European Central Bank Monetary Policy and the Expectations of Inflation

Authors:

Šeļegs Konstantīns
Tecuci Ana-Maria

Supervisor:

Ludmila Fadejeva

April 2016

Riga

Abstract

This paper analyzes the empirical effect of the European Central Bank monetary policy on the expected inflation from August 2008 till the end of 2015. The authors use the Wu-Xia shadow rate as a measure of the monetary policy stance and inflation-linked swaps as a measure of the expected inflation. Through a Vector Autoregressive Model(VAR) they found that expansionary monetary policy had positive effect on the expected inflation. The effect on long-term expected inflation was smaller than on shorter term expectations. The ECB's simulative monetary policy coincided with a period of commodity price drop and global slowdown. As a result the effect was relatively small and partly hidden by the impact of oil price shock and negative demand shock.

Keywords: European Central Bank, monetary policy effects, expectations of inflation, Vector Autoregressive Model

Table of Contents

1. Introduction

As the father of the modern economics, Adam Smith, stated around 300 years ago, "Money is a matter of belief". Today money markets play a central role in contributing to market efficiency and discipline, financial stability and financing as such and, of course, in the transmission of monetary policy. The monetary policy as a tool gained more attention only after the 1930's Great Depression which showed that indeed, it may cause effects on the real economy. Hence, both policy makers and academia devoted more attention in understanding the effects of monetary policy in order to use it for good. However, there is no consensus on its effects as the transmission channels' effectiveness is changing over time as the complexity of the economies evolves.

Until 2007, during "normal times", the European Central Bank (ECB) would have 3 main tools of monetary policy: open market operations(OMO), lending and borrowing facilities and minimum reserve requirements.

However, firstly during the sub-prime crisis, the central bankers had to use non-standard measures in order to deal with problems in the interbank markets and possible credit crunches. ECB started to use the standard tools at full by doing more aggressive cuts in interest rates; besides, it joined other central banks and started pursuing less standard policies too, an example being the fixed-rate full allotment policy introduced in 2008(Gonzalez-Paramo; ECB, 2011). Besides, the First Covered Bond Purchase Programme was launched in 2009 with a total value of €60 billion (Delivorias, 2015). Secondly, the sovereign debt crisis in 2010 left no other choice than intervening on the secondary sovereign bond markets. From 2010 ECB pursued several types of non-conventional monetary policy, including: quantitative easing (QE), credit easing(CE), outright monetary transactions(OMT), and forward guidance.

The main aim of the actions undertaken, mainly of the quantitative easing programs, is fulfilling the ECB price stability mandate, or getting the inflation to the target, below, but close to 2% over the medium term(ECB, 2015 a). The asset purchase program is expected to make access to credit easier for businesses across Europe, boost investments, lower unemployment and increase the economic growth(ECB, 2015 a). Overall, the theory suggests that QE can spur inflation and stimulate growth through different transmission channels (Cecioni et. al.(2011).

However, empirical evidence on this topic is ambiguous and the evidence does not support strong effects, especially for the European Monetary Union (EMU) (Gern

et.al., 2015). The most recent QE programme which started in March 2015 was planned to inject around €1.1trillion into the European economy during at least the following one and a half years (Bloomberg, 2015). However, the plan was revised at the end of 2015 and it was decided to continue buying €60billion every month until at least the beginning of 2017(ECB press conference, December 2015). Furthermore, Mario Draghi himself, the current central bank governor, stated that the ECB is ready to "review and possibly reconsider" their policy at the beginning of 2016, just a month after unleashing another round of stimulus (ECB press conference, January 2016). Also, so far the markets seem to react very strongly about the ECB actions with every press release (Financial Times, December 2015). Therefore the study of the effect of the ECB monetary policy on real economies is currently extremely topical.

Besides the polemic between market players, academia and ECB representatives, another reason for studying the topic is the Zero Lower Bound(ZLB); as many economies are hitting the ZLB monetary policy as such is transforming and gaining another aspect which have not been extensively studied before.

Moreover, another important factor affecting the way the monetary policy works or is perceived to work are commodity prices. Taking into account that currently the main aim of the monetary policy is still only price stability, any effect of the change in fundamentals will be affecting the monetary policy by affecting the inflation rate.

As the biggest program of the ECB started only recently, at the beginning of 2015, it is more appropriate to study the effectiveness of the ECB monetary policy not through the realized inflation, but through the expected inflation. However, the main reason for studying exactly inflation expectations is not the QE program start date. References about the importance of economic expectations date back to as early as the Ancient Greek philosophers and the Old Testament. More recently, after Keynes' General Theory, in 1950s and 1960s, expectations were used in many macroeconomic areas including inflation (Evans and Honkapohja, 2001). Adaptive inflation expectations, based on Fisher(1930) and formally introduced by Friedman (1957), Nerlove (1958), and Cagan (1956), played an important role in the 1960s and 1970s often being modeled in the expectations-augmented Phillips curve which incorporates the current expectations about future inflation. Inflation expectations are not only influencing the actual inflation but are also of great interest when forecasting and controlling inflation(Bernanke, 2007). Therefore, getting to know how a monetary shock would

influence inflation expectations would help getting insights about how the policy works and what should be done in the future.

Henceforward, in this paper we focus our research on the following question: ***What is the effect of ECB monetary policy on the expected inflation in the Euro-Zone?*** As most of the monetary policy ECB undertook recently can be classified as unconventional (see "Literature Review" section) we examine the overall monetary policy stance by using a shadow rate, instead of the policy rate.

Mario Draghi stated in the January 2016 press conference: "Let me make this clear. We are doing more, because it works, not because it fails. We want to consolidate something that has been a success." (ECB press conference, January 2016); but is it really a success? We want to dig deeper into the issue by finding what is the effect of the ECB policies on expectations of inflation.

This paper contributes to the current literature in several ways. Firstly, our research comprises a time-period in which ECB pursued monetary policy which has not been extensively researched. We took into account the latest Expanded Asset Purchase Program while there is not much ready research for this period for the Euro-Area. Besides, the time period also coincided with a tremendous decrease in oil prices which happened for the first time after the creation of the EMU and should certainly have an impact on the transmission mechanism and consequently on the effect of the policies. Secondly, we use a shadow rate instead of common approach of using the standard policy rates.

Hereafter, the paper is organized as follows. Section 2: firstly, reviews the existing ways of defining monetary policy and its transmission channels; and secondly, reviews the existing literature on the assessment of monetary policy effectiveness. Section 3 provides the econometric model specification, tests performed, the variables chosen and the robustness checks conducted. Section 4 represents the results and section 5 provides a discussion of the results. Lastly, conclusions are given in the section 6.

2. Literature review

In this section we are firstly examining what unconventional monetary policy means and, briefly, what are the transmission channels. Then, we discuss the studies on the topic outside of the EMU in order to find out the methods employed in order to research monetary policy for different geographical zones and time periods. In the end we discuss the current literature on the topic for the Euro Area.

A comprehensive summary of all the ECB interventions from 2007 till 2016 as well as a summary of the literature review can be found in Appendices B.1 and B.2.

2.1.1 Defining unconventional monetary policy

Currently there is no common definition for unconventional monetary policy. Instead, the existing literature is very rich in definitions and classifications of the unconventional policies. Even more, sometimes the difference between a conventional and an unconventional tool can be insubstantial, as Borio and Disyatat (2010) notice. Also, in certain cases one may argue that an unconventional policy is not as non-traditional as it may seem.

According to Stone, Fujita and Ishi(2011), balance sheet policies are mainly classified into: quantitative easing(QE) that normally refers to a central bank buying long term securities, and credit easing(CE), "or support for credit markets". However, Stone et.al.(2011) pinpoint that the terms are not used consistently: "QE bond purchases can be for the financial stability objective of boosting secondary market liquidity or for the macroeconomic goal of reducing long-term interest rates. Similarly, CE has been used to refer to support for financial stability objectives and to more direct support to borrowers".

Hence, different researchers propose different definitions. Stone et. al.(2011) propose a classification of the unconventional policies based on the ultimate objective of the policy, the criteria being whether the objective is macroeconomic or financial stability. Bini Smaghi (2009) proposes instead to classify the unconventional policies into: "endogenous credit easing – measures designed to provide abundant liquidity to commercial banks"; "credit easing – measures to address liquidity shortages and counter spreads in other dysfunctional segments of the financial market" and "quantitative easing – purchases of government bonds to reduce long-term risk-free rates". Bernanke

(2009) is doing a analogous classification. Borio et.al. (2010) suggest classifying the policies having as criteria the targeted financial market and the impact on the balance sheets of the private sector.

In our paper we embrace the definition proposed by Cecioni et. al.(2011) which includes a broader range of actions. Hereafter, an unconventional measure is "any policy intervention that aims to rectify a malfunctioning of the monetary transmission mechanism or to provide further stimulus to the economy when the official interest rates reach the zero bound" unless stated otherwise. Accordingly, all the measures that address "liquidity shortages both of depository institutions and of other important segments of the financial market, the direct purchase of private and public securities, and the adoption of particular forms of communication designed to restore a more normal functioning of the markets and influence expectations about future official interest rates" can be classified as unconventional tools(Cecioni, Ferrero and Secchi, 2011). In order to quantify the overall policy stance we use the shadow rate (as described in the methodology section).

2.1.2 Monetary transmission mechanism

Despite the fact that in our study we focus on the ultimate effect of the ECB policies and not on transmission channels it is vital to understand what are they and how each of them works as this should be a cornerstone in interpreting the results. As with almost any concept related to monetary policy there are different ways to classify the channels and their importance. We provide only the way the ECB perceives the mechanism and what empirical evidence says, as this chapter serves as support for the reader and is not aiming to analyse the literature on the topic.

Practitioners would say that there are two main stages in the transmission of the monetary policy mechanism. Firstly, transmission to the financial markets and then the second stage, transmission from the financial markets to spending and prices (ECB, 2000). Different geographical zones will have different transmission mechanism effectiveness depending on the financial and structural economic conditions at that point in time. ECB representatives believe that for the European Monetary Union the mechanism represented in the scheme below is valid(ECB, 2016).

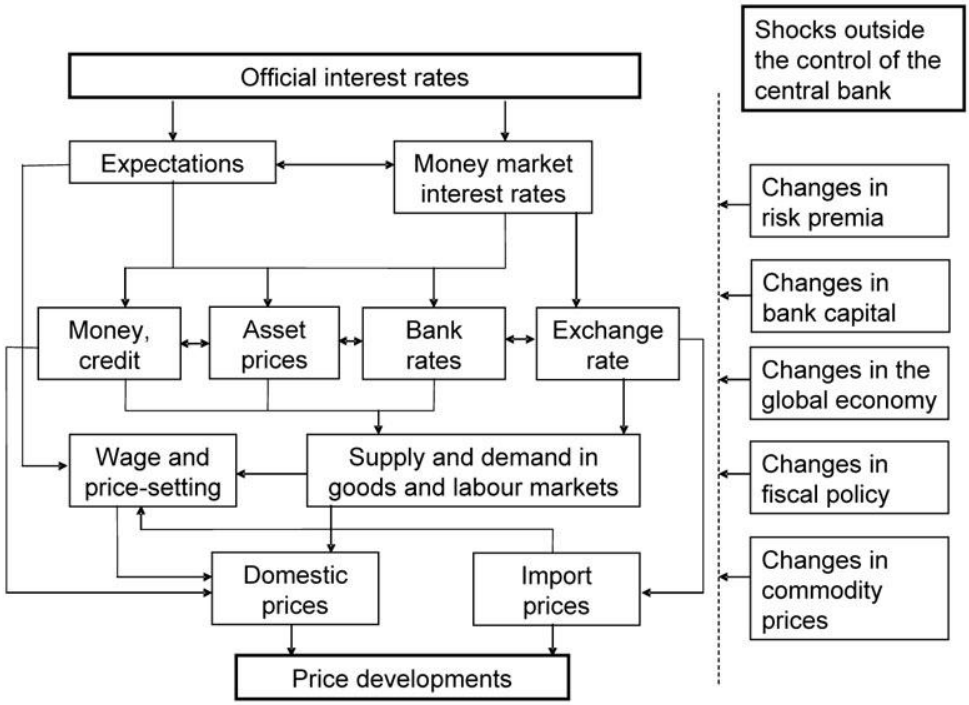


Figure: Monetary policy transmission mechanism. Source: ECB(2016)

Namely, changes in official rates are first of all seen in the money market, banks interest rates and expectations. Expectations about future interest rates as well as expectations of future inflation affect medium to long term rates and price development. A central bank with high credibility can guide markets' expectations of future inflation, hence, anchoring expectations of price stability (ECB, 2016). As a second stage in the chain, the changes in expectations and financing conditions will affect the exchange rate, which may directly affect inflation through consumption of imported goods, and asset prices. Besides, also in the second stage, saving and investment decision are affected. Change in interest rates, asset prices, or collateral value can all affect the consumption, saving investment decision(ECB, 2016). In turn, the consumption-saving decision will impact the demand relatively to supply and the labour markets.

A more theoretical view is provided by researchers. Krishnamurthy and Vissing-Jorgensen (2011) find that the main channels for the transmission of the policy in the US include: "*duration risk, liquidity risk, the safety premium, default risk and mortgage prepayment risk, a signaling and an inflation channel*". For the Euro-Area, Freatzcher et.al(2014) find that the most important are: *confidence channel* – being influenced by how decisive are the actions of the central bank, *bank credit risk channel*, *sovereign*

credit risk channel – or ECB affecting the sovereign credit risk secondarily and decreasing the sovereign risk premia, *international portfolio balance channel*.

However, one may also argue that during crisis times or when approaching the ZLB some of the channels are considerably less effective in transmitting the policy or not working(see Appendix A).

2.2 Brief introduction to the available literature

In recent years, the number of empirical studies of the central bank unconventional monetary policy effect sharply increased (see Cecioni et. al.(2011) or Carrasco et.al.(2014) for an extensive review of the ECB and FED policy effects). Mainly the literature on the topic is focused on two subtopics: the channels of transmission of the monetary policy and their change during "crisis times"; and the effectiveness of a program by examining in detail the effect on certain indicators. As we focus our study on the effect of monetary policy on inflation expectations for us is of more interest the later type of literature. Overall, one could classify the later in two categories: analyzing the effect on financial variables or on macroeconomic variables. At the same time geographical subcategorizations can be done as well.

Besides the recent studies on unconventional monetary policy from different geographical zones we also find a stringent need to view earlier literature, especially evidence from Japan, or literature which served as foundation for the recent literature.

