrate by additionally examining the impulse response functions corresponding to K-SSR, extracted from the 3-factor yield curve model (K-SSR(3)). Namely, the results in this case are now fully reconciled with the economic theory and would point towards the proper identification of a monetary shock in the Euro area. However, these responses are achieved at the expense of uninformative dynamics of the SSR measure from the perspective of indicating the monetary stance consistent with the actual monetary policy events. In other words, while the SSR measure, obtained from the 3-factor term-structure model, enables the identification of monetary transmission channel, the actual values of the SSR measure will not resemble the true stimulus provided by the ECB in a particular moment in time. Conversely, the EMS measure seems to meet both criteria: i) It develops dynamics consistent with the actual monetary policy events; ii) A monetary shock identified through the EMS produces responses that are broadly in line with the monetary wisdom and are strongly consistent with the stylized facts reported for conventional monetary policy rates and other country cases. In addition, the structural break analysis showed that the FAVAR incorporating the EMS exhibits no structural break in the estimated parameters, which expose the EMS as an eligible candidate measure to be used in a place of a conventional policy rates when it becomes uninformative due to a zero lower bound.

The above impulse response and structural break analyses, therefore, revealed EMS as the preferred alternative monetary stance measure for the Euro area. Along with the benchmark FAVAR specification incorporating 7 factors, our proposed data-rich modelling framework can then directly be compared to the standard monetary VAR, a baseline model widely used for the purpose of modelling monetary policy. The baseline impulse responses depicted in Figure 19 are produced by the 3-variate VAR model, incorporating the Euro-area industrial production index, HICP, and EMS measure as the policy rate.20

The upper panel of Figure 19 shows that the baseline VAR produces a puzzling price response for the overall sample period (1995Q1-2014Q2). In addition to the price puzzle,

20To determine lag order of the Baseline VAR model, the standard Dickey-Fuller test was performed for the overall and common currency sample, suggesting the lag order of 3 and 2, respectively. For the ZLB period, the lag order was set to 1 to enable a proper statistical inference.
a considerable counter-intuitive output response is revealed for the baseline VAR model as the industrial production index drops by 0.27 percentage points upon an unanticipated monetary expansionary shock (25 bps increase in EMS). Employing the information-rich FAVAR framework instead, offers a remedy for puzzling price and output responses that, according to Sims (1992), have a tendency to occur in a baseline monetary VAR analysis due to the information shortage. Likewise, increasing a number of explanatory factors in the FAVAR framework, generally improves results from the perspective of reducing the puzzling price effect for all three benchmark alternative measures considered. Figure 20 depicts the HICP responses to shocks in EMS, WX-SSR, and K-SSR, respectively, that were separately produced by 2-, 3-, 5- and 7-factor FAVAR specification, estimated on the full sample (1995Q1 - 2014Q4).

The upper left panel of Figure 20 discloses a significant puzzling response produced by all three alternative measures in the 2-factor FAVAR specification. By adding additional factors to the FAVAR, the counter-intuitive price response becomes almost non-existent for all three alternative measures. The gradual elimination of the puzzling effect with an increasing number of factors thus confirms the discussed implications of the model information shortage and further justifies our choice of preferred 7-factor FAVAR specification for representation of the Euro-area monetary transmission.

*Figure 20: FAVAR and the price puzzle phenomena*

Notes: Figure depicts impulse responses of HICP variable to shocks in respective alternative monetary measures that were separately obtained from 2-, 3-, 5-, and 7-factor FAVAR model, estimated for the full sample (1995Q1-2014Q4).
The main conclusions that can be taken out from the above analysis can thus be summarized around the following points: a) Out of the three alternative stance measures considered in the analysis, the Economic Stimulus Measure, proposed by Krippner (2014, 2015a), most consistently summarizes the actual monetary policy effects and can be considered as the best policy tool for the analysis of the Euro-area monetary transmission; b) the benchmark FAVAR framework successfully deals with the information-shortage present in the standard VAR analysis that can be associated with the common counter-intuitive responses of the key macroeconomic variables; c) the impulse responses, obtained in our benchmark FAVAR specification, suggest that in contrast to the rather sluggish dynamics of the output related to the monetary policy in the pre-crisis period, the translation of the monetary shock to output is much faster and more direct in the combined period of the global financial crisis and the ZLB, however, with an almost non-existent effect on prices.

4.4 Macroeconomic implications

In this section we attempt to put the actual tangible quantity on the effects of the ECB policies during the GFC-ZLB period. Namely, from 2008 till 2014, the ECB introduced several non-standard programs, including three covered bond purchase programs (CBPP), the collateral framework and the provision of additional liquidity, the securities markets program (SMP), and the outright monetary transactions program (OMT). In order to measure the impact of the non-standard programs we decompose our macroeconomic variables into their initial deterministic component and a stochastic component, incorporating the sum of all past shocks, an approach also employed by the Wu and Xia (2016) on the US data.

Hence, by setting contributions of the monetary policy rate variable to zero, we can observe the realization of macro variables, had the non-standard measures not been introduced. In accordance to the analyses, provided in Sections 4.2 and 4.3, the preferred policy variable choice is Economic Stimulus Measure, introduced by Krippner (2014, 2015a), as it exhibited most consistent dynamics with the actual policy events and provided the most reliable identification of a monetary policy shock. To elaborate on the points raised in Section 4.3, the analysis also reports results for the Wu and Xia’s SSR. The period for which the contribution of shock, recognized through the alternative policy variables, is excluded, encompasses the time between 2008Q3 and 2014Q4.

The solid line in the Figure 21 represents the actual realizations of macroeconomic variables, the dashed line represents the counter-factual path predicted by the EMS measure, and the dotted line are realizations that would occur in the absence of the ECB interventions according to Wu and Xia’s SSR measure. The evolution of the counter-factual path of the GDP, produced by the Wu and Xia’s SSR, above the realized quantities confirms
the initiated discussion in Section 4.2 on underestimation of the non-standard programs by the SSR measures, derived from the 3-factor yield curve models and with an explicitly calibrated lower bound parameter. Furthermore, as our counter-factual analysis reveals and as it was already suggested by Figure 18, by simply reading-off the dynamics of the Wu and Xia’s SSR would (e.g. in the late 2013 and 2014) suggest that the ECB’s policies were actually restrictive, which would be inconsistent with the intent of the non-standard programs introduced.

In contrast, the EMS measure points towards an accommodative nature of the unconventional policies, devised by the ECB throughout the GFC-ZLB period. In particular, for the period from 2009 to 2014, we estimate that the Euro-area industrial production index and the real GDP would have on average been lower by 0.8 and 0.6 percent, had the monetary policy measures not been introduced. Furthermore, the accommodative effects on the real economy were achieved at little or zero cost of higher inflation.