Below we categorize firstly by geographical region, then by time period, afterwards by the type of study, and in the end by the variables studied.

2.2.1 Outside the Euro Area

Globally

An earlier pivotal study of the monetary policy and its effect on inflation expectations was done in 1998 by Krugman. His study is a standard reference to theoretical impact and he states that in a liquidity trap the effectiveness of the monetary policy will depend on the credibility of the CB. Using the Japanese example he models the inflation expectations as a link between the future price level and the current price level. Hence, his theory says that inflation expectations can be generated when a Central

Bank credibly commits itself to higher future prices through an increased inflation today.

As Japan has an impressive history of quantitative easing programs there are a lot of studies starting from early 2000's. Overall there is mixed evidence on the effect of quantitative easing in Japan. Many papers state that quantitative easing decreased yields but the impact on economic activity was small. However, one should not necessarily think that the same results should be found for the Euro Area because the main reasons cited for a low effect were "a dysfunctional banking sector, which impaired the credit channel, and weak demand for loans during a period when corporates were deleveraging"(Berkmen,2012). Besides, the new Comprehensive Monetary Easing(CME) in 2010 fuelled even more research in the field. However, the CME program comprised: a "virtually zero interest rate policy", commitment to maintain the zero rate until price stability is reached, and a new asset purchase program, which makes it even less comparable with the situation in the European Monetary Union. The evidence shows that in case of Japan the program was significantly influencing the asset prices. Lam(2011) and Ueda(2011) find through event studies impact on asset prices and expected prices but no significant impact on exchange rates. Baumeister and Benati(2010) employ a Bayesian time-varying parameter structural VAR and find that long term yield spreads influenced inflation and output in Japan but also in the US, EMU and UK. In case of Japan the effect was less visible in early 2000's than in late 2000's.

US. Before Lehman collapse

Three programs where of bigger interest when studying the measures adopted by Fed before the Lehman collapse: Term Auction Facility(TAF), Term Securities Lending Facility(TSLF) and the Reciprocal Currency Agreements(RCA).

The TAF program was was providing collateralized long-term liquidity. The facility was mostly studied through event studies the main variable of interest being the LIBOR-OIS spread(Taylor and Williams (2010), McAndrews, Sarkar and Wang (2008), Wu (2010), Christensen, Lopez and Rudebusch (2009)) or the Ted spread (Thornton (2010)).

Taylor and Williams(2010) do not find any significant impact on the Libor-OIS spread. However, the authors make three assumptions regarding the credit and liquidity

risk. Wu (2010) and McAndrews et al. (2008) advocate that the specification used by Taylor and Willliams(2010) might have been faulty. Instead they suggest to change the dependent variable and both works find that TAF reduced the Libor-OIS spread in contrast to the results of Taylor and Williams.

Overall, the results showed either no effect on liquidity premium on the Libor market or small reductions in the Libor OIS-spreads. The TSLF program, studied through OLS regressions, also showed small reduction in spreads(Fleming, Hrung and Keane (2010), Hrung and Seligman (2011)).

US. After Lehman collapse

Because the post-Lehman period is characterized by more unconventional monetary policy there are more empirical studies also. The two main channels through which the QE influences the real economy are the signaling channel and the portfolio rebalancing channel.

A pivotal research in this sense was conducted in 2011 by Krishnamurthy and Vissing-Jorgensen in which they study particularly the channels of transmission of the QE1(2008-2009) and QE2(2010-2011) in the USA. In their research Krishnamurthy and Vissing-Jorgensen(2011) evaluate the effectiveness of the US QE policy, state conditions when the policy may or may not work and give suggestions about the amount of assets to be bought (by type). Through an event study they disentangle each of the channels. The main channels found were: risk duration, safety premium, liquidity, commitment, default risk, pre-payment risk and inflation. On the inflation side they find that the expected inflation increased by analyzing 10-year inflation swap rates and TIPS. However, the authors focus mainly on detecting the channels themselves and compare them rather than quantifying the effect through every channel. Another range of similar studies were conducted by Gagnon et al. (2011), Swanson (2011).

Besides event studies(Campbell, Covitz, Nelson and Pence (2011), Stroebel and Taylor (2009), Fuster and Willen (2010), Yellen (2011),) there have been done many time series studies (Hamilton and Wu (2010), Gagnon et al. (2011), Greenwood and Vayanos (2010)) for the post-Lehman period for the US. However, a shortcoming of the high frequency time series studies is that they are highly reliable on the assumptions on which they are based. Moreover, if the time series data on which the study is based is of a monthly or lower frequency the caution should be even bigger as

there might arise a causality identification problem. Still, the studies showed evidence of lowering the long-term interest rate.

Overall, both time series and event studies found that the Fed's actions had a significant effect on the Treasury yields; however, there is no broad consensus in quantifying the impact.

Another type of studies was the ones trying to estimate the impact of the Monetary Policy on some macroeconomic variable instead of financial variables. Of higher interest have been the output and the inflation. Again, in order to study the macroeconomic variables two approaches were normally defined: VARs or structural models(ex: DSGE).

Baumeister and Benati (2010) used a structural time-varying VAR simulating the effect of the reduction in the spread finding that the GDP would have been 10% lower. This means, that according to their findings, the actions of the CB prevented a huge deflation and decrease in GDP.

Del Negro, Eggertsson, Ferrero and Kiyotaki (2011), Chung et al. (2011), Fuhrer and Olivei (2011) use more structured models as the Calibrated DSGE and get to different results. After calibrating the model to match the United States' economy Del Negro et. Al(2011) find evidence that the output and inflation would be lower by 5pp each after the shock while the 2 other studies find evidence for an opposite direction of the result with a different magnitude.

2.2.2 Within the Euro Area

For the Euro Area there is considerably less literature available than for the US, as the Fed was more aggressive in its actions and undertook the unconventional monetary policies longer, or than for Japan, as Japan pursued QE earlier than ECB and there was more time to research the effects.

Some of the early works include studies about fixed rate full-allotment and refinancing operations program by Abbassi and Linzert (2011), and Angelini, Nobili and Piccillo(2010). Abbassi and Linzert(2011) studied the EURIBOR before and after the financial crisis. They state that the Lehman collapse was a turning point in how the transmission mechanism of the ECB policy worked. After the collapse EURIBOR rates

were affected much more by the outstanding liquidity. Besides, they find that the LTRO announcement had an impact on the EURIBOR rates lowering them.

Angelini, Nobili and Piccillo(2010) study is also focused on seeing what was the impact of the financial turmoil in 2007 on the way the policy was transmitted and on the effect of the FRFA program. They find that the unsecured and secured interbank spreads were lowered by 20-30bp as a result of the one and three months refinancing operations.

Later, a structural VAR used by Peersman (2011) provides evidence that an unconventional monetary shock is transmitted in the same way as a standard one but with a more sluggish transmission. His work aim is to provide stylized facts about the transmission mechanism after the crisis.

Giannone, Lenza, Pill and Reichlin (2011), employ a Bayesian VAR to compare forecasts with actual dynamics of certain credit and monetary variables. They conclude that the unconventional monetary policy was a success in insulating the impact of the financial crisis, as the prediction errors were found insignificant. Gambacorta et al. (2014) employs a panel structural VAR and estimates the effect of UMP in certain European countries. The authors find out that balance sheet innovations have the same effect as changing the policy rates. However, a strong assumption of the study is that there is implicit cointegration in the data and in case the assumption does not hold the results may be biased.

The most recent literature shows that the ECB actions in recent years had a very sluggish effect. Fratzcher et. al(2014) quantify the impact of the ECB actions from 2007 to 2012 on the Euro - Area and its spillovers globally and also asses the transmission channels. The results show a positive impact both on the Eropean Monetary Union countries and on other advanced and emerging markets through lowering credit risk, market fragmentation and having a positive impact on the asset prices in the Euro Area. A even more recent study by End and Pattipeilohy(2015) analyses the impact of the ECB policies on the exchange rates and inflation expectations. The authors divide the UMP into Quanitative and Credit easing and find only small effects in the Euro-zone in contrast with the findings for the US and UK. Chen, Lombardi, Ross and Zhu(2015) provide one of the most recent studies in which they compare through a Global VEC the unconventional monetary policies in the Euro Area and the US. In their study they use a

shadow rate developed by them earlier and find out that the effect of the US policy was stronger than the one in the Euro Area. The study is also focused a lot on the spillover effects.

Overall, many studies have been conducted for the programs run outside the Euro Area, especially for the US and Japan. No broad consensus about the effect of Unconventional Monetary Policy was reached, not even when studying the same country, period and through the same methodology.

The impact of the ECB actions on the Euro Area was studied to a much less extent especially because the ECB started acting more aggressively and decisive only in the last years. Besides, as to our knowledge there have been no studies that would include the ECB latest program that started in 2015. Moreover, there have been studies developing or assessing shadow rates but only a very limited number of studies using shadow rates as proxies for the CB policy in a VAR setting.

3. Methodology

As can be noted from the previous section, the analysis of monetary policy through Vector Autoregressive Models (VAR) is a well-established practice. VAR models are commonly used. The main reason is that compared to other models VARs are more flexible allowing a variable to depend on more than just its own lags which is highly relevant when studying monetary policy. For our analysis we have considered a VAR model, a vector error correction (VEC) model and before that performed several econometric tests on data as required: unit-root test, cointegration test, lag order test. The unit-root test was performed in order to find whether our time series data is stationary or non-stationary. The cointegration test was employed in order to find whether our variables, being non-stationary, have a common trend in the long run. We applied Schwarz information criterion in order to find the appropriate lag order. Afterwards, impulse response functions were computed to see the effect of a shock over time. Robustness check was performed for different versions of the key variables (inflation-linked swaps and shadow rates respectively). EViews statistical software was used to estimate the econometric models and perform tests.

3.1 Variables

3.1.1. Endogenous variables.

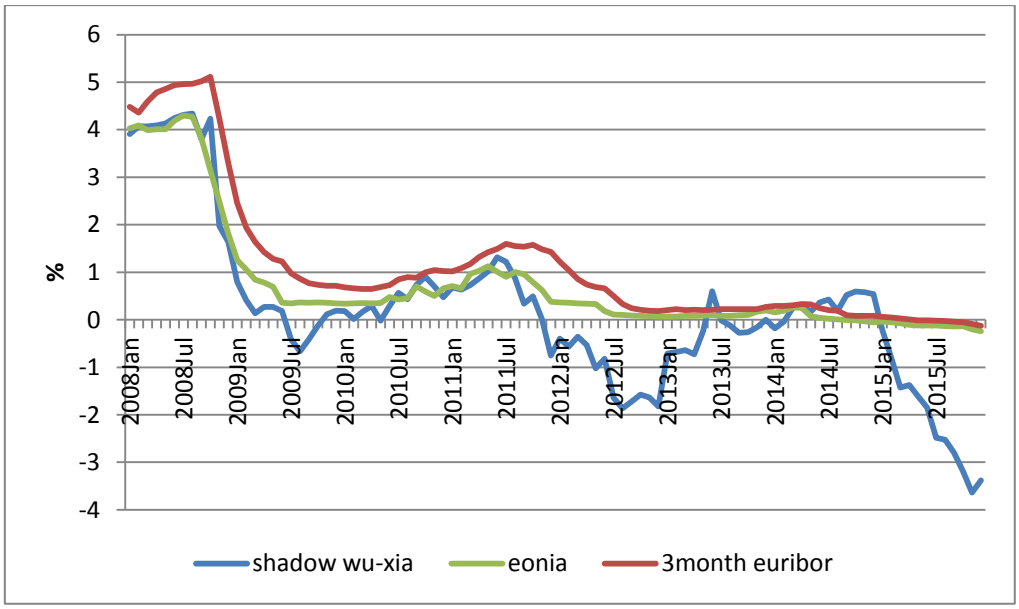
Measurement of the monetary policy stance. Wu-Xia shadow rate

Exercising the monetary policy at the zero lower bound (ZLB) is difficult. When reaching the ZLB, these monetary policies are not reflected in the central bank policy rates (Darvas, 2014). In the recent years, policy rates hit the ZLB in many countries. Thus CBs in the US, UK, Japan, Euro-Zone had to conduct non-standard policies like asset purchase programs in order to fulfill price stability obligations. Hence, the standard monetary models such as standard vector-auto regressions (VAR) that include the policy rate cannot be used in their standard forms for assessing monetary policy shocks in these countries.

Current literature proposes several ways to deal with this obstacle. The first possibility is to use the long term rates that remained above zero instead of short term rates (Damjanovic and Masten, 2015). However, in practice it may be very difficult to embrace such approach due to the multitude of factors incorporated in the long term rates. Another way to deal with this problem is to use money indicators like the Divisia-money aggregates, as proposed by Barnett(1980) and then researched by Wesche (1997), Reimers (2002), Barnett (2003), Stracca (2004), Binner et al (2009), Jones and Stracca (2012) and Barnett and Gaekwad-Babulal (2014). However, there are no Divisia-money aggregates available for the Euro Area. While such aggregates for the UK and the US are publicly available.

A final alternative is to use the shadow rate. The shadow rate is "a summary measure of the total accommodation provided by conventional and unconventional policies" (Hakkio and Kahn, 2014). The shadow rate calculation method was firstly introduced by Black (1995) and it was derived from forward rates. In his work Fisher Black is constructing the nominal short rate as an option. More recently, researchers developed different methods of shadow rate calculation. Wu and Xia (2015) use the term structure information. In their model, the shadow rate is basically the same when the policy rate is much above the ZLB, but when the policy rate is approaching the ZLB the shadow rate becomes negative. Wu and Xia (2015) provide shadow rates for the US, the UK and the euro area. Krippner (2012) provides similar calculations for Japan. The

rate developed by J. C. Wu, F. D. Xia and by L. Krippner estimates "what the rate would be, given asset purchases and forward guidance, if the rate could be negative. More precisely, it represents the policy rate that would generate the observed yield curve if the ZLB were not binding" (Hakkio and Khan, 2014). Lemke and Vladu (2014) provide estimates for the Euro Area shadow rate with a focus on the 2011 – 2014.



Graph: Wu-Xia Shadow rate. Created by the authors

In our paper we use the shadow rate for the Euro Area developed by Wu and Xia which was chosen because it is publicly available(Federal Reserve Bank of Atlanta, 2016), hence making our study easier to replicate. The rate is obtainable on a monthly frequency, starting from September 2004. The Wu-Xia shadow rate is based on the one month forward rates. The forward rates were computed with end-of-month Nelson-Siegel-Svensson yield curve parameters from the Gurkaynak, Sack, and Wright (2006) dataset. The rate is a function of 3 latent variables estimated through the extended Kalman filter.

3.1.2 Endogenous variables. Measurement of inflation expectations. Inflation linked swaps

In this study we analyse the effect of unconventional monetary policy pursued by ECB on expected inflation. There are different ways how to measure market estimates of expected future inflation. All these measures are summarized in the Appendix C. We used euro inflation-linked swaps of different maturities, namely 1, 2, 5

and 10 years, as measures of expected inflation for different time periods. The inflation linked swaps are financial contracts to transfer inflation risk from one counterparty to another (Huber and Maule, 2016). We choose this measure as Draghi emphasized the use of inflation-linked swaps as a proxy for inflation expectations in the global summit of central bankers in Jackson Hole, Wyoming (Financial Times, September 2014). He mentioned five-year, five-year euro inflation linked swap rate, but given the increased investors' attention (as well as speculations) to this rate, we decided to use inflation-linked swaps of different maturities as indicated previously. The data was extracted from Thomson Reuters Datastream.

3.1.3. Endogenous variables. HICP

We used actual inflation data from Eurostat for the Euro Area – Harmonized Index for Consumer Prices(HICP). Having an inflation rate close to 2% level is an ultimate goal for the European Central Bank, focused on price stability. According to the rational expectations theory people base their expectations on current and past information available, and according to adaptive expectations theory people base their expectations just on past information available**.** Also it is common to use actual inflation for monetary policy study (e.g., see End et al, 2015). Therefore, we included actual inflation into the model as it has an impact on the future inflation expectations.

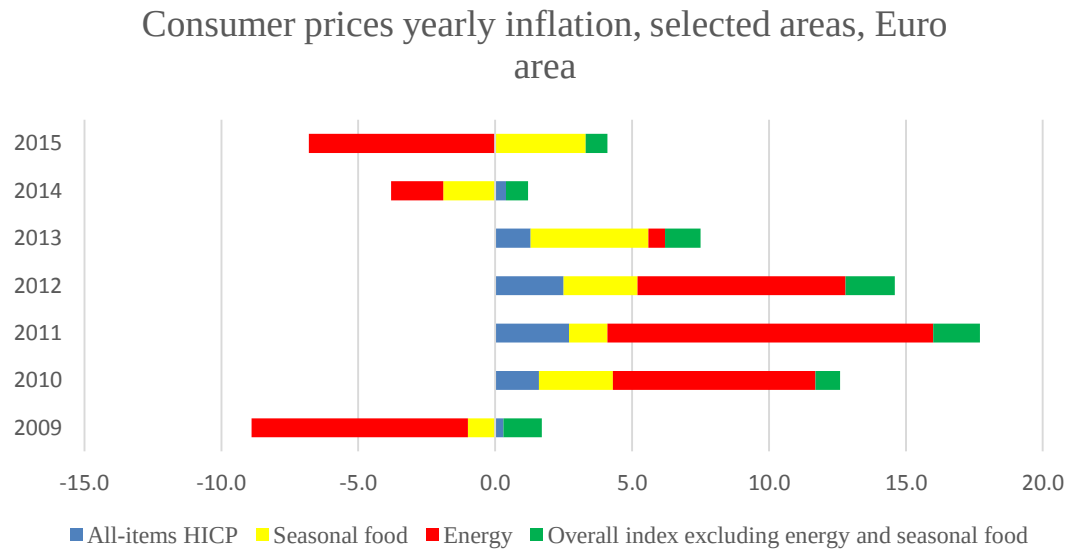
3.1.4. Endogenous variables. Effective exchange rate

The exchange rate is an important channel of monetary policy transmission mechanism, and is often used to analyse the effects of monetary policy (e.g., see Barnea et al, 2015). We used the nominal effective exchange rate index from Eurostat for the major 19 trading partners with the Euro Area. This variable enables to capture indirect (e.g., competitiveness, demand) and direct (e.g., imported price inflation) effects of change in euro exchange rate with major trading partners. Leitemo and Soderstrom (2001) highlighted the importance to include the exchange rates as an indicator of monetary policy.

3.1.5. Exogenous variables. Energy price

During the period studied, ECB monetary policy coincided with the biggest commodity shock in decades. Oil prices dropped by half in less than a year. The drop

unfavourably affected inflation in the Euro Area. Moreover, the anticipated recovery didn't happened and many investors started to expect that the oil prices will be "lower for longer". As a result, oil prices declined further reaching levels not seen from the early 2000s. Therefore, we added to the model variable that includes this developments – Bloomberg Energy Index determined in euro. The variable was obtained from Bloomberg. The variable is exogenous as monetary policy of the ECB does not affect world oil prices.



Graph: Consumer prices. Created by the authors based on Eurostat data

3.1.6. Exogenous variables. European stock volatility index

In recent years the ECB monetary policy coincided with the global growth decline. Therefore, we used the Euro Stoxx 50 volatility index in order to account for any effect from the negative demand shock. We obtained the data from STOXX indices. Large international companies that are domiciled in Europe are included into the index. The companies included in the index, e.g., Anheuser-Bush Inbev, BASF, Total etc., obtain a large chunk of revenue outside Europe, hence can represent demand shock consequences. The variable is exogenous as the ECB monetary policy does almost not affect these stocks volatility, because of international nature of their businesses.

We acknowledge that this variable is not the best activity variable. We have tried to use output gap variable with monthly estimation from quarterly data. The results got were similar to the results from the model we chose to proceed with. We chose European stock volatility index instead of output gap variable in order to account for the

demand shock, because output gap variable has lower variance (less informative) and is estimated from quarterly data (loss of information).

Our sample consists of monthly data for the timespan August 2008 to December 2015. During this period a lot of unconventional monetary policy measures, as defined by Borio et.al(2010) and Bini Smaghi et.al.(2008), were introduced by ECB starting with the Special Term Refinancing Operations, Fixed-Rate and Full-allotment on refinancing operations, continuing with the First Bond Purchase Programme and the Securities Market Programme and finishing with the most recent Expanded Asset Purchase Programme, The full list of the programs is present in Appendix B.1 Hence, the data captures the period of most interest for the ECB actions.

3.2. Econometric model

Vector Autoregressive (VAR) Model

Sims (1980) was first to promote VAR model for analysing simultaneous multivariate time series. VAR models are commonly used for stationary variables without trending behaviour. However, Granger (1991) and later Johansen (1995) introduced cointegration concept which makes VAR models applicable even for non-stationary variables.

Since we chose a standard form VAR we assume that our variables, $y_{n(t)}$, depend on themselves lagged, on the current and lagged values of the other variables in the model. Hence, this means having a system of equations in matrix notation as follows(Floyd, 2005):

$$y_t = v + A_0 y_t + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t, \quad (1)$$

where e_t, *v*, y_t are *m x 1* column vectors and $A_0, A_1, \ldots A_p$ are *m x m* matrices of coefficients. e_t is a zero mean error vector.

Error terms are correlated. Therefore impulse responses from the above stated version of the model are not independent and thus cannot have an economic interpretation. In order to provide economic interpretation the standard approach is to apply structure to the variance-covariance matrix of the error term. The common way of

doing so is by applying Cholesky decomposition to variance-covariance matrix of the error term, i.e. defining ordering of the impulse reactions.

$$E[e_t e_t'] = C^{-1} E[u_t u_t'] C^{-1'}, \quad (2)$$

where u_t are orthogonal error terms and C^{-1} is lower triangular matrix from the Cholesky factorization. Premultiplying all parts of (1) by C^{-1} results in

$$C^{-1} y_t = C^{-1} v + C^{-1} A_1 y_{t-1} + C^{-1} A_2 y_{t-2} + \cdots + C^{-1} A_p y_{t-p} + C^{-1} e_t$$

Hence, our final standard VAR model equation is represented by the following expression:

$$B y_t = c + B_1 y_{t-1} + B_2 y_{t-2} + B_3 y_{t-3} + \cdots + B_p y_{t-p} + u_t,$$

where p is the number of lags used.

In order to use a valid VAR one should firstly perform several tests (tests described in later sections) to determine the number of lags, the variables and whether VAR is at all appropriate to be used. Econometric laws state that in order to use a VAR model the data should be stationary, otherwise a VAR might not be appropriate. Differentiation or detrending can be applied to achieve stationary of data. However, it results in loss of some information about long term properties of the data (Canova, 2007). Therefore, a VEC is preferred to a differenced VAR because of the possibility of losing information about long term properties of the data(Canova, 2007). Another way is to check for cointegration, if variable stationarity is of the same order. If it holds vector error correction model (VEC) or VAR in levels can be used.

Impulse response function analysis

The impulse response functions are decisively depending on the ordering of the variables in the model. For our model, we followed a classical way of ordering, in increasing order of reaction speed. The first variable in the VAR is only affected contemporaneously by the shock to itself. The second variable in the VAR is affected contemporaneously by the shocks to the first variable and the shock to itself, and so on.

The following order was chosen: actual inflation, effective exchange rate, and inflation linked swap.

The effect of the monetary policy will be transmitted differently through different channels. According to practitioners (National Bank of Romania, 2016; Swiss National Bank, 2006), evidence (Roley, 1998), economic theory and our beliefs, the financial markets are the fastest to react. Even more, financial markets are also the ones

embedding information in asset prices before it is conveyed. Hence the effect to be seen the fastest will be on the inflation linked swaps. The exchange rate should also react very fast(Swiss National Bank, 2006). However, comparing with the inflation linked swap, the effective exchange rate should be slower in reaction, therefore is the second in the order. Finally, evidence shows that, for example for the US , the monetary policy shocks were transmitted to inflation in about two years before the crisis and approximately in 3 years after the crisis(IMF country report, 2009). Therefore, it is reasonable to assume that the last in the order should be the actual inflation, HICP.

3.3. Tests and Data Analysis

3.3.1 Choosing model specification and lag-length. Schwarz information criterion

In order to define VAR model lag length we applied the lag order selection criteria based on information that is a common practice (e.g., Nishi, 1988). The most widely used information criterions are Akaike information criterion and Schwarz information criterion. Both criterions employ penalty term for free variables addition to account for overfitting problem. The penalty term in Schwarz criterion is larger than in Akaike criterion, but depends on big amount of observation given amount of variables used. We used the Schwarz information criterion as it is an effective and widely used statistical tool for the selection of the suitable dimensionality of a model taken into consideration present observations. Schwarz information criterion was developed by Gideon E. Schwarz (1978). It doesn't need priors' specification and is based on the maximization of log-likelihood. The general formula is as (Wit et al, 2012):

$$Schwarz\ information\ criterion = -2 * \ln(\max\ p(x|\theta, M)) + k * \ln(n)$$

k - is the amount of free variables that will be estimated

n – is the amount of sample plots in the observed data

max p(x| θ , M) – is the maximized value of the likelihood function of the model M, where x is the observed data and θ represents the variables values which maximize the function.

The model that has smaller Schwarz information criterion is more appropriate.

3.3.2 Unit-root test

The simple Dickey-Fuller test can be conducted using the following simplified autoregressive equation with y_{t-1} subtracted from both sides:

$$y_t - y_{t-1} = (a - 1) * \ y_{t-1} + \ \varepsilon_t$$

The Dickey-Fuller test is the t-statistics on the dependable variable. The variable is stationary, if $a < 1$. However, Dickey-Fuller test has a result's bias in terms that the residuals in the test might have serial correlation. Therefore, we used Augmented Dickey-Fuller to test unit-roots as we can include as many lags as needed to get rid with the problem of serial correlation. Augmented Dickey-Fuller test regression allows to use the intercept, trend and intercept or none of them to increase explanatory power. All variables in the model are non-stationary.

3.3.3 Cointegration test

If our variables are observed to be non-stationary, we should analyse whether variables diverge in the long run or there exists long-run relationship among them. We employed the Johansen integration test (Johansen, 1991). Under the Johansen test, the null hypothesis H(*r*) is that the number of cointegration vectors is less or equal to *r* (trace test) or *r+1* (maximum eigenvalue). If the variables are of the same order, we can test for cointegration between the variables and use VEC; alternatively VAR in levels can be used.

4. Results

All our variables tested with Augmented Dickey-Fuller test were found to be non-stationary and integrated of order one. Besides, we found that our time series has one long run relationship. Therefore, in our paper we use a VAR in levels.

Also, we used a VAR approach as proposed by End (2015) in order not to inflict ex ante restrictions on the estimated effects of central bank unconventional policy on expected inflation. The variables included in the model were: shadow rate Wu-Xia, euro inflation-linked swap rate, nominal effective exchange rate and HICP. We included one lag to the model as recommended by Schwarz information criterion.

Using the Cholesky decomposition on the VAR model with one lag and with the base ordering: actual inflation, effective exchange rate, euro inflation-linked 1 year swap rate, shadow rate and computed the impulse response functions for the shadow rate one standard deviation shock.

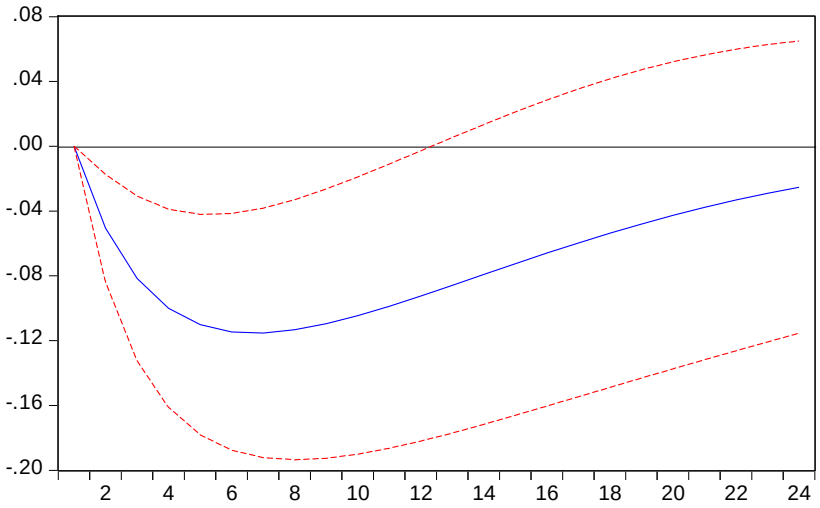


Figure: Impulse respone function: response of 1 year inflation linked swap to Wu-Xia Shadow rate

One standard deviation (equals to 1.7%) positive shock to the shadow rate decreases the euro inflation-linked 1 year swap rate. The impact is significant over the first year and becomes statistically insignificant afterwards, at 95% confidence interval. The effect becomes more pronounced after half a year – the swap rate decreases by approximately 0.12 percentage points due to the increase of monetary policy rates as measured by shadow rate by one standard deviation.