**Figure 21: Counterfactual analysis**

<table>
<thead>
<tr>
<th>Year</th>
<th>Industrial production index</th>
<th>Real GDP (mio EUR)</th>
<th>HICP (2005=100)</th>
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<tbody>
<tr>
<td>2010</td>
<td>100</td>
<td>2280</td>
<td>104</td>
</tr>
<tr>
<td>2012</td>
<td>103</td>
<td>2300</td>
<td>106</td>
</tr>
<tr>
<td>2014</td>
<td>105</td>
<td>2320</td>
<td>108</td>
</tr>
</tbody>
</table>

Source: Eurostat; author’s calculations.

### 4.5 Conclusion

This paper explored usefulness of the recently proposed alternative policy stance measures for a continuous assessment of monetary policy effects throughout the period encompassing conventional interest rate policies as well as the period demanding the employment of non-standard measures with interest rates at the zero lower bound. In particular, our focus was placed on the Economic Measure of Stimulus, introduced by Krippner (2014, 2015a), and the shadow rates obtained from the respective benchmark yield curve models, proposed by Wu and Xia (2016) and the model of Krippner (2011-2015). We estimated the factor-augmented VAR (FAVAR) model in order to examine the capability of proposed measures to identify monetary policy shock in the Euro area. We find that the shocks to Economic Stimulus Measure and Wu and Xia’s benchmark SSR produce intuitive macroeconomic responses, consistent with the conventional economic wisdom. However, a detailed analysis of the SSR measures reveals that the assessed impact on the
real economy will essentially be specific to the yield curve modelling framework used for their extraction. With respect to that, we can consider the Economic Measure of Stimulus the most adequate to summarize the monetary stance continuously through conventional and unconventional periods.

From the perspective of the monetary transmission analysis in the Euro area, an increasing factor structure successfully removes puzzling price responses, commonly present within the standard monetary VAR model. In that manner, the information-rich content of the FAVAR in combination with the Economic Stimulus Measure provides a reliable framework for empirical modelling of monetary policy in the lower bound period. In the period spanning the global financial crisis and the zero lower bound, however, both, the standard baseline VAR model and the FAVAR model, produce an expected effect on the output and prices. This indicates that the unconventional monetary policies have indeed had the accommodative effects on the Euro-area economy. In particular, we show that in the period between 2008Q3 and 2014Q4, the realization of the Euro-area industrial production would on average, in the absence of the ECB interventions, be approximately 0.8% lower.
Conclusion

After the global financial crisis, erupting in 2008, applied economists and central bank practitioners in most of the developed economies found themselves in an uncharted territory of the near-zero interest rate environment. The Euro area was not unique in this with the ECB introducing several non-standard measures to complement the usual interest rate policies. The purpose of this dissertation was to provide a timely exposition of modelling tools to be used in such environment and to offer an assessment of effectiveness of the unconventional monetary policy and its transmission to the Euro area. This chapter briefly summarizes the main findings and offers pointers for future research.

Main findings

The doctoral dissertation was divided in four chapters, ordered in a way to complement each other in content and methodology. The first chapter provided the in theory-based principles for the effectiveness of unconventional monetary policies and elaborated on measurement issues related to empirical modelling of monetary policy. In the second paper an event-study analysis was performed to assess the impact of monetary policy decisions on various financial market segments and to determine the channels through which this change was implied. The third paper examined the usefulness of the newly proposed shadow rate measures for assessing the monetary stance and financing conditions in the Euro area and individual member countries. The fourth paper relied on the data-rich modelling framework to consistently estimate the impact of unconventional monetary policies on the real economy and to compare competing alternative monetary stance measures. The main findings of the overall dissertation can be discussed in the context of the research questions postulated in the Introduction:

1. What was the role of the ECB in averting the consequences of the global financial crisis and how credible was this role in the eyes of the financial markets?

The ECB responded to the crisis by introducing several non-standard measures, six of which were aimed directly at the Euro-area asset markets. The model based examination of yield changes upon the announcement of the programs showed that the monetary policy decisions were channelled to financial markets predominantly through changes in monetary policy expectations and to a much lesser extent by influencing the supply of particular asset and its corresponding term premium. This result may not be so surprising, considering a rather modest volume of asset market programs unveiled before 2014, especially when compared to the ones introduced by the FED early into the crisis. In any case, the model-based inspection of the risk-free yields conducted in the first paper revealed that within non-standard measures introduced before 2012, market participants did not recognize the ECB’s commitment to a looser monetary policy. Instead, strong
expectations of future correction to tighter financing conditions were revealed. The reasoning for that can be developed along two lines. First, the degree of commitment and the size of the non-standard measures were strongly conditioned by the narrow single price-stability mandate of the ECB. In that respect, the communication strategy before 2012 explicitly stressed the temporary nature of the non-standard measures, which caused counter-intuitive effects of unconventional policies on bond yields. Likewise, the amount of stimulus may not have met the market expectations that were developed based on the programs introduced by the FED. Second, the nature in which the crisis in Europe developed called for non-standard measures that were highly targeted and aimed at addressing specific market segments and countries, which resulted in a rather dispersed impact on yields across the Euro area. In contrast to period before 2014, a clear shift in perception of the ECB’s monetary policy could be observed with introduction of the Extended Large Asset Purchase Program, where significantly reduced expectation component of the 10-year sovereign yields indicated the extended period of low interest environment.

2. How effective were the non-standard measures introduced by the ECB in improving financing conditions?

While the non-standard measures introduced before 2014 did not indicate a signal of looser monetary policy in the future, they did manage to reduce yields and ease financing conditions of the countries most distressed by the financial and in particular the sovereign crisis. There are several implications of that throughout the dissertation. First is a significantly dampened effect noticed for the Spanish yields at the announcement dates of the non-standard programs. The simultaneous increase of German yields indicates a start of reversal of flight-to-safety flows that occurred in the asset markets after the introduction of the non-standard programs. Similar implications can be drawn by observing the converging trend of the shadow short rate series of core Euro area countries, Germany and France, and two periphery countries, Italy and Spain, following the introduction of particular ECB’s unconventional policies. This is further stipulated by the quantitative analysis performed in the second paper, which proves the effectiveness of the common monetary policy in improving financing conditions of the most distressed countries. The improvement coincides heavily with programs directly engaged in government bond markets (SMP, OMT, and EAPP) and with a shift to a more assertive communication strategy.

3. How effective were the non-standard measures introduced by the ECB in reviving the real economic activity?

The macroeconomic implication of the non-standard measures can be considered in the context of counter-factual analyses performed separately in the third and fourth paper. In the third paper the counter-factual analysis is based on the nullified monetary shock, identified by the Krippner SSR within the standard VAR analysis, whereas in the fourth paper the FAVAR analysis is performed with exemption of the shock identified by the
Economic Measure of Stimulus by Krippner (2014, 2015a), which is also perceived as the most reliable alternative stance measure. In both cases the assessed impact of non-standard measures is rather limited, however, the counter-factual analysis based on the EMS measure points towards a consistent accommodative nature of the unconventional policies in the period between 2008 and 2014. Namely, the realizations of the industrial production index and the real GDP level are assessed to be 0.8 % and 0.6 % lower, had the non-standard measures not been employed.

4. **How did a common monetary policy affect individual member countries in the Euro area?**

The dissertation thoroughly examines the implications of the unconventional monetary policy and its transmission for the two Euro periphery countries, Italy and Spain, that endured a significant stress during the financial and sovereign distress. Positive effects of the monetary policy on the financing condition were already outlined under point 2, so the focus hereafter is only on the real economy. The macroeconomic effects of monetary policy on the two periphery countries assessed within the standard VAR analysis is rather modest with runs of contractionary realizations. This implies that the improved financing conditions resembled in the sovereign bond market did not translate into increased financing of household and firm sectors that could potentially restore demand and production. The counter-factual analysis in the case of individual member countries is conducted only for the SSR measure as the EMS measure is not applicable in the country-specific cases due to the safety and risk premia that would distort the concept of neutral interest rate, the idea that EMS essentially relies on.

In addition to the main results connected to the effectiveness of the ECB’s monetary policy in the combined period of the global financial crisis and the zero lower bound, the dissertation also draws several methodological implications:

5. **How can we properly model monetary policy expectations in the ZLB environment?**

The workhorse empirical framework that the dissertation closely follows is the Shadow ANSM model proposed by Krippner (2011-2015). In the second paper we used the yield curve modelling approach to decompose yields into the monetary expectation component and term premium. Since the concept of monetary policy expectation is proxied as the conditional forecast of short rates over a given maturity span, the accuracy of estimates and the goodness of fit will be of particular importance. Chapter 2 compares the performance of the Shadow/ANSM against the baseline ANSM that does not accommodate for the lower bound. For the Euro area yield curve we confirm the consistent overestimation of the expectation component in the ZLB period for the basic ANSM model, the result that is in the literature suggested also for the US and Japan cases, Ichue and Ueno (2013). The estimation bias occurs as the ANSM does not properly account for the
stickiness and reduced volatility of the short rates in the low interest rate environment, therefore, wrongly anticipates an earlier than expected lift-off from the ZLB. In the empirical analysis this becomes particularly evident in light of the ECB’s, in volume, the largest asset market program, the EAPP, without explicitly determined tapering data, where an extended period of low interest rate would be the most intuitive expectation about the future monetary policy and it is in turn not captured by the basic ANSM model.

6. How to properly quantify the stimulus provided by the non-standard measures?

The third paper examines the usefulness of recently proposed shadow short rates for analysing the effects of unconventional monetary policies. In particular the focus was put on the SSR estimates proposed by Krippner (2011-2015) as in the case of US it exhibited the highest robustness towards different sample lengths, maturity spans, initial parameter set and estimation techniques. Whether the dynamics of Krippner’s SSR measure properly summarizes the stimulus, induced by the ECB’s unconventional policies, was validated by exploring dynamic relation of the SSR with the key macroeconomic variables. Namely, an increase in the SSR should, according to the conventional monetary wisdom, induce contractionary responses in the GDP and prices. The impulse responses of the real GDP and consumer price index, obtained from the structural VAR analysis, are in general reconciled with the economic theory, but compared to some past empirical results for the Euro area, the peak responses are delayed and exhibit greater persistence. Similar results are obtained for the two periphery countries, where the reported dynamic correlation between the SSR measure and macroeconomic variables implies that interpreting SSR in terms of financing condition and liquidity stance is justified from the perspective of the individual country cases.

7. What is the adequate alternative monetary stance measure for the Euro area, once the key Euro interest rates become uninformative?

The validity test of the SSR measure and impulse responses of macroeconomic variables obtained in the third chapter can only be discussed within a particular time sample and a subjective variable set chosen to represent economic activity and the general price level. To avoid a personal judgement, connected to the SSR and macroeconomic variables choice, paper 4 performs an extended robustness analysis within varying specification of the data-rich FAVAR framework. In this context three alternative monetary stance measures were considered for the Euro area: the benchmark SSR estimate, proposed by Krippner (2011-2015), the benchmark SSR measure, proposed by Wu and Xia, and the Economic Measure of Stimulus, proposed by Krippner (2014, 2015a). The results expose the EMS measure as an adequate alternative for monitoring the Euro area monetary stance in the non-ZLB and ZLB period. It exhibits a strong robustness towards different yield curve modelling specifications, shows consistency with the actual monetary policy events, and reconstructs dynamic relation with macro variables, observed for the conventional rates.
In contrast, the monetary transmission analysis based on the SSR shows considerable sensitivity towards different yield curve modelling frameworks employed for the estimation of shadow rates.

8. What is the appropriate framework for assessing the effects of the monetary policy and its transmission in the Euro area?

An important deficiency of the standard monetary VAR analysis is a limited number of variables that can be included in the system. Policy decisions, in turn, are usually determined based on a state of a large panel of macroeconomic and financial variables prevailing in a particular economy. In line with that, it has been empirically proven that excluding an important piece of information from the system may produce misleading results. In particular, standard monetary VAR analysis shows tendency of producing a puzzling price response by not properly accounting for the future expected inflation that usually enters the decision making process of central bankers. In contrast, the FAVAR framework relies on a large set of information and should in principle overcome these anomalies. Paper 4 directly compares the two models in the context of three alternative stance measures, outlined above, and different time samples. The results confirm a puzzling price response for the two out of three policy measures in the case of the baseline VAR. In contrast, within the FAVAR framework the price puzzle fades away with the number of factors included in the system. Instead of relying on factors that summarize the common dynamics of the large set of macroeconomic variables, increasing information contained within the baseline VAR would in turn have to involve the practitioner’s judgement on selecting the appropriate variable to remove the bias. In addition, compared to the FAVAR, the baseline model exhibits instances of weaker and statistically insignificant impulse responses.

Policy implications

The results presented above carry several potential policy implications. The event-study analysis showed that the policy signalling channel strongly dominates the monetary transmission to financial markets. In fact, we observed that the non-standard measures became particularly effective once they are accompanied by the communication strategy stating a permanent commitment to unconventional monetary policies. In that manner, the active forward guidance policy should enter the regular monetary conduct and should become a necessary add-on to the non-standard measures.