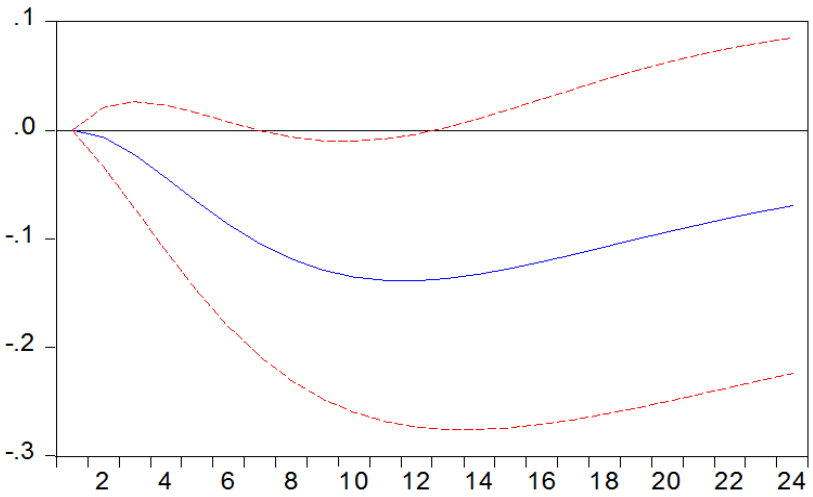


Figure: Impulse response function: response of HICP to Wu-Xia shadow rate

One standard deviation positive shock to the shadow rate decreases HICP index by approximately 0.12 per cent after one year. The decrease is small and statistically insignificant during the first half of a year and then becomes statistically significant at 95% confidence interval. The outcome reflects the sluggish effect from monetary policy

on actual inflation and that contractionary monetary policy reduced actual inflation with effect taking full strength after one year after shock.

One standard deviation positive shock to the shadow rate decreases the nominal effective exchange rate, however the result is statistically insignificant at 95% confidence interval. We expected increase in nominal effective exchange rate, decrease in competitiveness due to the higher interest rates. However, the response to the shock we got is statistically insignificant that also fell in line with our expectations. The result might come from the fact that we used not complicated VAR model.

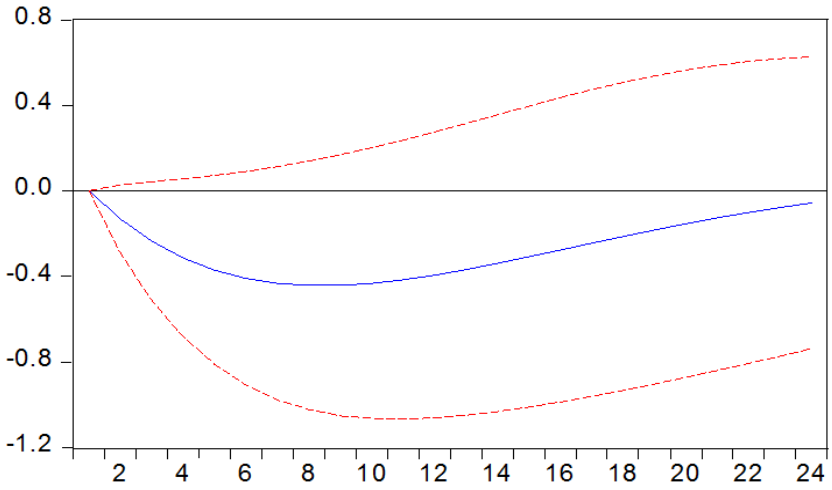


Figure: Impulse response function: response of Nominal Effective Exchange Rate to Wu-Xia shadow rate

4.1 Robustness check

We conducted a robustness check by including different explanatory variables such as the euro inflation-linked swap rates. Namely, we used 1, 2, 5, 10 years swap rates, different shadow rates, and different exogenous variables.

In the case of different swap rates, the effect of shadow rate shock was the same for all periods – the only slight difference, was the size of effect which can be seen in Appendix F. We found that the effect on the swap rates for 1 and 2 years were slightly more pronounced to the shadow rate shock.

We used the Euro area GDP output gap (monthly data) as alternative to the Euro Stoxx 50 volatility index in order to account demand shock. We got the same results in both cases. Also we got that output gap impulse response to the shock was both statistically and economically insignificant. That was in line with our expectations as the output gap variable is estimated from quarterly data (potential loss of information) and has relatively small variance (see Appendix H).

In current literature, different shadow rades(Wu and Xia(2015), Dornbusch et.al.(2014) lead to similar results. We find the same. However, the effect of the response was more expressed with Wu shadow rates as they reflected monetary policy near ZLB through more negative rates. Different exogenous variables: Bloomberg energy index, Europe stock volatility index, highlighted the general result we got – negative response of expected inflation to the one standard deviation shock of the shadow rate. Meaning that ECB expansionary monetary policy positively affected expected inflation.

Alternative Cholesky orderings

Besides, we checked the robustness of our results to alternative Cholesky orderings. Given that our model includes 4 endogenous variables, there are 24 ways of ordering. All the alternative orderings employed yielded similar results to our base model. For convenience we display IRFs of only 2 other alternative orderings in Appendix G.

5. Other considerations and discussion of results

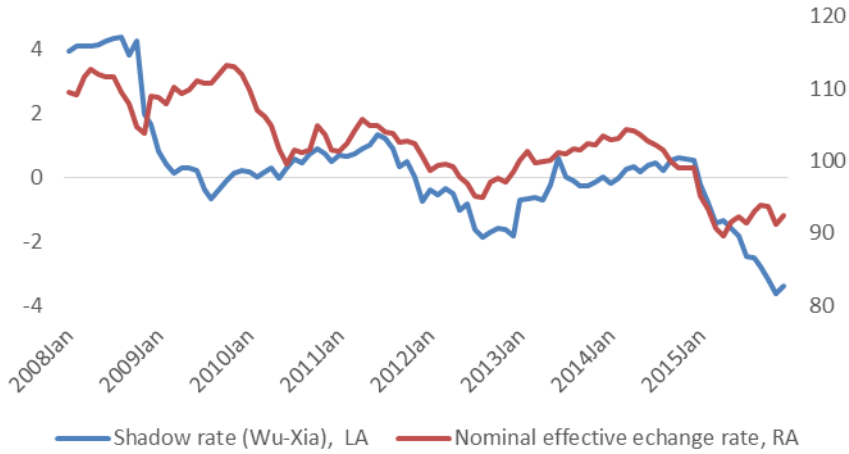
In this section we discuss the results and also link them with previous studies. At the same time, we include in our discussion other factors to be taken into consideration that were not accounted for in the model but are important for understanding the intuition behind the results.

According to our results, the positive effect of expansionary monetary policy of one standard deviation size as measured by shadow rate, increased the expected inflation by at most 0.1% after half a year. This is a small impact on the expected inflation as the ultimate goal of the ECB is inflation of close to, but below 2%, and actual inflation (HICP) stays significantly below this target. However, such sluggish effect of the monetary stimulus matches the conclusion of Fratzcher et. al(2014) or End and Pattipeilohy(2015) that the recent ECB's policy had sluggish effects.

We are prone to think that the exchange rate transmission channel was acting according to theory. However, the result might seem counter-intuitive when looking at the inflation-linked swap rate term structure pattern. During the past years inflation expectation, measured by financial derivatives, had experienced a clearly pronounced

downward trend. The ECB monetary stimulus packages coincided with several negative shocks such as negative oil prices shock and negative demand shock in hand with other European internal and external problems such as Greek sovereign debt crisis, immigration crisis.

The ECB was approaching the ZLB during the study period. Some of the channels became considerably less effective (see Appendix A) in transmitting the monetary policy. Therefore, increasingly important became the exchange rate transmission channel that can affect the expected inflation directly through imported price inflation.

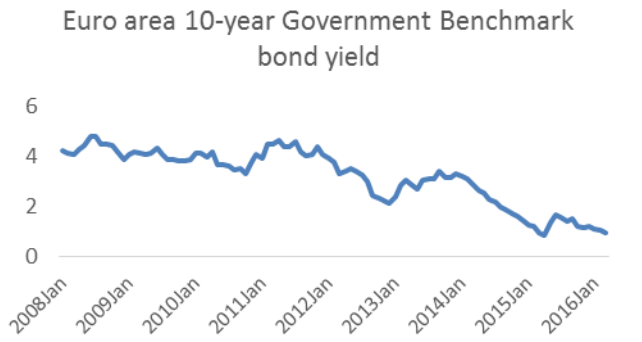


Graph: Shadow rate and Effective Exchange rate. Created by the authors based on Eurostat and Wu, Xia (2015) data.

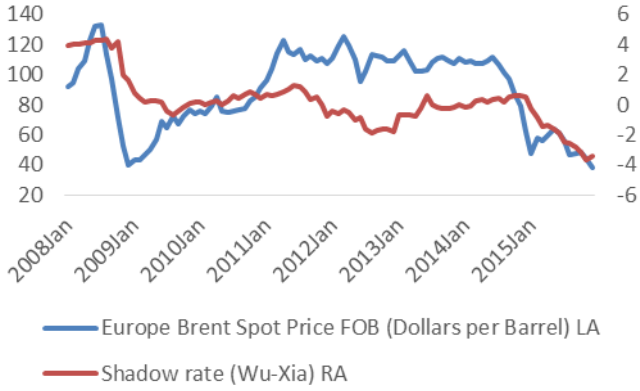
The nominal effective exchange rate reaction to the shadow rate change during the study period, reflected the theoretical exchange rate channel of the monetary policy transmission mechanism. The reaction to expansionary monetary policy was a decrease in the nominal effective exchange rate. The reaction reflected Dornbusch (1976) concept of price stickiness which states that prices are unchanged in the short-term, instead we have exchange rate changes. The ECB's monetary policy decreases the Euro Area's nominal interest rates below foreign interest rates. According to the conditions of uncovered interest parity, the euro should depreciate to make the risk-adjusted returns on domestic and foreign securities equal. The change in the exchange rate affects expected inflation directly through imported price inflation. Imported inflation occurs when goods and service import prices have an impact on domestic price levels. For instance, the long-term pass-through rate of effective imported input prices to domestic producer prices in France, Germany and Netherlands ranges from 79 (Campa et al, 2005) to almost 100 percent (Ahn et al, 2016). The biggest drop in the nominal effective exchange rate was in the early 2015, when market adjusted the exchange rates to the expected start of QE

programme by the ECB. However, the channel seems to be exhausted as the evidence from ECB meetings in December 2015 and March 2016 suggests. After the December meeting the euro appreciated, because the QE programme was not extended as markets expected – unveiled changes in QE programme were smaller than implied by market prices. After the 2016 March meeting the euro again appreciated as the ECB available policy instruments were rapidly moving toward their limits according to the first observations from the Central Bank's representatives. Also, in the recent time, more prominent became the monetary policy of the euro area's biggest trade partner – the U.S. FED slowing pace of interest rate increase weakened the dollar. The cheaper the dollar in euro terms made European exports less competitive in the U.S., and decreased imported price inflation from the U.S.

Other important monetary policy channels for the euro area are the bank lending channel, and sovereign credit risk easing as defined by Freatzcher et.al(2014). Europe had experienced a large credit boom during the end of 2000s. As a result, the region finished the decade with high public and private debt burden. The problem has been described by Krugman and Eggertsson (2012). They argued that ECB's monetary policy efficiency was harmed by closeness to ZLB – potential liquidity trap and deleveraging from the large debt burden. Particularly the later affected the bank lending channel negatively. However, monetary policy instruments used by the ECB largely increased liquidity in the euro area and decreased rates, such as Euribor. As a result of these developments, lending conditions have improved and demand for new loans has raised



Graph: 10-year Euro area government benchmark bond yield. Created by the authors based on ECB data.



Graph: Shadow rate and Brent crude oil price. Created by the authors based on EIA and Wu, Xia (2015) data

(ECB press release, January 2016). Euro area 10-year Government Benchmark bond yield declined considerably in the recent years, implying lower sovereign credit risk in the region. Thus, we concluded that the bank lending and sovereign bond yields dynamic in Europe showed calming evidence that monetary policy transmission channels have been working.

Overall, we conclude that the transmission channels of the ECB's monetary policy were not broken supporting our finding that the policy had a positive effect on the future inflation expectations.

The ECB's expansionary unconventional monetary policy coincided with the largest oil prices drop in decades. We included the Bloomberg Energy Index variable to the model in order to account to this shock. As Europe is a net oil importer the oil prices sharp decline caused negative pressure to the already subdued inflation. In a recent publication, IMF stated that in a low-oil price environment, low inflation and inability of the central banks to lower policy interest rates increases the real interest rate (IMF, March 2016). A positive effect on demand from increased consumer spending due to lower energy expenditures has not been realized yet. Therefore, the ECB has faced only disinflationary consequences on the expected inflation from sharp oil price drop. Certainly, the oil shock negatively influenced the expected inflation and clouded positive effects on the expected inflation from the ECB's monetary stimulus. However, market expectations that oil prices will be "lower for longer" supports believe of oil price boost.

The ECB's expansionary unconventional monetary policy also coincided with the global economic slowdown. In order to account for the effect of the shock we used the European stock volatility index as well as Bloomberg Commodity index as these variable can reflect the shock impact (e.g., see End et al, 2015). IMF has decreased its global economic growth forecast for the nearest two years in the latest update of World Economic Outlook in January 2016. The main reasons the fund cited were developing economies growth slowdown, China's economy shift from investment to service driven economy, lower commodity prices, change of the FED monetary policy (IMF, January 2016). The ECB by itself has decreased its forecast for the euro area economic growth rate in 2016, 2017 and 2018 year citing slow pace of global economy growth (ECB press release, March 2016). The lower economic growth and as a result lower demand

negatively impacted the expected inflation damping positive effect on the expected inflation from ECB's monetary policy.

Moreover, the timing of ECB's expansionary policy coincided with Greek sovereign debt crisis, Grexit and Brexit vote campaign against membership in European Union, and immigration crisis. Each of these events had a negative influence on the confidence in the euro area and, as a result, could deteriorate the expected inflation.