The fact that the portfolio rebalancing effect remained practically muted for almost all policy announcements before 2014 suggests that majority of the non-standard measures were perceived as too little and probably too late. Namely, the SMP was introduced almost 2 years after the eruption of the crisis and with volume that was significantly lower compared to other central banks and in the time when large portion of QE programs in
the US and UK were already in the phasing out process. The reasons for this delayed and small response can be sought in the rather restrictive institutional framework to which the ECB adheres. Namely, as the ECB was obliged to stay compliant with the 2% target inflation it was not able to pursue other objectives in the same way as other central banks. In that sense, the policy implication related to this particular result does not necessarily relate to central banking per se, but it is also a political matter and functioning of the European Union in general. In other words, a shift to a multidimensional monetary policy, described throughout the dissertation, cannot be fully implemented with single mandate framework still formally being in place. The institutional platform of the ECB should therefore constitute the multitude of objectives including price stability, employment, and financial stability.

On the positive note, what the dissertation results suggest is that the unconventional monetary policy did in fact successfully improve financing conditions in the most distressed countries and effectively averted the sovereign and currency crisis. However, the question at what expense of mispriced financial risk this was achieved still remains unclear. Namely, the covered bond purchasing programs significantly reduced spreads between the best performed and B-rated corporate bonds. A similar reduction could also be observed in case of the intra-euro sovereign spreads which in the period between 2008 and 2015 reduced by more than 700 basis points. However, this reduction can predominantly be ascribed to monetary policy and the general low interest environment which pushed the investors down the quality line and less so to the actual structural improvements in those countries. The reduced intra-euro spreads are in that manner extremely sensitive to potential future monetary tightening and global increase in interest rates, which might induce capital outflows from the most distressed countries. To ensure sustainability of the non-standard measures, the future monetary policy will necessary be conducted in a close interaction with the fiscal policy. A step in this direction could already be observed in case of the OMT program which includes conditional asset purchases that are based on issuers’ commitment to implement certain bundle of structural reforms. In addition, fiscal and tax policy should be conducted in a way that it does not offset monetary policy effort by producing incentives for the undesirable capital outflows.

A somewhat similar question is how to harness monetary policy spill-overs that could potentially hamper the effectiveness of domestically employed non-standard measures. Particularly, monetary policies of the ECB and the FED seem to be, at the time of writing, taking diverging paths. In February 2016 the FED announced its reversion to the tighter monetary policy with decision to raise target Federal Funds rate, whereas the ECB has committed to the zero-interest policy rate till 2016. This can induce several potential consequences for the Euro area markets. First, tighter monetary conditions in the US may lead to a decline in bank funding. Next, the increasing interest rates in the US may initiate capital outflows and put upward pressure on the Euro-area interest rates. In addition,
the diverging monetary policy would lead to depreciation of euro vis-a-vis the dollar. The latter would favourable affect the Euro-area exports, but positive effects would partly be neutralized as the depreciated exchange rate could also imply deflationary pressure through commodities since oil is treated in dollars, which would reduce its demand and price (Bernoth and König, 2016). To maintain the accommodative monetary stance, the ECB would have to engage in further and more aggressive asset purchases. However, the moderate response of the interest rates shown in the Chapter 2 raises doubt whether the asset purchases would be enough to completely offset the spill-over effects. In addition, as we could see the financial markets form certain expectations about unconventional programs, which in case of not meeting them could lead to even tighter stance than the one in the baseline scenario. Likewise, the reactionary policies introduced by the ECB would also impact the initial policy efforts by the FED. In the world of free capital flows, therefore, an international policy coordination seems like a necessary ingredient of the future monetary policy conduct. In fact, Taylor (2013) proposes a formation of central bank forum on rule-based monetary policies, which would enable transparency and timely policy adjustments to central banks.

Putting long-term perspective aside, it is reasonable to expect that the ECB will keep re-introducing non-standard measures and maintain low interest policies in the short to medium period. Namely, chapters 3 and 4 suggest that despite an enormous stimulus provided by unconventional monetary policy, the economic recovery has been sluggish. Reasons for that can in part be sought in the fact that the liquidity induced through unconventional policies did not translate into bank lending. Especially in the periphery Euro area, banks and small and medium enterprises are still piled with non-performing assets and are exhibiting an extensive deleveraging process. To support this process the monetary policy in medium term is forced to keep commitment to maintain liquid debt markets and low interest until the desired restructuring or deleveraging is achieved. This policy, however, has to be supported by proper supervisory and regulatory policies which separate banks that are fully engaged in a restructuring process from the banks that are curtailing additional lending until the holding assets recover in value.

Future research

The main results of the analysis initiated within this dissertation open a floor for several potential future research paths. A further extension of our analysis highly depends on data availability. In particular, the yield curve data was, at the time of writing, still relatively incomplete and incomparable at individual country levels. Namely, the maturity gaps and short time series samples exhibited for the country level yield curve data prevented the extension of the analysis to a wider panel of the Euro member countries. Therefore, with the availability of the country data, a more coherent analysis of heterogeneity of monetary transmission will be allowed. Consequently, methodologies for
monitoring liquidity misalignments related to particular geographical segments could be allowed, which would improve the operational aspect of the centralized monetary policy. In addition, availability of disaggregated monetary stance data would allow employment of econometric techniques for panel data. The merits of the latter could be reflected in the elimination of information loss that occurs due to the data aggregation within the monetary policy analysis, conducted for the overall Euro area. The prolonged period of observed data is another aspect of the data that will allow the use of more elaborate time-series methods, e.g. Time-varying FAVAR or smooth-transition FAVAR that should in principal suit better the non-linear nature of the SSR measure.

Furthermore, this dissertation recognizes the economic stimulus measure by Krippner (2014, 2015a) as the most reliable alternative for monitoring monetary stance in the Euro area. In addition, it establishes the FAVAR as the modelling framework that allows for a consistent analysis of monetary policy effects on an arbitrarily large set of macroeconomic and financial variables. Both findings could therefore be used to develop the analysis of monetary transmission in the Euro area on levels of disaggregated economic sectors. This would offer recognition of the parts of economy that are most sensitive to monetary policy actions and parts where monetary policy is ineffective. In the context of non-standard measures, especially those related to the asset market purchases, the price distortions and wealth distributional effects could be directly assessed in that fashion.