Overall, we can conclude that the ECB actions had a positive impact on the expectations of inflation. However, this impact was smoothed out by the impact of other events. The future developments in the expected inflation will largely depend on the development in the global economic growth, whether the oil prices will boost realize and limited ability of the ECB to increase further its stimulus. In such circumstances increasingly important becomes the central bank communication with the market. We find challenging and fascinating the opportunity to study further implications of the communication of the ECB's monetary policy and its effects on the expected inflation that is beyond the scope of this paper.

Limitations

We used inflation-linked swaps as a proxies for the expected inflation. This is a commonly acknowledge approach. In this case we assumed that investors are liquidity risk neutral, otherwise the financial derivatives would provide not only information about the expected inflation, but also liquidity premium. Also there might be other smaller effects on the expected inflation besides oil price shock and demand shock, which have an impact on the result.

We used short time series as we had limited data since most of unconventional monetary policy (QE) has started just a year ago and has yet to bear fruits.

The VAR model we employed has several limitations such as lack of information on individual transmission channels. Impulse responses are sensitive to omitted variables and, hence, the outcome from the model should be interpreted with cautiousness.

6. Conclusions and final remarks

The results show that the ECB monetary policy had an influence on the expected inflation, and the central bank was performing according to its mandate. However, several shocks, coming from variables such as oil price and demand, clouded the positive effect from the monetary policy.

The effect of the ECB monetary policy on the expected inflation is relatively small. Therefore, reaching the goal of inflation close to, but below 2% will largely depend on the anticipated oil price boost and development of the global economy, taking into account that the ECB has limited potential to increase its monetary stimulus.

According to our results a significant monetary stimulus measured by one standard deviation change in shadow rate increased the expected inflation measured as inflation-linked 1 year swap rate by 0.12 percentage points. We found that the positive effect from expansionary policy on the expected inflation is larger for the shorter period expectations. Therefore, larger monetary policy changes are needed to influence long-run expectations.

7. References

Abbassi, P. and Linzert, T.(April, 2011). The Effectiveness of Monetary Policy in Steering Money Market Rates during the Recent Financial Crisis. ECB, Working Paper Series, 1328.

Ahn J., Park C.-G., ParkC. (2016). Pass-Through of Imported Input Prices to Domestic Producer Prices: Evidence from Sector-Level Data. *IMF Working Paper* WP/16 / 23. Retrieved from: https://www.imf.org/external/pubs/ft/wp/2016/wp1623.pdf

Angelini, P., Nobili, A. and Piccillo, C. (2011) The Interbank Market after August 2007: What has Changed, and Why? Journal of Money, Credit and Banking.

Barnea, E., Landskroner, Y., Sokoler, M. (June, 2015). *Monetary Policy and Financial Stability in a Banking Economy: Transmission Mechanism and Policy Tradeoffs* Journal of Financial Stability, v. 18, pp. 78-90.

Barnett, W. A. (1980). Economic monetary aggregates: an application of index number and aggregation theory. *Journal of Econometrics* 14, 11–48.

Barnett, W.A. (2003). Aggregation-Theoretic Monetary Aggregation over the Euro Area, when Countries are Heterogeneous. *ECB Working Paper*, 260.

Barnett, W. A. and Neepa, G. (August, 2014). Divisia Monetary Aggregates for the European Monetary Union, paper presented at the inaugural conference of the Society of Economic measurement, Chicago.

Baumeister, C. and Benati, L. (October, 2010). Unconventional monetary policy and the Great Recession. ECB, Working Paper Series, no. 1258.

Bernanke, B. S. (July, 2007). Inflation Expectations and Inflation Forecasting. Retrieved from: https://www.federalreserve.gov/newsevents/speech/bernanke20070710a.htm

Bernanke, B. S. (January 13, 2009).The Crisis and the Policy Response. Stamp Lecture, London School of Economics. www.federalreserve.gov/newsevents/speech/bernanke20090113a.htm

Berkmen, P. (January, 2012). Bank of Japan's Quantitative and Credit Easing: Are they now more effective?. IMF working paper, 12/2

Bini Smaghi, L. (2009). *Conventional and unconventional monetary policy.* Keynote lecture by Mr Lorenzo Bini Smaghi. http://citeseerx.ist.psu.edu/viewdoc/versions?doi=10.1.1.362.4513

Binner, J. M., Rakesh, K. B., Elger, T. C., Jones, B. E., and Mullineux, A. W. (2009). Admissible monetary aggregates for the euro area, *Journal of International Money and Finance* 28, 99-114

Black, Fischer. (1995). *Interest Rates as Options.* Journal of Finance. Dec1995, Vol. 50 Issue 5, p1371-1376.

Bloomberg. (2015). *Battles over bond buying*. Retrieved from: http://www.bloombergview.com/quicktake/europes-qe-quandary

Borio, C. and Disyatat, P. (2010). Unconventional Monetary Policies: an Appraisal. *The Manchester School, University of Manchester*, 78: 53-89.

Campa J. M., Goldberg L. S., Gonzalez-Minguez J. M. (2005). Exchange Rate Pass-Through to Import Prices in the Euro Area. *Federal Reserve Bank of New York Staff Reports*, no. 219.

Campbell, S., Covitz, D., Nelson, W. and Pence, K. (2011). Securitization Markets and Central Banking: An Evaluation of the Term Asset-Backed Securities Loan Facility. Federal Reserve Board, Finance and Economics Discussion Series 2011-16.

Canova, F. (2007). Methods for applied macroeconomic research. Retrieved from: http://apps.eui.eu/Personal/Canova/Articles/ch4.pdf

Carrasco, C. A., and Rodríguez, C. (2014). ECB Policy Responses between 2007 and 2014: a chronological analysis and a money quantity assessment of their effects. *FESSUD*, Working Paper Series 65, ISSN 2052-8035

Chen, Q., Lombardi, M., Ross, A., and Zhu, F.(2015). *Global impact of US and euro area unconventional monetary policies: a comparison*. Draft prepared for the IMF Sixteenth Jacques Polak Annual Research Conference on "Unconventional monetary and exchange rate policies". Retrieved from: https://www.imf.org/external/np/res/seminars/2015/arc/pdf/Zhu.pdf

Cecioni, M., Ferrero, G. and Secchi, A. (September, 2011). Unconventional monetary policy in theory and in practice. *Occasional Papers, Questioni di Economia e Finanza*, 102, 38 http://www.bancaditalia.it/pubblicazioni/qef/2011-0102/QEF_102.pdf

Christensen, J., Lopez, J. and Rudebusch, G. (2009). Do Central Bank Liquidity Facilities Affect Interbank Lending Rates? Federal Reserve Bank of San Francisco, Working Paper 2009-13.

Chung, H., Laforte, J.P., Reifschneider, D. and Williams, J.C. (January, 2011). Have We Underestimated the Probability of Hitting the Zero Lower Bound? Federal Reserve Bank of San Francisco, Working Paper 2011-01.

Damjanovic, M. and Masten, I. (2015). Shadow Short Rate and Monetary Policy in the Euro Area. Retrieved from: http://www.econlab.si/igor.masten/Research_files/dm1_11082015.pdf

Darvas, Z. (November, 2014). Does money matter in the Euro Area? Evidence from a new Divisia Index. Bruegel Working Paper, 12, 43. http://bruegel.org/wp-content/uploads/imported/publications/WP_2014_14.pdf

Del Negro, M., Eggertsson, G., Ferrero, A.and Kiyotaki, N. (2010). The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities. Retrieved from: https://www.princeton.edu/~kiyotaki/papers/DEFK_final.pdf

Delivorias, A. (2015). Monetary policy of the European Central Bank. Strategy, conduct and trends. *EPRS*, PE 549.005, 22. http://www.europarl.europa.eu/EPRS/EPRS-IDA-549005-Monetary-policy-ECB-FINAL.pdf

Dornbusch, R. (1976). Exchange Rate Expectations and Monetary Policy. *Journal of International Economics* 6(3): 231–244

Dudenhefer P. (2009). A Guide to Writing in Economics. Retrieved from: http://lupus.econ.duke.edu/ecoteach/undergrad/manual.pdf

ECB. (2015, a). *ECB announces expanded asset purchase programme*. Retrieved from: https://www.ecb.europa.eu/press/pr/date/2015/html/pr150122_1.en.html

ECB press conference. (December, 2015). https://www.youtube.com/watch?v=vH1bk_eebdI&list=PL5C2C2383444CDA3D

ECB. (2016). Transmission mechanism of monetary policy. Retrieved from: https://www.ecb.europa.eu/mopo/intro/transmission/html/index.en.html

ECB press conference. (January, 2016). https://www.youtube.com/watch?v=xfqmin4Skwo&list=PL5C2C2383444CDA3D&index=1

ECB press release. (January, 2016). Results of the January 2016 euro area bank lending survey. Retrieved from: https://www.ecb.europa.eu/press/pr/date/2016/html/pr160119.en.html

ECB press release. (March, 2016). *Introductory statement to the press conference (with Q&A)*. Retrieved from: https://www.ecb.europa.eu/press/pressconf/2016/html/is160310.en.html

ECB monthly bulletin. (July, 2000). Monetary policy transmission in the euro area. Retrieved from: https://www.ecb.europa.eu/pub/pdf/other/mbjul2000_article07.pdf

ECB monthly Bulletin (February, 2011). *Inflation expectations in the Euro Area: A Review of Recent Developments.* Retrieved from the ECB website: https://www.ecb.europa.eu/pub/pdf/other/art1_mb201102en_pp73-86en.pdf

End J. W., Haan, J., Frost, J and Pattipeilohy C. (May 2015). *Central bank balance sheet policies and inflation expectations.* DNB Working Papers, No. 473. Retrieved from: http://www.dnb.nl/en/binaries/Working%20paper%20473_tcm47-322340.pdf

Evans, G.,W. and Honkapohja S. (2001): Learning and Expectations in Microeconomics. *Princeton University Press*, Princeton NJ

Federal Reserve Bank of Atlanta. (2016). Wu-Xia Shadow Federal Funds Rate. Retrieved from the official web-site: https://www.frbatlanta.org

Financial Times. (December, 2015). *ECB pledges to extend easing until March 2017 'or beyond'*. Retrieved from: http://www.ft.com/intl/cms/s/0/88d23588-99b6-11e5-987b-d6cdef1b205c.html#axzz3ys4gYFMM

Financial Times. (September, 2014). *ECB's Draghi takes up new weapon in war on deflation*. Retrieved from: http://www.ft.com/intl/cms/s/0/55a3b1c4-433f-11e4-be3f-00144feabdc0.html#axzz44jj689PD

Fisher, I. (1930). *The theory of interest*. NY: The Macmillan Co.

Fleming, M., Hrung, W. and Keane, F. (2010). Repo Market Effects of the Term Securities Lending Facility. American Economic Review, 100(2): 591-96.

Floyd, J. E. (September, 2005). Vector Autoregression Analysis: Estimation and Interpretation. Retrieved from: https://www.economics.utoronto.ca/jfloyd/papers/varnote.pdf

Fratzscher, M., Lo Duca, M., Straub, R.. (2014). ECB Unconventional Monetary Policy Actions: Market Impact, international Spillovers and Transmission Channels. Paper presented at the 15th Jacques Polak Annual Research Conference Hosted

by the International Monetary Fund Washington, DC─November 13–14, 2014. https://www.imf.org/external/np/res/seminars/2014/arc/pdf/fratzscher_loluca_straub.pdf

Fuhrer, J., Olivei, P. G. & Tootell G.M. B. (2011). Inflation dynamics when inflation is near zero. Working Papers 11-17, Federal Reserve Bank of Boston.

Fuster, A. and Willen, P. (2010). $1.25 Trillion is Still Real Money: Some Facts About the Effects of the Federal Reserve's Mortgage Market Investments. Federal Reserve Bank of Boston, Public Policy Discussion Papers, no. 10-4.

Gambacorta, L., Illes, A. and Lombardi, M.J. (2014). Has the transmission of policy rates to lending rates been impaired by the Global Financial Crisis? BIS Working Papers 477, Bank for International Settlements.

Gagnon, J., R., Remache, M. J., and Sack, B.(2010) Large-scale asset purchases by the Federal Reserve: Did they work? Federal Reserve Bank of New York Staff Reports no. 441.

Gern, K.,J. , Jannsen N., Kooths S. and Wolters M. (2015), *Quantitative Easing: What are the key policy messages relevant for the euro area?* Briefing Paper for the Monetary dialogue at 23 March. Retrieved from: https://polcms.secure.europarl.europa.eu/cmsdata/ upload/b7278e81-bb5a-4aef-86ab-a0d208c96b7c/IfW_KIEL_QE_FINAL.pdf

Giannone, D., Lenza, M., Pill, H. and Reichlin, L. (2011). Non-standard monetary policy measures and monetary developments", ECB Working Paper no. 1290.

Gonzalez-Paramo, ECB, (October, 2011). *The ECB's monetary policy during crisis.* Retrieved from: https://www.ecb.europa.eu/press/key/date/2011/html/sp111021_1.en.html

Granger, C. W. J. (1981). *Some properties of time series data and their use in econometric model specification.* Journal of Econometrics, Vol. 16, pp. 121–130

Greenwood, R. and Vayanos, D. (February,2010). Bond Supply and Excess Bond Returns", NBER Working Paper, no. 13806.

Hakkio, C., S. & Kahn, G. A. (2014). *Evaluating monetary policy at the zero lower bound.* Economic Review, Federal Reserve Bank of Kansas City, Q II, pages 5-32.

Hamilton, J. and Wu, C., (2010). The Effectiveness of Alternative Monetary Policy Tools in a Zero Lower Bound Environment. *NBER working paper no. 16956,* April.

Hrung, W. and Seligman, J. (January,2011) Responses to the Financial Crisis, Treasury Debt, and the Impact on Short-Term Money Markets. Federal Reserve Bank of New York, Staff Report no. 481.

IMF Staff Country Reports. (July, 2009). Euro Area Policies: Selected Issues. IMF Country Report No. 09/224

IMF. (March, 2016). *Oil Prices and the Global Economy: It's Complicated.* Retrieved from: https://blog-imfdirect.imf.org/2016/03/24/oil-prices-and-the-global-economy-its-complicated/

Johansen, S. (1991). *Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models.* Econometric Society: Vol. 59, No. 6 (Nov., 1991), pp. 1551-1580

Johansen, S. (1995). *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford University Press, Oxford.

Jones, B. E. and Stracca, L. (2012). *Does Money Enter into the Euro Area IS Curve?*

Krippner, L. (July, 2012). Measuring the Stance of Monetary Policy in Zero Lower Bound Environments. *CAMA Working Paper*, 35/2012; http://dx.doi.org/10.2139/ssrn.2112758

Krishnamurthy, A. and Vissing-Jorgensen, A. (2011). The Effects of Quantitative Easing on Interest Rates. Brooking Papers on Economic Activity, forthcoming.

Krugman, P. (1998) It's Baaack: Japan's Slump and the Return of the Liquidity Trap. Brookings Papers on Economic Activity, Economic Studies Program, The Brookings Institution, 29(2): 137-206.

Krugman P., Eggertsson G. (2012) Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach. *The Quarterly Journal of Economics (2012)* 127 (3): 1469-1513

Lam, W. R. (2011). Bank of Japan's Monetary Easing Measures: Are They Powerful and Comprehensive?. *IMF Working Paper*, WP/11/264.

Leitomo K., Soderstrom U. (2001). Simple monetary policy rules and exchange rate uncertainty. Retrieved from: http://www.frbsf.org/economic-research/files/0103conf1.pdf

Lemke, Vladu. (September, 2014). *A Shadow-Rate Term Structure Model for the Euro Area.* Retrieved from the ECB website: https://www.ecb.europa.eu/events/pdf/conferences/140908/lemke_vladu.pdf?61396d9bac181a677c5900e198e77344

McAndrews, J., Sarkar, A. and Wang, Z. (2008) The Effect of the Term Auction Facility on the London Inter-Bank Offered Rate. Federal Reserve Bank of New York, Staff Report no. 335.

National Bank of Romania. (2016). Monetary Policy Transmission Mechanism. Retrieved from: http://www.bnr.ro/Monetary-Policy-Transmission-Mechanism--3242.aspx

Nishi, R. (1988) Maximum likelihood principle and model selection when the true model is unspecified. *Journal of Multivariate Analysis* 27: 392-403

Nomura Global Economics. (2012). How the ECB transmission mechanism is broken. Retrieved from: http://ftalphaville.ft.com//2012/02/22/892291/diagram-du-jour-how-the-ecb-transmission-mechanism-is-broken/

Peersman, G. (2011) Macroeconomic Consequences of Different Types of Credit Market Disturbances and Non-Conventional Monetary Policy in the Euro Area. Ghent University.

Reimers, H. (2002). Analysing Divisia Aggregates for the Euro Area. *Economic Research Centre of the Deutsche Bundesbank*, Discussion Paper 13/02

Roley, V. V. and Sellon, G. H. Jr (1998). Market reaction to monetary policy announcements. Retrieved from: https://www.kansascityfed.org/PUBLICAT/RESWKPAP/pdf/rwp98-06.pdf

Schwarz, G. (1978). Estimating the dimension of a model. *The Annals of Statistics*, 6, 461-464

Sims, C. A. (1980). *Macroeconomics and reality*. Econometrica, Vol. 48, pp. 1–48.

Smaghi, B., L.(April, 2009). *Conventional and Unconventional Monetary Policy.* Keynote lecture at the International Center for Monetary and Banking Studies (ICMB), Geneva,.

Stone, M., Fujita, K. and Ishi, K. (2011). Should Unconventional Balance Sheet Policies be Added to the Central Bank Toolkit? A Review of the Experience So Far. IMF

working paper, 11/145, 70. https://www.imf.org/external/pubs/ft/wp/2011/wp11145.pdf

Stroebel, J. and Taylor, J. (December, 2009) Estimated Impact of the Fed's Mortgage-Backed Securities Purchase Program. NBER Working Paper Series, no. 15626.

Stracca, L. (2004). Does Liquidity Matter? Properties of a Divisia Monetary Aggregate in the Euro Area. *Oxford Bulletin of Economics and Statistics* 66(3), 309-331

Swanson, E. (February, 2011). Let's Twist Again: A High-Frequency Event-Study Analysis of Operation Twist and Its Implications for QE2. Federal Reserve Bank of San Francisco, Working Paper Series no. 2011-08.

Swiss National Bank.(2006). Monetary Policy and financial markets. Speech of Philipp M. Hildebrand, Member of the Governing Board, Zurich, 2006. Retrieved from: https://www.snb.ch/en/mmr/speeches/id/ref_20060407_pmh/source/ref_20060407_pmh.en.pdf

Taylor, J. and Williams, J.(2010) A Black Swan in the Money Market. *American Economic Journal*: Macroeconomics, 1(1): 58–83.

Thornton, D. (2010) The Effectiveness of Unconventional Monetary Policy: The Term Auction Facility. Federal Reserve Bank of St. Louis, Working Paper Series no. 2010-044A.

Ueda, K. (2012). The Effectiveness of Non-traditional Monetary Policy Measures: the Case of the Bank of Japan. *The Japanese Economic Review,* Vol. 63(1).

University of Southern California. (n.d.). USC Writing Guide. Retrieved from http://libguides.usc.edu/writingguide

Verbeek, M. (2004). *A guide to modern econometrics.* Rotterdam: Johan Wiley & Sons

Wesche, K.(1997) The Demand for Divisia Money in a Core Monetary Union. *Federal Reserve Bank of St. Louis Review*, vol. 7, 51-60.

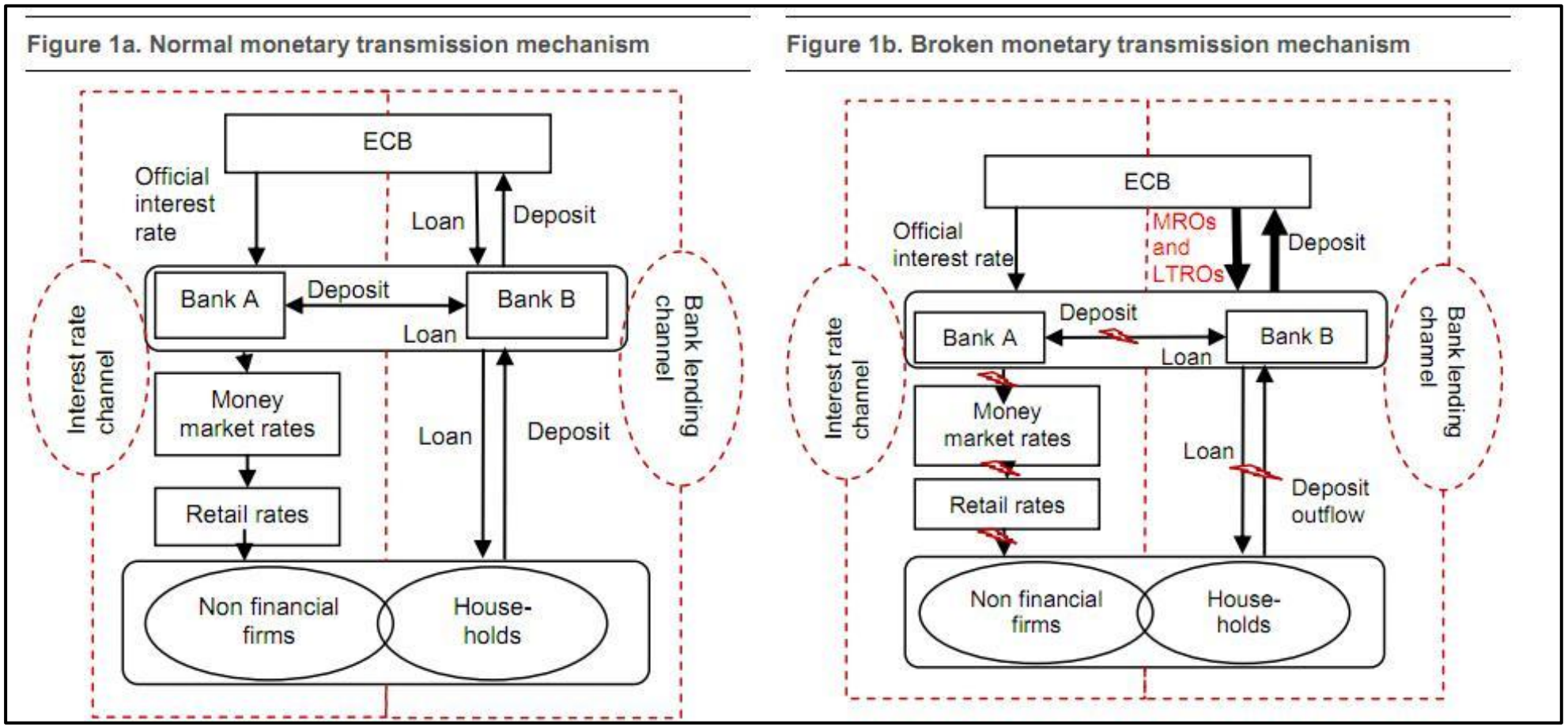
Wit E., Heuvel E., Romeyn J.-W. (2012). All models are wrong...': an introduction to model uncertainty. *Statistica Neerlandica* 66 (3): 217–236

Wu, Xia. (May, 2015). *Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound.* Working paper No. 13-77. The University of Chicago Booth School of Business.

Yellen, J. (February, 2011). Unconventional monetary policy and central bank communications. Speech at The University of Chicago Booth School of Business US Monetary Policy Forum, New York.

8. Appendices

Appendix A. Normal versus Broken monetary policy transmission mechanism



Source: Nomura Global Economics(2012)

Appendix B.1 Interventions' summary (2007-2016).

	1	2	3	4	5	6	7
	Fine-tuning operations	Reciprocal currency agreements	Long-term 6-month operations	Special term refinancing operations	Fixed-rate and full allotment on refinancing operations	Long-term 12- month operations	Covered Bond Purchase Programme (CBPP)
Announcement date	Quick tender	Dec. 12, 2007	Mar. 27, 2008	Sep. 29 2008	Oct. 9-15, 2008	May 7, 2009	May 7, 2009
Start date	Facility already existing in the ECB operational framework	Dec. 17, 2007	Mar. 28, 2008	Sept. 30, 2008	Oct. 15, 2008	Jun. 24, 2009	Jun. 4, 2009
End date	-	February, 2013	May 12, 2010	June 10, 2014	-	Dec. 16, 2009	Jun. 30, 2010
Participants	All banks that have access to Eurosystem credit operations	All banks that have access to Eurosystem credit operations	All banks that have access to Eurosystem credit operations	All banks that have access to Eurosystem credit operations	All banks that have access to Eurosystem credit operations	All banks that have access to Eurosystem credit operations	All banks that have access to Eurosystem credit operations and euro-area based counterparties used by the Eurosystem for the investment of its euro-denominated portfolios
What are they borrowing?	Funds	Funds in US dollars, Swiss francs and pound sterlings	Funds	Funds	Funds	Funds	-
Collateral	Collateral eligible for Eurosystem credit operations	Collateral eligible for Eurosystem credit operations	Collateral eligible for Eurosystem credit operations	Collateral eligible for Eurosystem credit operations	Collateral eligible for Eurosystem credit operations (expanded as of decision of 15 Oct. 2008)	Collateral eligible for Eurosystem credit operations (expanded as of decision of 15 Oct. 2008)	-
Term of the loan	From overnight to 5 days	7, 28, 35 and 84 days	6 months	Same as the length of the maintenance period for the banks' reserve requirement	1 week, 1, 3, 6 and 12 months	1 year	Outright purchases in the primary and secondary markets
Frequency of the program	As necessary (auction)	In connection with the US $ TAF at the Federal Reserve	As necessary (auction)	Once at the beginning of each maintenance period		3 auctions in 2009 (June, September, December)	
Average impact on the Eurosystem's consolidated balance sheet	-	€ 62 bn	€ 66 bn	€ 58 bn		€ 417 bn	€ 31 bn
Max impact on the Eurosystem's consolidated balance sheet	-	€ 249 bn	€ 155 bn	€ 135 bn		€ 614 bn	€ 61 bn
Objective	Assure orderly conditions in the euro money market	Assure liquidity in foreign currencies to euro-area banks	Support the normalisation of the functioning of the euro money market.	Improve the overall liquidity position of the euro-area banking system	Assure the provision of liquidity to all euro-area banks	Encourage the provision of credit by banks to the private sector	Restore the covered bonds market segment

Table B.1. Compiled by the authors based on Cecioni et.al.(2011), Carrasco et.al.(2014) and ECB press releases

	8	9	10	11	12	13
	Securities Markets Programme (SMP)	Extention of LTRO maturities	Covered Bond Purchase Programme 2(CBPP2)	Outright Monetary Transactions	Very Long Term Refinancing Operations(VLTROs)	Reducing the minimum reserve requirements from 2% to 1%
Announcement date	May 9, 2010	December, 2011	October, 2011	August 2012	December 2011	December 2011
Start date	May 14, 2010	-	November, 2011	September 2012		January 18, 2012
End date	Relaunched on August 7, 2011; Discontinued on September 6, 2012 all the assets being transferred into the OMT accounts	-	October 31, 2012			-
Participants	All banks that have access to Eurosystem credit operations and euro-area based counterparties used by the Eurosystem for the investment of its euro-denominated portfolios	-	All banks that have access to Eurosystem credit operations and euro-area based counterparties used by the Eurosystem for the investment of its euro-denominated portfolios	Appropriate European Financial Stability Facility/European Stability Mechanism (EFSF/ESM) programme. Such programmes can take the form of a full EFSF/ESM macroeconomic adjustment programme or a precautionary programme (Enhanced Conditions Credit Line)		-
What are they borrowing?	-	-		Transactions will be focused on the shorter part of the yield curve, and in particular on sovereign bonds with a maturity of between one and three years.		-
Collateral	-	-				-
Term of the loan	Outright purchases in the secondary market	36 months maturity and the option of early payment after one year	Outright purchases in the primary and secondary markets		36-month maturity and the option for early repayment after one year	-
Frequency of the program		2 operations	-		December 2011 with an amount of €489 bn and February 2012 with an amount of €529 bn	-
Average impact on the Eurosystem's consolidated balance sheet	€ 71 bn + 218bn	-	€ 16bn	No ex ante quantitative limits are set on the size of Outright Monetary Transactions.	€489+529bn	-
Max impact on the Eurosystem's consolidated balance sheet	€ 157 bn +218bn	-	€ 40bn		€489+529bn	-
Objective	Address the malfunctioning of securities markets and restore the monetary transmission mechanism	-	Restore the covered bonds market segment; easing funding conditions for credit institutions and enterprises and (b) to encouraging credit institutions to maintain and expand their lending to customers	Safeguarding an appropriate monetary policy transmission and the singleness of the monetary policy		to reduce the banking system's need for liquidity and support activity in the euro area money market