Moreover, large asset purchase programs and an extensively increased central banks' balance sheet call for a more detailed analysis of the effects of unconventional policies from the perspective of financial stability. While this dissertation shows that non-standard measures successfully improved financing conditions for the most distressed countries, it is not clear at what expense of risk-distortions this was achieved. Namely, the low interest rate environment incited investors into seeking higher yields in arguably riskier assets, whereas the wealth of economic agents in countries with a higher savings ratio was significantly eroded. It has also remained unexplored to what extent has the asset relocation encouraged a moral hazard behaviour in the Euro area financial markets. In addition, to this point, the central banks’ exit strategy related to piled balance sheets is heavily dependent on the realized maturities of the assets held. The risk connected to that is especially relevant for the case of the ECB, which engaged in quantitative easing relatively late into the GFC-ZLB period.
References


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APPENDICES
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**Appendix A: Estimation parameters and test statistics**

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<tr>
<th>Table A1: Parameter estimates of Shadow/ANSM(3) and ANSM(3) model</th>
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<table>
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</tr>
<tr>
<td>Italy</td>
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<tr>
<td>Spain</td>
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*Notes: *, ** indicate significance at 5 % and 1 %. The LM statistics refers to null hypothesis of no autocorrelation present in the system’s residuals. The Jarque Bera statistics tests the null hypothesis of normally distributed residuals.*
Appendix B: Impulse responses to Euro area and country-specific shadow rate shocks

Figure B1: Impulse responses of output and prices to a monetary policy shock in Italy and Spain

(a) Italy

(b) Spain

Notes: Shaded areas represent 95% confidence intervals.
Figure B2: Impulse responses to Euro area and country-specific shadow rate shocks - Italy

(c) Euro area SSR shock

(d) Italian SSR shock

Notes: Shaded areas represent 95% confidence intervals.
Figure B3: Impulse responses to Euro area and country-specific shadow rate shocks - Spain

(e) Euro area SSR shock

(f) Spanish SSR shock

Notes: Shaded areas represent 95% confidence intervals.
Appendix C: Detailed FAVAR impulse response analysis

Figure C1: 2-Factor FAVAR

(g) Full sample

(h) Common currency sample

(i) GFC-ZLB period
Figure C2: 3-Factor FAVAR

(j) Full sample

(k) Common currency sample

(l) GFC-ZLB period
Figure C3: 5-Factor FAVAR

(m) Full sample

(n) Common currency sample

(o) GFC-ZLB period
Figure C4: IRFs - macro variables (95% CI to EMS response)
Figure C5: HICP - disaggregated (95% CI to EMS response)
Appendix D: FAVAR database description

Table D1: FAVAR database description

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### Table D1: FAVAR database description

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Table D1: FAVAR database description

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**Financial market**

| Exchange Rates-USD/EUR                                      | 5        | Eurostat |
| Exchange Rates-JPY/EUR                                      | 5        | Eurostat |
| Exchange Rates-GBP/EUR                                      | 5        | Eurostat |
| Exchange Rates-CHF/EUR                                      | 5        | Eurostat |
| Dow Jones Euro Stoxx Index-DJE 50                           | 5        | SDW      |
| Dow Jones Euro Stoxx Index-DJE Broad                         | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Industrials                       | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Utilities                        | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Oil and Gas Energy                | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Consumer Goods                    | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Consumer Services                 | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Basic Materials                   | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Technology                        | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Healthcare                        | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Telecommunications                | 5        | SDW      |
| Dow Jones Euro Stoxx Index-Financials                        | 5        | SDW      |

**Money aggregates**

| Money Aggregate (mil. EUR, SAWD)-M1                          | 5        | SDW      |
| Money Aggregate (mil. EUR, SAWD)-M2                          | 5        | SDW      |
| Money Aggregate (mil. EUR, SAWD)-M3                          | 5        | SDW      |
| Money Aggregate (mil. EUR, SAWD)-MFI credit to Government    | 5        | SDW      |
| Money Aggregate (mil. EUR, SAWD)-Consumer Credit             | 5        | SDW      |

**Balance of payments**

| BOP Items (Net, mil. Eur, SA, BPM5)-Current Account          | 5        | SDW      |
| BOP Items (Net, mil. Eur, SA, BPM5)-Capital Account         | 5        | SDW      |
Table D1: FAVAR database description

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DALJŠI POVZETEK DOKTORSKE DISERTACIJE V SLOVENSKEM JEZIKU

Ta disertacija je močno motivirana z, v času pisanja, prevladujočim okoljem nizkih obrestnih mer in v mnogih pogledih prehodnih ukrepov monetarne politike. Knjigo po izbruhu krize v letu 2008 so bile obrestne mere centralnih bank v večini razvitrih ekonomij zreducirane do točke, ko njihovo nadaljevanje ni bilo več možno. V tem okvirju je bilo za ustrezen odziv na velikost in resnost krize potrebno vpeljati ukrepe komplementarne standardnih politik obrestnih mer. Ti ukrepi so bili v večji meri povezani s povečanim zagotavljanjem likvidnosti ter vplivanjem na cene finančnih sredstev in instrumentov denarnega trga preko centralno bančnih bilanc. Poleg tega so centralne banke vpeljale aktivno uporabo komunikacijske strategije z namenom zagotavljanja kredibilnosti ukrepov skozi transparentne napovedi bodočega razvoja monetarne politike. Da Evropska centralna banka v tem ni bila izjema dokazuje najmanj 9 ukrepov med letoma 2008 in 2015, ki se lahko klasificirajo kot nestandardni in so bili oblikovani z namenom odpravljanja anomalij v monetarni transmisiji. Obseg nestandardnih ukrepov je najbolj nazorno prikazan v več kot podvojenih bilanci Evropske centralne banke v obravnavanem obdobju. Prav tako je z razvojem krize moč razbrati jasen premik k bolj odločni komunikaciji ECB-ja, ki se najbolje odraža v nagovoru javnosti guvernerja Maria Draghija na vrhuncu dolžniške krize leta 2012: »(...)

Skoraj ničelne obrestne mere so pojav, ki (z izjemo Japonske) v razvitrih ekonomijah pred krizo ni bil poznan, zaradi česar nekonvencionalne monetarne politike ostajajo relativno neraziskano področje, tako z vključitvijo samih učinkov kot tudi metodologije. Nestandardne monetarne ukrepe so torej potrebno postaviti v kontekst splošnih zakonitosti monetarne teorije na podlagi standardnih politik obrestnih mer v predkriznem obdobju. Z drugimi besedami, potrebno je opredeliti kanale skozi katere se monetarna politika udejanja v nekonvencionalnih časih in raziskati njen učinek na makroekonomske spremenljivke in monetarno transmisijo. Navezujemo se na slednje, je pomembno vprašanje, ki se samo po sebi postavlja, kako ob nestandardnih ukrepih ustrezno kvantitativno opredeliti stanje monetarne politike, ko ključne obrestne mere monetarne politike več ne zagotavljajo tovrstne informacije. Alternativne mere monetarne politike so bile v pretekli literaturi že poznane, a nobena od njih ni dosegla ustreznega nivoja empirične konsistentnosti, ki bi zagotavljal zanesljivo informacijo o prevladujočem nivoju kontrakcije oziroma ekspanzije v sistemu. Kot alternativa kratkoročnim obrestnim meram so se v preteklosti pogosto uporabljale obrestne mere daljših ročnosti, ki odražajo pričakovanje bodočega razvoja kratkoročnih obrestnih mer in posledično monetarne politike. A dolgoročne obrestne mere ne nudijo enostranske informacije glede stanja monetarne politike, saj poleg same komponente pričakovanj glede monetarne politike odražajo tudi presežni donos, ki ga in-
vestitorji zahtevajo, zaradi negotovosti povezane z bodočim makroekonomskim stanjem. Vendar ločnice med obema omenjenima komponentama iz samega nivoja obrestne mere ni moč razbrati. Prav tako je pogosto ponujena alternativa stanje denarnih agregatov, a so le ti še zlasti v kriznem obdobju izkazovali empirično nekonsistentnost in neintuitivno povezavo z makroekonomskimi spremenljivkami.