	14	16	16	16	17
	Forward guidance	Covered bond purchase programme 3(CBPP3)	ABS purchase programme (ABSPP)	Expanded Asset Purchase Programme, including Public Sector Purchase Programme (PSPP), CBPP3 and ABSPP	Series of four TLTRO II
Announcement date	Mid-2013	September 4, 2014	September 4, 2014	January 22, 2015	March 10, 2016
Start date	-	October, 2014	October, 2014		June, 2016
End date	-	At least until October 2016	At least until October 2016	Until at least September 2016 Revised in April 2016, to last until March 2017	March, 2017
Participants	-	Eurosystem collateral framework is guiding principle for eligibility of assets for purchase			All banks that have access to Eurosystem credit operations
What are they borrowing?	-	A broad portfolio of euro-denominated covered bonds issued by MFIs domiciled in the euro area	A broad portfolio of simple and transparent asset-backed securities (ABSs) with underlying assets consisting of claims against the euro area non-financial private sector	Bonds issued by euro area central governments, agencies and European institutions; PSPP: euro-denominated marketable debt instruments issued by regional and local governments located in the euro area	refinancing all types of loans to nonfinancial institutions (NFI), except for house purchases and sovereign bonds Counterparties will be able to borrow in the operations a total amount of up to 30% of a specific eligible part of their loans as at 31 January 2016, less any amount which was previously borrowed and is still outstanding under the first two TLTRO operations conducted in 2014
Maturity	-				4 years maturity with possibility of repayment in 2 years
Frequency of the program	-				Quarterly frequency; June, September and December 2016 and in March 2017
Average impact on the Eurosystem's consolidated balance sheet	-			monthly asset purchases to amount to €60 billion Revised to €80billion, until March 2017	The rates for LTRO had a spread of 10 bp over the MRO rate and an initial amount of 400 billion
Objective	Clarify the future path of key interest rates, reducing uncertainty and the interest rate volatility; announcement of a conditional future behavior of key policy instruments	Enhance transmission of monetary policy, support provision of credit to the euro area economy and, as a result, provide further monetary policy accommodation		Programme designed to fulfil price stability mandate, address the risks of a too prolonged period of low inflation. Easing of financial conditions	Reinforce the ECB's accommodative monetary policy stance and to foster new lending; incentivising bank lending to the real economy

Table B.2. Compiled by the authors based on Cecioni et.al.(2011), Carrasco et.al.(2014) and ECB press releases

Appendix B.2 Summary of literature

	Paper	Programme evaluated	Methodology	Variable of interest	Results
US	Taylor and Williams (2010)	TAF	event study	LIBOR-OIS spread	no big effect
US	McAndrews, Sarkar and Wang(2008)	TAF	event study	First difference of the LIBOR-OIS spread	reduction in the LIBOR-OIS spread by 50bp
US	Wu(2010)	TAF	event study	LIBOR-OIS spread	reduction in the LIBOR-OIS spread by 50 bp
US	Christensen,Lopez and Rudebusch(2009)	TAF	multifactor arbitrage-free model for the term structure; counterfactual analysis	LIBOR	reduction in the liquidity risk component of the LIBOR by 70 bp
US	Thornton(2010)	TAF	event study	Ted spread	no impact
US	Fleming,Hrung and Keane(2010)	TSLF	OLS regression	repo rats and spread between Treasury repos and repos based on other less liquid collateral	for each billion of Treasury lent, 0.4bp reduction in repo spreads
US	Hrung and Seligman(2011)	TSLF	OLS regression	spread between federal funds and Treasury GC repos	for each billion of Treasury lent, 1bp reduction in spread between federal funds and Treasury GC repos
US	Krishnamurthy and Vissing-Jorgensen(2011)	LSAP Treasuries	event study	treasury yields,agency debt, MBS corporate yields & TIPS	change in 10yr Treasury yields: -100(QE1); -30(QE2)
US	Gagnon et.al(2010)	LSAP Treasuries	event study	Treasury yields, agency debt yield, swap rate	-91 bp in Treasury 10-yr
US	Hamilton and wu	LSAP Treasuries	time series	10yr Treasury yields	yields drop by 14 bp
US	Baumeister and Benati(2010)		Structural time-varying VAR	identification of a "pure spread shock"	GDP would contract by 10% in 2009Q1
US	Del Negro, Eggertsson, Ferrero and Kiyotaki (2011)		Calibrated DSGE model	assesment of macro effects of a swap of liquid for illiquid assets by the CB with and without the ZLB	Output-5 pp lower; inflation - 5pp lower;
US	Chung et al. (2011)		FRB/US model	simulating macro effects of CB purchasing assets in the large-scale macro-econometric model used at the FED sugumented with a term premium, depending on th net supply of assets	real GDP increasing by 3% above baseline; inflation 1pp higher; increase in employment by 3mln. Jobs
US	Fuhrer and Olivei (2011)		VAR, Boston Fed and FRB/US models	effects of 600bn$ purchase of long term Treasuries	real GDP increase by 60-90bp after 2 years
EMU	Abbassi and Linzert (2011)	FRFA	event study; OLS	EURIBOR	100 bp reduction in Euribor rates; significant (but limited) impact of the announcement of 12-month LTRO operations on 12-month Euribor
EMU	Angelini, Nobili and Piccillo(2010)	FRFA	panel data study based on interest rates on actual unsecured interbank loans	Spread between unsecured and secured interbank loans	Around 10-20 bp reduction in the interbank spreads

EMU	Peersman (2011)	Structural VAR	transmission mechanism of unconventional monetary policy	sluggish effect, comparing with conventional monetary policy
EMU	Giannone, Lenza, Pill and Reichlin (2011)	Large Bayesian VAR	conditional forecasts if the spreads between unsecured and secured money market interest rates remained at the October 2008 level	lower industrial production, by 3pp; 0.5pp lower inflation; 3pp lower loans to financial corportions
Italy, Spain, UK, US	Gambacorta et al. (2014)	factors for breaking down of the cointegration relationship	lending rate on new loans to non-financial firms and the policy rate	more sluggish effect than in the past
EMU	Fratzcher et. al(2014) SMP, LTROs	event study	equity prices, interest rates, yields, exchange rates, CDS spreads and implied volatilities	ECB policies were beneficial on impact for asset prices in the euro area and lowered market fragmentation in bond markets; lower credit risk
EMU	End and Pattipeilohy(2015)	VAR	Quantitative Easing, Credit Easing	statistically significant effects on the real economy

Table. Compiled by the authors. Based on Cecioni et.al.(2011), Carrasco et.al.(2014)

Appendix C. Measurement of inflation expectations

	Agents	Frequency	Start	Horizons
Survey-based measures				
European Commission consumer survey	Consumers	Monthly	1985	12 months ahead (asks for direct change)
ECB Survey of Professional Forecasters (SPF)	Financial and non-financial institutions	Quarterly	1999	Point forecasts and probability distributions: - Current, next, calendar year after next (rolling one and two years ahead) - Five years ahead
Consensus Economics	Financial and non-financial institutions	Monthly (short term) and biannual (medium to longer term)	1990	Point forecasts - Current and next calendar years - Three, four, five and six to ten years ahead
Euro Zone Barometer (MJEconomics)	Financial and non-financial institutions	Monthly (short term) and quarterly (medium to longer term)	2002	Point forecasts - Current and next calendar years - Two, three and four years ahead
World Economic Survey (IFO)	International and national institutions	Quarterly	1991	- Six months ahead (asks for direction of change) - Current calendar year
Financial market indicators				
Break-even inflation rates	Financial market participants	Intra-day	2004	At present, three to about 30 years ahead
Inflation-linked swap rates	Financial market participants	Intra-day	2003	One to 30 years ahead

Table C.1. Inflation expectation measurement. Source: ECB monthly Bulletin (February 2011)

Appendix D. Unit Root Tests

Null Hypothesis: SWAP1Y has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.641036	0.4574
Test critical values:	1% level	-3.508326	
	5% level	-2.895512	
	10% level	-2.584952	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on Euro 1 Year Inflation linked Swap. I(0).

Null Hypothesis: D(SWAP1Y) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.259978	0.0000
Test critical values:	1% level	-3.508326	
	5% level	-2.895512	
	10% level	-2.584952	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on Euro 1 Year Inflation linked Swap. I(1).

Null Hypothesis: EER has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.319791	0.6177
Test critical values:	1% level	-3.501445	
	5% level	-2.892536	
	10% level	-2.583371	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on Nominal Effective Exchange Rate. I(0).

Null Hypothesis: D(EER) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.674278	0.0000
Test critical values:	1% level	-3.501445	
	5% level	-2.892536	
	10% level	-2.583371	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on Nominal Effective Exchange Rate. I(1).

Null Hypothesis: HICP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.276203	0.6380
Test critical values:	1% level	-3.500669	
	5% level	-2.892200	
	10% level	-2.583192	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on HICP. I(0).

Null Hypothesis: D(HICP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.853729	0.0000
Test critical values:	1% level	-3.501445	
	5% level	-2.892536	
	10% level	-2.583371	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on HICP. I(1).

Null Hypothesis: SHADOW_WU has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.253175	0.6485
Test critical values:	1% level	-3.500669	
	5% level	-2.892200	
	10% level	-2.583192	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on Shadow Rate. I(0).

Null Hypothesis: D(SHADOW_WU) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.118273	0.0000
Test critical values:	1% level	-3.501445	
	5% level	-2.892536	
	10% level	-2.583371	

*MacKinnon (1996) one-sided p-values.

Unit Root Test on Shadow Rate. I(1).

Appendix E. Johansen Cointegration test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.640772	142.5330	69.81889	0.0000
At most 1 *	0.382964	52.43882	47.85613	0.0174
At most 2	0.068052	9.949935	29.79707	0.9810
At most 3	0.026434	3.747875	15.49471	0.9228
At most 4	0.015676	1.390406	3.841466	0.2383

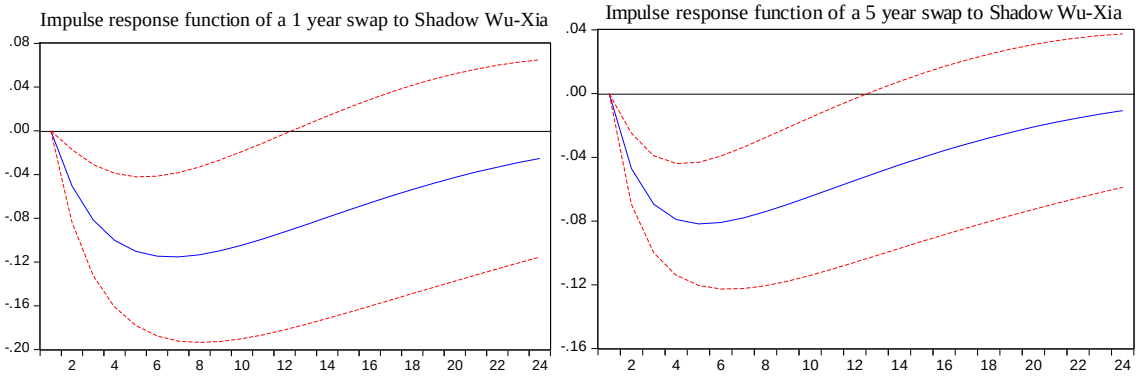
Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

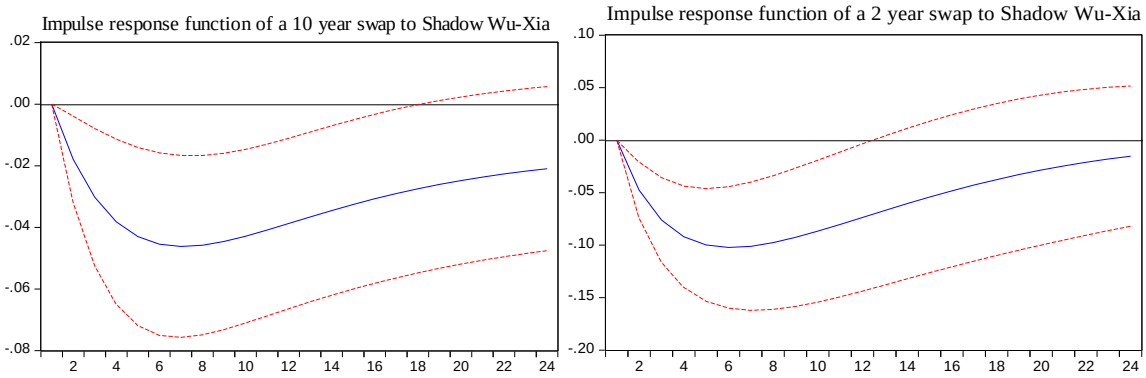
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.640772	90.09420	33.87687	0.0000
At most 1 *	0.382964	42.48888	27.58434	0.0003
At most 2	0.068052	6.202060	21.13162	0.9786
At most 3	0.026434	2.357468	14.26460	0.9801
At most 4	0.015676	1.390406	3.841466	0.2383

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

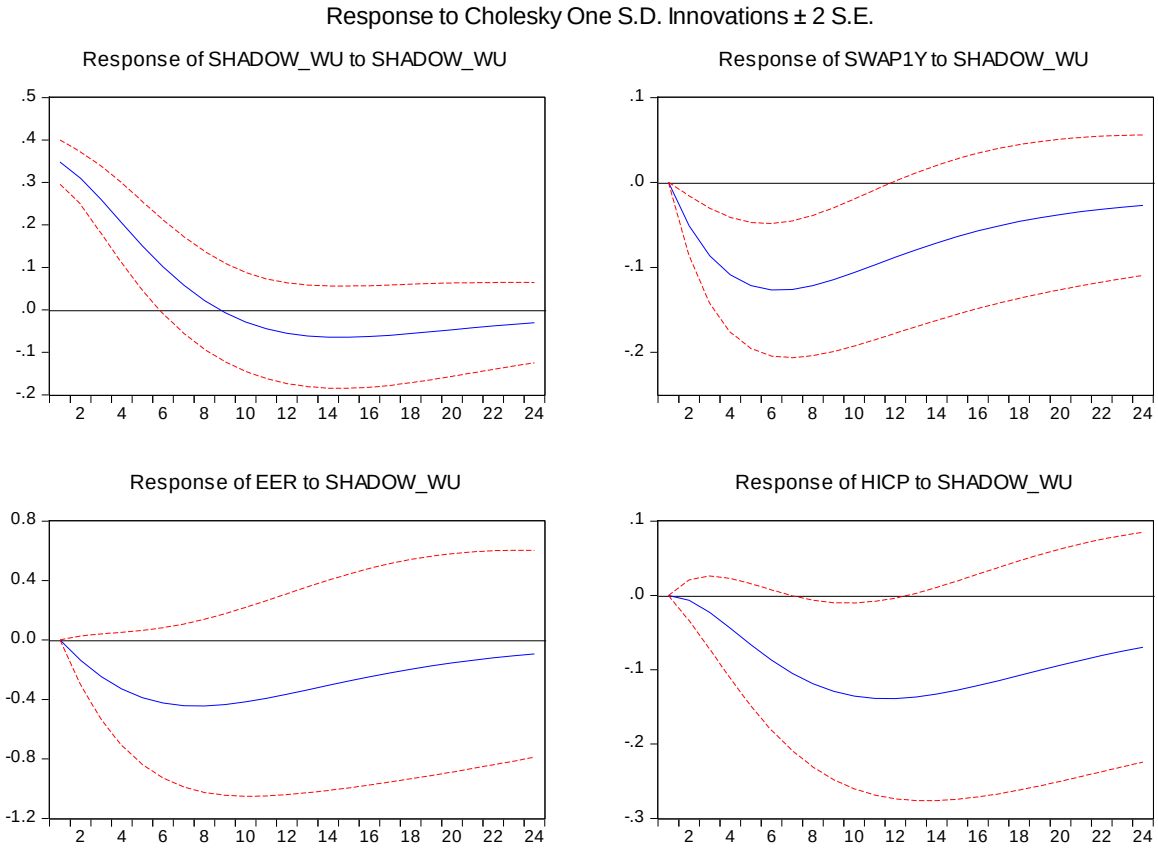
Appendix F. Robustness check. Euro inflation - linked swap rates of different periods response to the shadow rate shock



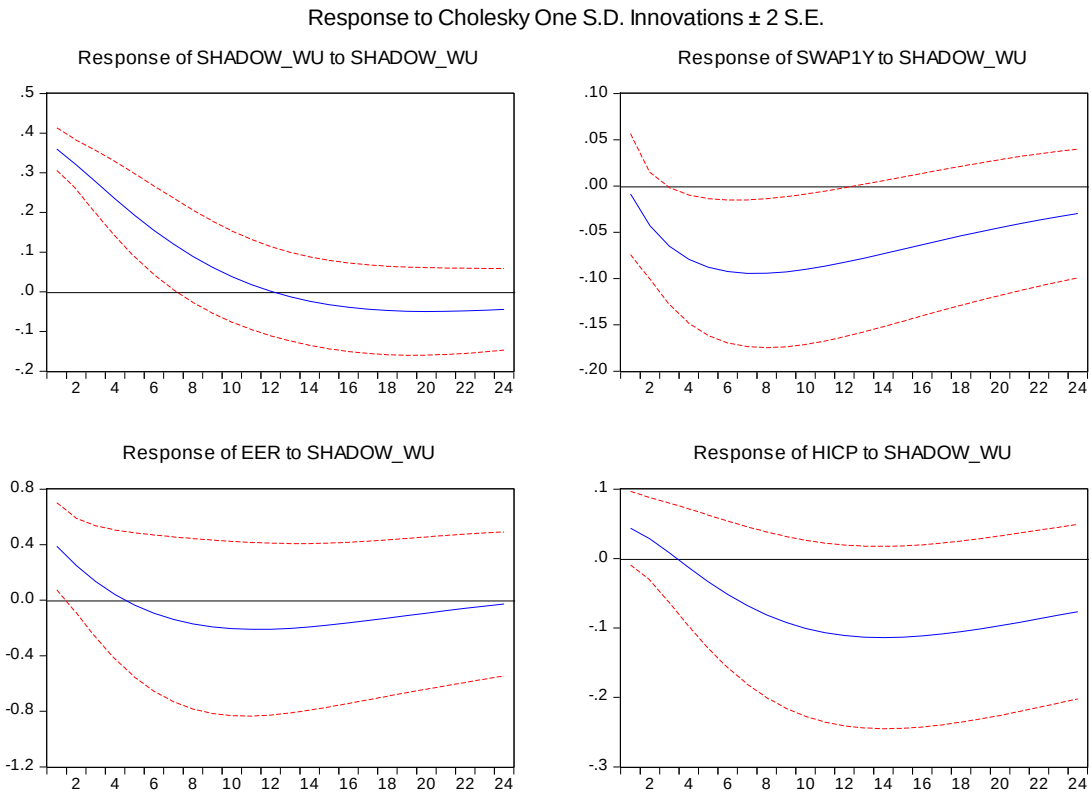


Appendix G. Robustness check. Alternative Ordering

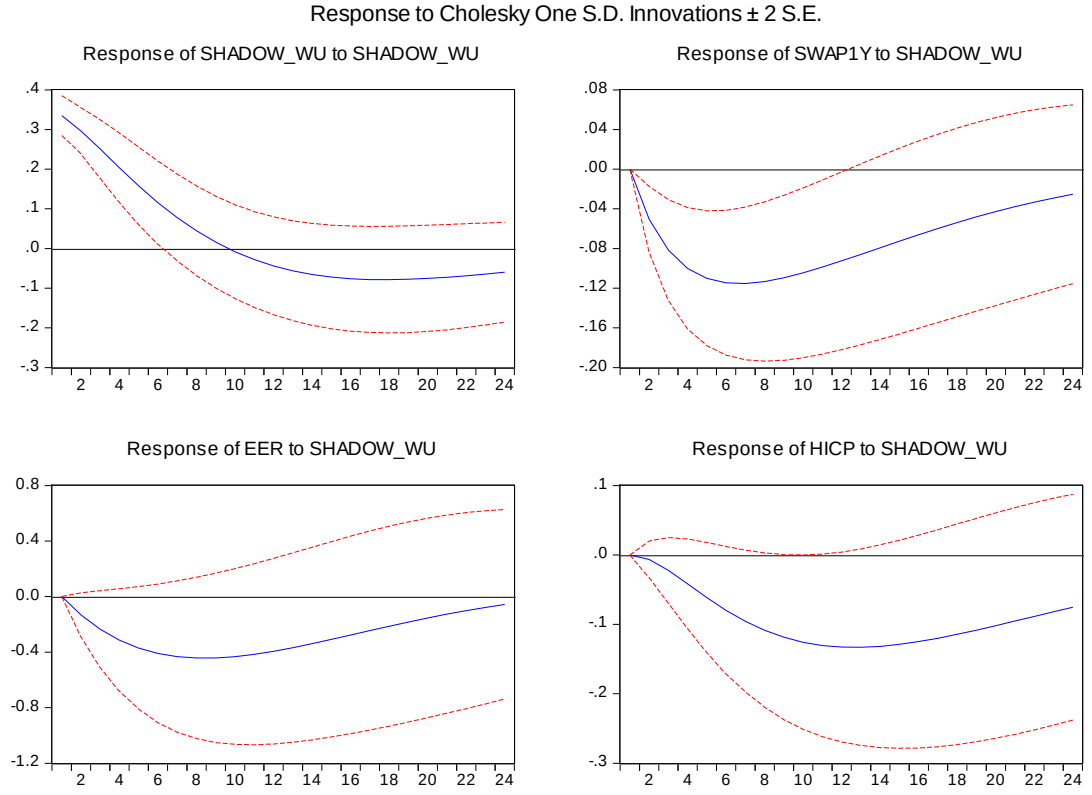
Figures F.1- 4. Impulse response functions in base ordering: HICP(actual inflation), EER(effective exchange rate), SWAP1Y(1 year inflation-linked swap), Shadow Wu-Xia



Figures F.5-8. Impulse response functions in reverse ordering: Shadow Wu-Xia, SWAP1Y(1 year inflation-linked swap), EER(effective exchange rate), HICP(actual inflation)

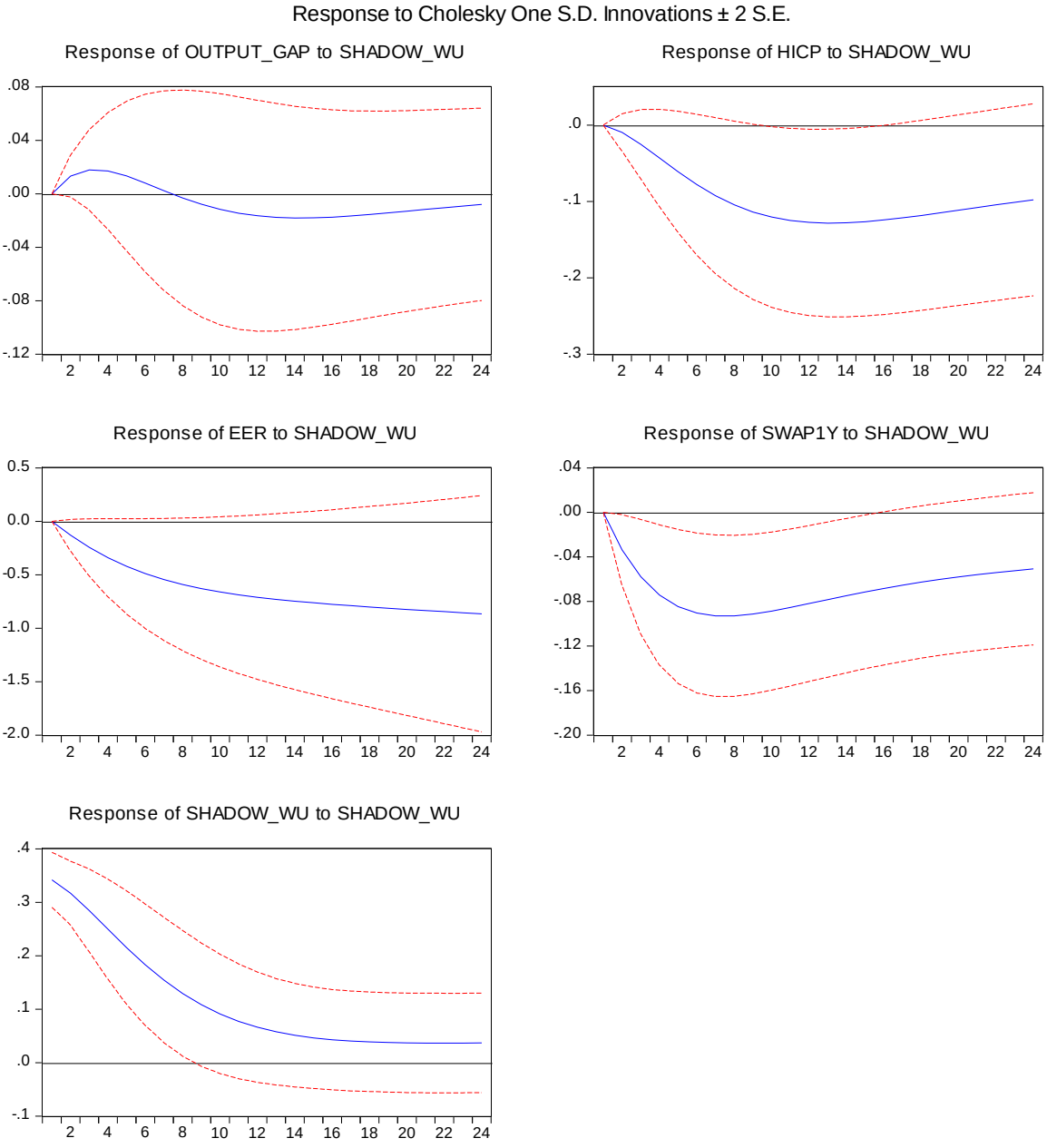


Figures F.9-12. Impulse response functions for ordering: HICP(actual inflation), , SWAP1Y(1 year inflation-linked swap, EER(effective exchange rate),), Shadow Wu-Xia

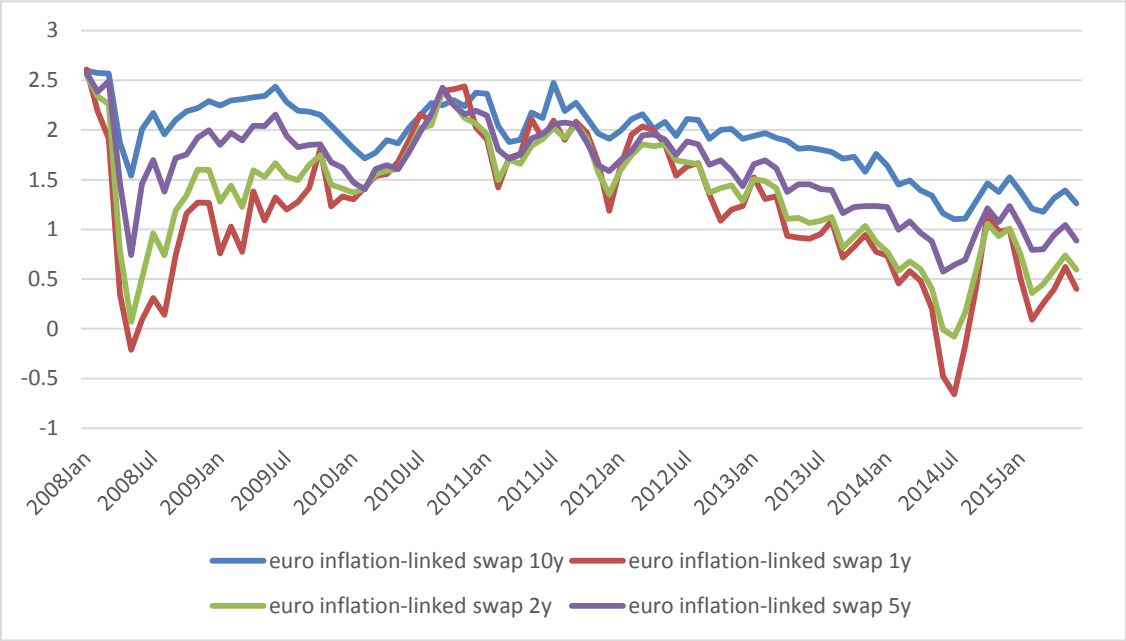


Appendix H. Robustness check. Alternative Variables

Figures H.1-5. Impulse response functions to the one standard deviation shock to the shadow rate for VAR in levels with one lag (endogenous variables: Euro area output gap, HICP (actual inflation), , SWAP1Y(1 year inflation-linked swap), EER(nominal effective exchange rate), Shadow Wu-Xia rate; exogenous variables: Bloomberg Energy Index).



Appendix I. Euro inflation-linked swaps



Source: Thomson Reuters Datastream