V nasprotju z dolgoročnimi obrestnimi merami in denarnimi agregatami se je krivulja donosnosti v literaturi izkazala kot zanesljiv indikator bodoče ekonomske aktivnosti in inflacijskih pričakovanj, koncepcov, ki v osnovi predstavljava podlago monetarnim odločitvam. Krivulja donosnosti je ocenjena na podlagi terminskih strukturnih modelov, ki jih lahko v grobem obravnavamo kot faktorske modele. Terminski strukturni modeli namreč opredeljuje obrestne mere kot funkcijo preostale ročnosti in ocenjenih faktorjev, ki povzemajo skupno dinamiko terminske strukture. Ocjenjeni faktorji in parametri terminskega strukturnega modela torej določajo obliko krivulje donosnosti, ki odraža tržna pričakovanja glede monetarne politike. Krivulja donosnosti torej ekvivalentno povzema vse ukrepe, ki imajo vpliv na pričakovanja in razvoj monetarne politike v prihodnosti, ne glede na to ali gre za konvencionalno politiko obrestnih mer ali nestandardne ukrepe, Krippner (2015b). A okolje nizkih obrestnih mer je močno vplivalo tudi na samo relevantnost in uporabno vrednost terminskih strukturnih modelov. Ti namreč prihodnji razvoj kratkoročnih obrestnih mer opredeljujejo kot dinamiko v okviru normalne porazdelitve ocenjene na podlagi njihove trenutne vrednosti, kar pri nizkih obrestnih merah dovoljuje realizacijo negativnih obrestnih mer. To pomeni, da aplikacija modelov v okolju nizkih obrestnih mer postane empirično nekonsistentna, saj je neskladna z opazovanimi podatki in dovoljuje arbitražne možnosti. Da bi terminski strukturni modeli nudili zanesljivo informacijo o stanju monetarne politike, morajo torej ustrezen upoštevati spodnjo mejo obrestnih mer.

na dolgoročno ustaljeno stanje obrestnih mer, nanašajoč se na monetarno politiko, ki ni
ne ekspanzivna ne kontrakcijska.

Namen doktorske disertacije je torej preučiti novo predstavljene metodološke koncepte na
področju modeliranja monetarne politike in jih podrobneje testirati in uporabiti z vidika
analize nekonvencionalnih ukrepov in monetarne transmisije v Evro območju.

**Raziskovalna vprašanja**

V skladu z opredelitvijo problema in motivacijo predstavljeno zgoraj lahko raziskovalna
vprašanja razdelimo v dve kategoriji:

**Raziskovalna vprašanja, ki se nanašajo na analizo nekonvencionalne monetarne politike v
Evro območju:**

- Kako kredibilna je bila monetarna politika Evropske centralne banke v očeh fi-
nančnih trgov v času finančne krize in kateri ukrepi so bili sprejeti za blaženje
njenih posledic?
- Kako učinkoviti so bili nestandardni ukrepi Evropske centralne banke z vidika pogo-
jev financiranja in zadolževanja v Evro območju?
- Kako učinkoviti so bili nestandardni ukrepi Evropske centralne banke z vidika gospo-
darske aktivnosti v Evro območju?
- Kako učinkovita je bila skupna monetarna politika Evro območja na nivoju posameznih
držav članic?

**Raziskovalna vprašanja, ki se nanašajo na empirično modeliranje monetarne politike v
času ničelnih obrestnih mer:**

- Kako ustrezno modelirati monetarna pričakovanja v času ničelnih obrestnih mer?
- Kako ustrezno kvantificirati monetarne spodbude odražene v nestandardnih ukrepih
monetarne politike?
- Katera je adekvatna alternativna mera monetarne politike v Evro območju?
- Kateri metodološki okvir je najbolj ustrezen za analizo monetarne transmisije v
Evro območju?

Disertacija naslovi zgornja raziskovalna vprašanja v štirih poglavjih. Poglavlje se med
seboj dopolnjujejo tako z vidika metodologije kot tudi analize učinkov nekonvencional-
nih monetarnih ukrepov v Evro območju. Prvo poglavje vsebinsko umesti doktorsko dis-
sertacijo v raziskovalno okolje in nudi deskriptivno analizo učinkovitosti monetarne politike
v času krize. Kot osnovo za detaljnije analizo učinkovitosti v naslednjih poglavjih, prvo
poglavje opredeli zakonitosti, ki izhajajo iz monetarne teorije in bi jih centralne banke
moraše zasledovati za dosego želenega učinka nestandardnih ukrepov na gospodarstvo in finančne trge. V povezavi z analizo učinkov na finančne trge in realno ekonomijo, prvo poglavje prav tako naslovi probleme, ki se nanašajo na empirično modeliranje nekonvencionalne monetarne politike.

V drugem poglavju so predstavljeni nestandardni programi monetarne politike, ki jih je Evropska centralna banka uvedla med letoma 2008 in 2015, in njihov vpliv na finančne trge. Natančneje, vpliv na finančnih trgih je analiziran z vidika dveh kanalov skozi katera se monetarna politika lahko udejanja. Prvi se nanaša na odziv trgov preko prilagojenih monetarnih pričakovanj, medtem ko drugi odraža vpliv preko prilagoditve obstoječih finančnih portfeljev, zaradi spremenjene ponudbe določene vrste vrednostnih papirjev. Opredelitev posameznih kanalov skozi katere se monetarna politika odraža na finančnih trgih je še posebej pomembna v kontekstu nestandardnih ukrepov, saj bo njihov učinek pogojen zmožnostjo vplivavanja na pričakovanja glede bodoče monetarne politike. Z namenom osamitve vloge ECB od ostalih dejavnikov vpliva, analiza opredeljuje spremembe v donosih na Evrskih dolžniških trgih na dan po uradni najavi uporabe nestandardnega ukrepa, kjer je sprememba donosov analizirana z vidika obeh kanalov navedenih zgoraj. Poleg odziva na najavljene ukrepe ECB-ja, analiza prav tako mudi vpogled v potencialno prelivanje monetarnih ukrepov drugih centralnih bank. V ta namen je modelsko predstavljen tudi odziv donosov evrskih dolžniških trgov na najave nekonvencionalnih politik s strani ameriške centralne banke (FED). Analiza predstavljena v drugem poglavju je v osnovi statična in temelji na dokaz močni predpostavki, ki domneva, da so najave posameznih ukrepov bile popolno presenečenje za finančne trge ter da so se prilagoditve na finančnih trgih v celoti udejali na dan po objavi.


Podatki in raziskovalne metode

ocenjena se mera monetarne ekspanzije. Shadow/ANSM je za Evro območje ocenjen na podlagi Evro OIS (»Over-night index swap«) donosov, za oceno modela za posamezne države so uporabljeni donosi brez kuponskih državnih obveznic, medtem ko je v drugem poglavju za voljo analizirali učinkov na finančne trge ocenjen tudi Shadow/ANSM na podlagi sestavljenih donosov trojnih-A državnih obveznic.

Kot je že bilo izpostavljeno zgoraj, sta za analizo monetarne transmisije in učinkov nekonvencionalnih monetarnih ukrepov bila uporabljena standardni VAR model in FAVAR model. Prvi je na ravni Evro območja in posameznih držav ocenjen na podlagi treh spremenljivk, in sicer realnega BDP, BDP deflatorja in senčne obrestne mере. FAVAR analiza temelji na 129 makro in finančnih spremenljivkah z natančnejšim opisom v Prilogi D.

Rezultati

Rezultate doktorske disertacije je mogoče opredeliti v kontekstu zastavljenih raziskovalnih vprašanj.

1. Kako ustrezno modelirati monetarna pričakovana v času ničlinskih obrestnih mer?

Evropska centralna banca se je na krizo odzvala s šestimi ne-standarnimi programi monetarni politike neposredno usmerjenimi v nakupe vrednostnih papirjev. Modelsko analizo donosov je pokazala, da so odločitve monetarne politike vplivale predvsem na spremembe v monetarnih pričakovanjih in v manjšem obsegu na spremembe v pripadajoči terminski premiji. Ti rezultati niso presenetljivi, upoštevaje relativno skromen obseg programov pred 2014 zlasti v primerjavi z ukrepi kvantitativnega sproščanja sprejetih s strani FED. Analiza sprememba komponente monetarnih pričakovanj kaže, da finančni trgi v nestandardnih ukrepih niso prepoznali zaveze ECB k dolgoročnejši ekspanzivni politiki. Razloge za to je mogoče iskati v nestanovitini in neodločni komunikacijski strategiji, ki smo ji bili priča pred 2012. Iz sprejetih odločitev Evropske centralne banke in načina na kateri so bile posredovane javnosti je bilo namreč moč razbrati močan poudarek na začasni naravi sprejetih ukrepov, kar se je odrazilo v neintuitivnih odzivih finančnih trgov na račun pričakovane bodoče popravka v monetarni politiki. Tovrstno komunikacijsko strategijo je mogoče pripisati relativno restriktivnemu enojnemu mandatni stabilnih cen v okviru katerega deluje ECB. Poleg omenjenega, se je kriza v Evropi udejala drugače kot v drugih svetovnih gospodarstvih in v skladu s heterogenostjo Evro območja. To je zahtevalo oblikovanje nestandardnih ukrepov, ki so bili precej ozko usmerjeni k najbolj ranljivim državam članicam in je zato njihov učinek bil razpršen in nestanoviten z vidika celotnega Evro območja.

2. Kako učinkoviti so bili nestandardni ukrepi Evropske centralne banke z vidika pogojev financiranja in zadolževanja v Evro območju?

Medtem ko pred letom 2014 z vidika finančnih trgov ni bila prepoznana trajna zaveza
k ekspanzivni monetarni politiki, so nestandardni ukrepi vplivali na izboljšanje pogojev financiranja v državah najbolj prežetih s krizo. Na to kaže več rezultatov v disertaciji. Prvič, analiza evrski dolžniških trgov kaže na možno znižanje donosov v španskih obveznicah ob simultanem zvišanju nemških donosov, kar nakazuje na obrat od "bega v kvaliteto" zaznanega na začetku krize. Podobne zaključke je mož potegniti na podlagi izrazite konkurence med pripadajočimi senčnimi obrestnimi merami perifernih držav, Španije in Italije, in jedrnimi državami, Nemčije in Francije, ki je nastopila po vpeljavi nestandardnih ukrepov monetarne politike ECB. To je podkrepljeno v poglavju 3 s kvantitativno analizo, ki kaže na močan vpliv skupne monetarne politike ECB na izboljšanje pogojev financiranja v Italiji in Španiji, ki so vključeni v programs neposredno usmerjeni v dolžniške trge (SMP, OMT in EAPP) in odločenje komunikacijsko strategijo ECB.

3. Kako učinkoviti so bili nestandardni ukrepi Evropske centralne banke z vidika gospodarske aktivnosti v Evro območju?

Makroekonomski učinki nestandardnih ukrepov so v disertaciji obravnavani v tretjem in četrtem poglavju, in sicer v okviru hipotetične realizacije makroekonomskih serij ob odsotnosti monetarnega šoka prepoznanega s pomočjo alternativnih mer monetarne politike. Analiza na podlagi preferenčne alternativne mere kaže, da so nestandardni ukrepi blagodajno vplivali na ekonomsko aktivnosti kar je obdobja z veliko inflacijo napenčeno 0.8 % nižji hipotetični realizaciji indeksa industrijske proizvodnje ob odsotnosti monetarne politike med letoma 2008 in 2014.

4. Kako učinkovita je bila skupna monetarna politika Evro območja na nivoju posameznih držav članic?

V nasprotju z izboljšanimi pogoji financiranja predstavljenimi pod točko 2, je učinek nestandardnih ukrepov na ekonomsko aktivnost obravnavanih perifernih držav bil neznaten oziroma v dolgoobdobjih celo kontraproduktiven. Z drugimi besedami, rezultati kažejo, da omilitev dolžniške krize in boljši pogoji zadolževanja niso prenesli v dejansko kreditiranje gospodarstva.

Poleg analize učinkov nekonvencionalne monetarne politike v Evro območju, doktorska disertacija nudi tudi več metodoloških zaključkov:

5. Kako ustrezno modelirati monetarna pričakovanja v času ničelnih obrestnih mer?

Poglavje 2 doktorske disertacije nudi neposredno primerjavo Shadow/ANSM s temeljnim ANSM modelom, ki ne upošteva spodnje meje obrestnih mer, z vidika modeliranja monetarnih pričakovanj. Kot približek slednjim je mož uporabiti pogojne napovedi kratko-oročnih obrestnih mer. Primerjava nakazuje na konzistentno preceževanje dolgoročnih napovedi obrestnih mer v obdobju ničelnih obrestnih mer v okviru temeljnega ANSM modela. Pristranskost napovedi v primeru temeljnega ANSM modela je posledica konstantnih porazdelitev obrestnih mer skozi celotno obdobje, zaradi katerih ni upoštevana
lepljivost obrestnih mer v obdobju ničelne spodnje meje. Z vidika modelske analize donosov je to še posebej izrazito ob napovedi prvega programa kvantitativnega sproščanja v Evropi. Na podlagi slednjega bi namreč bilo moč pričakovati daljše obdobje nizkih obrestnih mer, kar pa se za razliko od Shadow/ANSM ne izkaže v ocenah temeljnega ANSM modela.

6. Kako ustrezno kvantificirati monetarne spodbude odražene v nestandardnih ukrepih monetarne politike?

V tretjem poglavju je bila testirana uporabnost senčnih obrestnih mer za namen analize učinkov nekonvencionalnih ukrepov. Ustreznost mere je bila validirana z vidika izkazane dinamične korelacije z makroekonomskimi spremenljivkami. Izhajajoč iz splošnih monetarnih načel je moč pričakovati, da restriktivna monetarna politika, izražena skozi povišanje senčne obrestne mere, rezultira v nižji ekonomski aktivnosti in nižjih cenah. Impulzni odzivi ocenjeni s pomočjo standardne VAR analize so v osnovi skladni s predpostavkami monetarne teorije, a izkazujejo nekoliko višjo persistenčnost in odložen maksimalni odziv v primerjavi s preteklimi rezultati za Evro območje. Prav tako analiza impulznih odzivov kaže, da je Krippnerjevo senčno mero mogoče interpretirati tudi z vidika likvidnostnega stanja in pogojev financiranja posameznih držav članic Evro območja.

7. Katera je adekvatna alternativna mera monetarne politike v Evro območju?

Rezultate analize impulznih odzivov predstavljenih v tretjem poglavju je moč interpretirati zgolj v kontekstu preučevanega časovnega okvira, spremenljivk vključenih v analizo in izbora senčne obrestne mere. Poglave 4 doktorske disertacije lahko potem takem obravnavamo kot detajlnejšo analiza robustnosti, ki za oceno impulznih odzivov uporablja informacijsko bogat FAVAR model in neposredno primerja z možnost identifikacije monetarne šoka za tri alternativne mere monetarne politike. Rezultati analize monetarne transmisije opravljene v poglavju 4 izpostavljajo Mero Monetarne Ekspanzije kot najbolj adekvatno z več aspektov. Mera Monetarne Ekspanzije izkazuje največjo robustnost nasproti različnim specifikacijam terminskih strukturnih modelov, kaže empirično konzistentnost v odnosu do realiziranih monetarnih politik in ponazarja dinamično korelacijo z makroekonomskimi spremenljivkami, ki je skladna z načeli monetarne teorije. Nasprotno, rezultati analize monetarne transmisije na podlagi senčnih obrestnih mer kažejo močno občutljivost v odnosu do terminskih strukturnih modelov uporabljenih za oceno alternativnih mer.

8. Kateri metodološki okvir je najbolj ustrezen za analizo monetarne transmisije v Evro območju?

Pomemben prispevek poglavja 4 je neposredna primerjava FAVAR modela in standardnega VAR modela z vidika analize monetarne transmisije v Evro območju. Pri slednjem rezultati potrjujejo v literaturi pogosto izražen pojav ne-intuitivnega odziva cen na mone-
tarni šok do katerega pride, zaradi deficita informacij, ki pogojujejo monetarne odločitve. Nasprotno, v okviru FAVAR modela je pojav ne-intuitivnega odziva cen uspešno odpravljen z večjim številom ocenjenih faktorjev vključenih v analizo. Obogatitev informacije v FAVAR-u poteka nepristransko in na podlagi glavnih komponent, ki povzemanjo skupno dinamiko širokega nabora makroekonomskih in finančnih spremenljivk. V standardni VAR analizi bi za to bila potrebna inherentna ekspertna presoja o spremenljivki, ki predstavlja najboljši približek manjkajoči informaciji.

Znanstveni prispevek

Znanstveni prispevek doktorske disertacije je moč opredeliti tako z vidika modeliranja monetarne politike v času ničelnih obrestnih mer kot tudi v kontekstu analize učinkov nekonvencionalne monetarne politike v Evro območju.

Glede na raziskano literaturo, disertacija nudi prvi prispevek, ki jasno opredeljuje kanale skozi katere se je nekonvencionalna politika Evro območja udejanjala na finančnih trgih. Prav tako ponušena analiza nudi vpogled v prelivanje učinkov nestandardnih ukrepov sprejetih s strani drugih centralnih bank na Evro območje.

Medtem ko je moč zaznati hitro rast čisto literaturo, ki preučuje uporabnost alternativnih mer monetarne politike na primerih ZDA, Japonske in Anglije, ta še vedno ostaja praktično neobstoječa z vidika Evro območja. Doktorska disertacija v tem kontekstu kot prva raziskuje makroekonomske odzive na monetarni šok prepoznan s pomočjo mere monetarne ekspanzije in senčnih obrestnih mer za Evro območje. Poleg tega disertacija obravnava senčne obrestne mere tudi z vidika posameznih držav članic in na ta način ponudi indikator likvidnostnega stanja in pogojev financiranja za države, ki ne praktičirajo svoje lastne monetarne politike. Navezujoče se na to, disertacija jasno opredeli metodološki okvir za analizo heterogenosti učinkov centralizirane monetarne politike Evro območja.

Nadalje, disertacija predstavlja enega redkih primerov aplikacije strukturnega FAVAR modela za analizo makroekonomskih učinkov monetarne politike in unikaten primer kar zadeva uporabo tovrstnega metodološkega okvira za primerjavo alternativnih mer in obravnavo nestandardnih ukrepov v Evro območju. Prav tako disertacija na primeru Evro območja empirično testira dobrobičite uporabe FAVAR modela in njegovo zmogljivost odpravljanja anomalij prisotnih v standardni VAR analizi. Na ta način doktorska disertacija predlaga najbolj ustrezen metodološki okvir za analizo monetarne transmisije v Evro območju, tako v obdobju nizkih obrestnih mer kot tudi v konvencionalnih ekonomskih časih.